Intertrochanteric Valgus-Lengthening-Femoral Neck Osteotomy for Developmental and Posttraumatic Conditions of the Hips

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Objective: To review the results of the treatment of coxa vara associated with femoral neck shortening and high-standing greater trochanter using the new technique of intertrochanteric valgus-lengthening-femoral neck osteotomy.

Material and Method: Twelve of the fifteen hips treated by the present technique of osteotomy were reviewed. Seven of the twelve cases were posttraumatic (four malunion, two nonunion and one childhood fracture of the femoral neck) and five were developmental conditions (three ischemic necrosis of the femoral head and one physeal dysplasia, all of which secondary to DDH and one coxa plana). The mean follow-up period was 34.3 months (range, 12-106). There were 5 male, 7 female. The mean age of the patients at the time of surgery was 26.6 years (range, 13-50). The operation consisted of: intertrochanteric opening wedge valgus osteotomy, femoral neck lengthening by lateralization of femoral shaft and trochanteric lateralization. No bone grafting or substitute was used.

Results: Mean preoperative Harris hip score of 51.8 points (range, 32-67) was significantly improved to 94.8 points (range, 60-100) at the last follow-up study (p = 0.002). The mean femoral shaft-neck angle was changed from 113 degrees (range, 70-140) preoperatively to 138.2 (range, 110-165) degrees at the last follow-up (p = 0.002). Mean length gain at the last follow-up was 12.7 mm (range 5-29 mm). No complications, including delayed or non-union, implant failure and neurovascular injuries were encountered.

Conclusion: The newly present technique could simultaneously address coxa vara associated with femoral neck shortening, and high-standing greater trochanter. The technique is safe and reliable.

Keywords: Coxa vara, Intertrochanteric osteotomy, Valgus, Femoral neck lengthening

During normal gait, the hip joint should have an optimal femoral neck length and angle to lever effectively the pelvis around the femoral head of the hip joint[1]. Coxa vara plus shortening of femoral neck, combined with elevation of greater trochanter are the sequelae of many pathological conditions such as malunion, non-union and growth disorders of the femoral head. Legg-Calve-Perthes disease, childhood injuries of the epiphysial and focal necrosis of the femoral head secondary to developmental dysplastic hip may cause the growth disorders of the femoral head. In cases of non-union or malunion there is usually associated short femoral neck, resulted from bone resorption. Coxa vara and shortening of femoral neck reduces tension of the pelvi-trochanteric muscles and shorten the abductor lever arm, leading to a positive Trendelenburg’s sign and leg-length discrepancy[2]. The associated high-standing greater trochanter results in trochanteric impingement and limited hip abduction. Pain and limping gait are often the results. By restoring the hip biomechanics, pain and limb-length inequality would be decreased or eliminated and the range of motion would also be improved.

The conventional Muller’s valgus intertrochanteric osteotomy cannot address all problems associated with coxa vara (short femoral neck and high-standing greater trochanter). In addition, it may not adequately correct limb shortening if large wedge of bone was removed[3,4]. The authors have developed a new technique of intertrochanteric osteotomy, named “Ratchaprasong Osteotomy” (according to location of Police General Hospital) which can address all problems associated with coxa vara. This new type of intertrochanteric osteotomy can create valgization plus lengthening of femoral neck, correction of high-standing of
greater trochanter and increase limb length. The Ratchaprasong Osteotomy has been used to treat developmental and posttraumatic conditions with coxa vara in combination with short femoral neck and high-standing greater trochanter. The purpose of the present study was to evaluate the short-term results of this new technique of the intertrochanteric valgus-lengthening-femoral neck osteotomy.

**Material and Method**

Between November 1994 and June 2007, fifteen intertrochanteric valgus lengthening-femoral-neck osteotomies were performed in the Department of Orthopaedic Surgery of Police General Hospital, Bangkok. Twelve of these patients (80% retrieving rate) could be followed-up. The present study has been approved by the Medical Ethic Committee of Police General Hospital. There were seven women and five men. The mean age of the patients at the time of surgery was 26.6 years (range, 13-50 years) and the left hip was affected in nine cases and the right in three. Seven of the twelve cases were posttraumatic: four malunion; two non-union; and one childhood fracture of the femoral neck and five were developmental conditions: three ischemic necrosis of the femoral head; one physeal dysplasia (all of which secondary to DDH) and one coxa plana.

