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*

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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 epiphyseal 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

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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

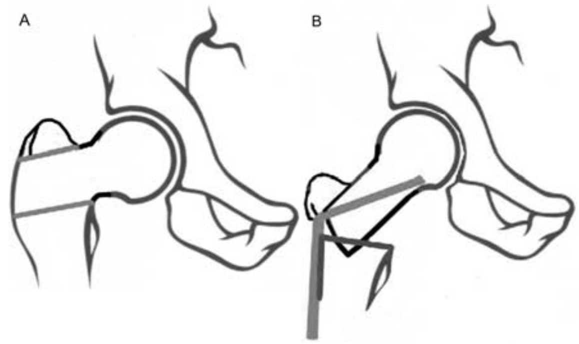

Fig 1. (A) Two parallel osteotomies aligned with the femoral neck at its upper and lower border. The femoral shaft is displaced laterally by at least 1 cm relative to the proximal end of the femur. Valgisation to restore the normal shaft neck angle of about 130 degrees. (B) Impaction of proximal fragment into the distal fragment. Lateralization of greater trochanter of about 1-1.5 cm along the femoral neck

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[5] were measured. The clinical results were evaluated in terms of the Harris Hip Score[6].

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

case	sex	age	F.U. (mo.)	pain1	pain2	TDB1	TDB2	LG(mm)	ATD1(mm)	ATD2(mm)	CCD1	CCD2	HHS1	HHS2	Note
1	F	28	37	20	44	+	-	10	-3	19	116	138	43	100	
2	M	23	12	30	44	+	-	22	-32	7	70	125	59	100	FL
3	F	13	60	30	44	+	-	10	-7	12	120	135	61	99	FL, TL
4	M	17	12	30	44	+	-	15	-5	20	95	135	53	97	
5	M	27	106	30	44	+	-	8	-17	10	120	130	67	100	FL
6	F	19	17	10	44	+	-	18	-11	21	110	130	39	100	FL
7	F	13	14	30	40	+	-	13	-3	18	130	150	63	95	
8	F	24	24	20	40	+	-	12	11	30	125	165	62	90	
9	F	45	60	10	20	+	+	10	10	25	135	150	36	60	
10	F	50	28	20	44	+	-	10	-5	5	140	150	64	96	
11	M	12	23	10	40	+	-	10	-3	15	90	110	32	96	
12	M	