The principle of the present technique of intertrochanteric valgus-lengthening femoral neck-osteotomy consists of double osteotomies parallel to the femoral neck: one just above the lesser trochanter and the other at the base of greater trochanter, the femoral shaft is displaced laterally by at least 1 cm relative to the proximal part of the osteotomy (Fig. 1A). The femoral neck is anti-clockwise rotated to restore the normal shaft neck angle of about 130 degrees. The proximal fragment is impacted into the distal fragment. The greater trochanter is laterally displaced about 1-1.5 cm (Fig. 1B). In two cases a Chiari pelvic osteotomy for better coverage of the femoral head was performed at the same session of the intertrochanteric osteotomy (case 8,9). Four cases had had associated ipsilateral limb shortening which were treated with distraction osteogenesis. Two out of these four cases had associated femoral shaft shortening (case 2, 5) and one had both femoral and tibial shortening (case 3), resulting from abnormal mechanical axis secondary to physeal dysplasia of the femoral neck. One out of these four cases (case 6) had associated femoral shortening secondary to ipsilateral femoral shaft fractures (Table 1). Ten out of twelve patients a trochanteric lateralization was performed. The other two without trochanteric lateralization were nonunion and malunion, which had no associated high-standing greater trochanter (case 4, 12). The mean follow-up period was 34.3 months (range, 12-106 months). Indication for surgery was limping, hip pain, leg length discrepancy of 2 cm or more. All the patients were operated by the authors. Radiographic assessment included both antero-posterior (AP) views of both hips, lateral cross-table. The femoral neck-shaft angle or CCD angle, the length gained and the articulo-trochanteric distance (ATD), i.e. distance between the apex of the greater trochanter and the femoral head was measured. The clinical results were evaluated in terms of the Harris Hip Score.

**Operative Technique**

The patient is operated on fracture table in supine position. For fixation of the intertrochanteric osteotomy the authors have used a 130°-angle blade plate for adult and 120°-osteotomy plate for children. A 10-cm longitudinal skin incision is made downwards from the greater trochanter along the femoral shaft and from the greater trochanter the incision extending upwards of about 5 cm long. The gluteal fascia and fascia lata are divided to expose gluteal muscles, greater trochanter and the vastus lateralis muscle. The latter is then detached from the greater trochanter by an L-shaped incision. Three K-wires guide are inserted: the first K-wire marking the line of osteotomy at the level just above the lesser trochanter and parallel to the femoral neck; the second one inserted perpendicular...
Table 1. Clinical radiological and Harris hip score data before surgery and the last follow-up study

<table>
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<tr>
<th>case</th>
<th>sex</th>
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<th>FU (mo.)</th>
<th>pain1</th>
<th>L.G. (mm)</th>
<th>TDB1</th>
<th>TDB2</th>
<th>LG(mm)</th>
<th>ATD1(mm)</th>
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Data was presented as a mean

FU = follow-up; TDB1 = Trendelenburg’s sign; LG = length gained; ATD1 = articulotrochanteric distance; ATD1 = angle between the line perpendicular to the femoral shaft and the K-wire guide for the blade, X = correction angle. Positive Y means the K-wire lying below the line perpendicular to the femoral shaft, negative Y means the K-wire lying above it (Fig. 2). The angle of the plate inserting to the femoral shaft axis is the desired correction angle (for valgization) which is determined preoperatively in the template. After insertion of the seating chisel, the osteotomy parallel to femoral neck is made at the level just above lesser trochanter. The proximal fragment is mobilized using the seating chisel as a lever and the femoral shaft is displaced laterally and distally by longitudinal traction. Insertion of the plate blade with the lower end of the blade protruding from the entry point by 1-1.5 cm, to align the plate on the laterally displaced femoral shaft. Temporary fixation of the plate to the femoral shaft by bone holding forceps, the preoperative planned femoral shaft neck angle can be achieved. The proximal fragment was then impacted to the proximal femoral shaft using compression device and then fixed the plate to the bone.

A saw cut is made at the base of greater trochanter, running parallel to the axis of the first osteotomy. The greater trochanter is displaced laterally and distally by 1-1.5 cm along the osteotomy line and then fixed with a tension band wiring (Fig. 3).
Fig. 3  (A) Radiograph of a 28-year-old woman with malunion of intertrochanteric fracture right hip two years after motorcycle accident. She had pain, limping gait and adductor contracture. Percutaneous adductor tenotomy and Ratchaprasong Osteotomy were performed. (B) Radiograph immediate after surgery shows valgization of proximal fragments lateral and distal displacement of proximal femur, which was fixed with a $130^\circ$ angle blade plate. The greater trochanter was displaced along the femoral neck and fixed with a tension band wiring. The medial gap at the osteotomy was noted. (C) One year after surgery. Spontaneous filling the medial gap with new bone formation. (D) Radiographic findings three years after surgery: no limb length discrepancy, normal shaft-neck angle and normal height of greater trochanter. (E, F) Three years after surgery she has negative Trendelenburg’s sign, full ROM, and Harris hip score is 100

Statistical analysis
SPSS for Windows, version 13.0 was used for data analysis and $p < 0.05$ was considered to be significant. Comparing Harris hip score, CCD angle and ATD between preoperative value and the last follow-up study using Wilcoxon signed-rank test

Results
All of the intertrochanteric and greater trochanteric osteotomy healed without bone grafting or substitutes. No delayed union, non-union, implant failure, loss of fixation or other perioperative complications were encountered. All patients except one (case 9) had no pain, no limping gait and no positive Trendelenburg sign. The mean ATD was improved from -5.7 mm (range, -32-11 mm) preoperatively to 16.5 mm (range, 5-30 mm) at the last follow-up ($p = 0.002$). The mean length gain at the last follow-up
was 12.3 mm (range, 8-29 mm). The mean femoral shaft-neck or CCD angle was changed from 113 degrees (range, 70-140) preoperatively to 138.2 (range, 110-165) degrees at the last follow-up \( (p = 0.002) \). Harris Hip Score was improved from 51.8 (range, 32-67) preoperatively to 94.8 (range, 60-100) at the last follow-up \( (p = 0.002) \) (Fig. 4). Complete equalization of the leg length could not be successful in four cases by the intertrochanteric osteotomy because of associated shortening of lower limb (case 2, 3, 5 and 6). Limb equalization was finally successful in these cases by additional bone lengthening with distraction osteogenesis (Fig. 5). At the last follow-up examination eleven out of twelve patients had negative Trendelenburg sign and normal gait. The other one (case 9) with limping gait and positive Trendelenburg sign underwent a total hip arthroplasty six years after the osteotomy, because of severe osteoarthritic change.

**Discussion**

The present technique of osteotomy could simultaneously address all problems associated with coxa vara. Namely coxa vara was corrected by open wedge valgus osteotomy, short femoral neck lengthened by osteotomy parallel to the femoral neck and lateralization of the femoral shaft and the high-standing greater trochanter treated by distalization and lateralization. The results of the present study have shown that the present technique of osteotomy could restore the hip biomechanics as evidenced by significant improvement of the Harris hip score at the last follow-up. The results of femoral neck lengthening in combination with opening wedge valgus osteotomy increased the limb length with mean length gained of

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**Fig. 4**  (A) Radiograph of a 24-year-old woman with early osteoarthritis of the hip as a result of ischaemic necrosis of femoral head secondary to DDH. Anterior pelvic tilt as a result of hyperlordosis is noted. (B) Radiograph after valgus extension osteotomy, femoral neck lengthening and trochanteric lateralization. Additional Chiari pelvic osteotomy for better coverage of the femoral head. Note that, the extension component relaxes the stresses of hyperlordosis and anterior pelvic tilt is corrected. (C) Radiograph made two years after surgery showing healing of all osteotomies, and better femoral head coverage with remodeling of the femoral head. (D, E) Two years after surgery she had no pain, limb equalization, normal gait and negative Trendelenburg sign
Fig. 5 (A) A 23-year-old man presented with 7-cm of femoral shortening and external malrotation. He had had a childhood fracture of femoral neck treated by a local bone-setter. (B) Radiograph shows fibrous nonunion of fracture neck of the femur, stiff in short neck-varus deformity with high-standing greater trochanter. (C) Ratchaprasong osteotomy in combination with derotation of femoral shaft was performed. (D) The residual femoral shaft shortening was successfully treated with distraction osteogenesis. (E) Radiograph taken two years after surgery shows improvement of hip biomechanics and (F) excellent hip function (Harris hip score 100).

12.3 mm at the last follow-up.

The present technique of osteotomy is similar to that described by Morscher, who in 1980 introduced a double osteotomy [7]. This technique consists of two parallel osteotomies upper and lower of the femoral neck, making an angle to the femoral shaft corresponding to the desired femoral shaft-neck angle. In 1999 Hasler and Morscher showed good results in 32 out of 37 patients treated by this technique with a mean follow-up of eight years [8]. Likewise, with the technique of double osteotomies Lengsfeld and his associates showed satisfactorily results in their long term follow-up study [9]. Wagner showed that the trochanteric distalization and lateralization could restore normal tension of the pelvi-trochanteric muscles and lengthen the lever arm of the muscles, thereby diminishing pressure on the hip joint. This can also increase the range of abduction in the case of high-
standing greater trochanter\(^{(2)}\). The authors have modified these techniques by double osteotomies parallel to femoral neck and valgization of the femoral neck-shaft angle by opening wedge osteotomy. To increase the stability the proximal fragment was impacted into the distal fragment. It is noteworthy that all opening wedge intertrochanteric osteotomy healed, despite no bone grafting in the medial gap at the osteotomy site. Blood clot at the osteotomy site serves as a source of signaling molecules such as transforming growth factor-beta and platelet-derived growth factor, which are important in regulating cell proliferation and differentiation of mesenchymal stem cells\(^{(10)}\). With this type of osteotomy, there is compression force at the medial gap from pulling of iliopsoas muscles. Under compressive load, stable fixation, and the presence of hematoma new bone formation could therefore occur in the medial gap.

One possible disadvantage of the present technique of osteotomy is the problem of difficulty with subsequent total hip replacement. This might not always be true, because one case of the present study (case 9) had undergone subsequent total hip replacement without difficulty.

**Conclusion**

Based on the results of the present study the newly present technique of osteotomy named “Ratchaprasong osteotomy” would be safe and reliable for the treatment of coxa vara associated with short femoral neck and high-standing greater trochanter.

**Potential conflicts of interest**

None.

**References**

การผ่าตัดเปลี่ยนแนวรับน้ำหนักของสะโพกและยืดกระดูกสะโพกให้ยาวขึ้นในผู้ป่วยที่กระดูกสะโพกงุ้มและสั้นผิดปกติ

ชาญชิต แสงแก้ว, พีรพงศ์ ปิยพิทยานันต์

วัตถุประสงค์: เพื่ศึกษาผลการรักษาภาวะกระดูกสะโพกงุ้ม (coxa vara) รวมกับกระดูกคอสะโพกสั้น (femoral neck shortening) และกระดูกส่วน greater trochanter อยู่สูงด้วยการทำผ่าตัดเทคนิคใหม่โดยการแก้ปรับมุมกระดูกสะโพก (valgus osteotomy) รวมกับการทำผ่าตัดยืดกระดูกสะโพกให้ยาวขึ้น (femoral neck lengthening) และเลื่อนตำแหน่งส่วน greater trochanter ให้กลับลงมาด้านข้าง (trochanteric lateralization)

วัสดุและวิธีการ: การศึกษาแบบย้อนหลังในผู้ป่วย 12 ราย จากจำนวน 15 รายที่ได้รับการผ่าตัดดังกล่าว ซึ่งในผู้ป่วย 12 รายนี้ 7 รายมีสาเหตุของภาวะผิดปกติของสะโพกต่ำกว่า (กระดูกติดผิดรูป 4 ราย, กระดูกไม่ติด 2 ราย และกระดูกสะโพกหักตั้งแต่ยังเป็นเด็ก 1 ราย) และ 5 รายมีสาเหตุจากภาวะผิดปกติต้นเท้าเด็ก (กระดูกคอสะโพกสั้น 3 ราย และกระดูกส่วน greater trochanter มีการเจริญเติบโตเร็ว 1 ราย) ซึ่งนั้นจะต้องเป็นที่ทราบว่ามีความผิดปกติมากที่สุดจากการกระดูกสะโพก (femoral neck lengthening) 12 ราย, มีผลการผ่าตัดทางเข็ม 34.3 เดือน (พิสัย 12-106 เดือน) เพศชาย 5 ราย เพศหญิง 7 ราย อายุเฉลี่ย 26.6 ปี (พิสัย 13-50 ปี) เทคนิคการผ่าตัดประกอบด้วยการผ่าตัดกระดูกสะโพกขึ้น (opening wedge intertrochanteric valgus osteotomy) และการผ่าตัดยืดกระดูกสะโพกให้ยาวขึ้น (femoral neck lengthening) และการเลื่อนกระดูกส่วน greater trochanter ออกไปด้านข้างโดยไม่มีการปลูกถ่ายกระดูก (bone grafting) หรือกระดูกเทียมโดย (bone substitute)

ผลการศึกษา: จากการตรวจดูผลการรักษาพบว่าคะแนนการทำงานของสะโพก (Harris hip score) ดีขึ้นกว่าก่อนการผ่าตัดสะโพกอย่างมีนัยสำคัญ ลดลงเป็นคะแนนเฉลี่ย 51.8 (พิสัย 60-46) ในผู้ป่วยที่มีการกระดูกส่วน greater trochanter มีการเจริญเติบโตเร็วมากกว่า 94.8 (พิสัย 60-100) (p = 0.002) และการกระดูกสะโพกมีการเจริญเติบโตพร้อมกัน 12.3 มม. (พิสัย 8-29) ในพื้นผิวด้านข้างของกระดูกส่วน greater trochanter

สรุป: เทคนิคการผ่าตัดสะโพกที่นำเสนอมาสามารถแก้ไขภาวะกระดูกสะโพกที่มีภาวะผิดปกติของกระดูกจะมีผลให้กระดูกสะโพกสั้น และกระดูกส่วน greater trochanter อยู่สูงอย่างได้ผลเป็นวิธีการที่ปลอดภัยและมีประสิทธิภาพ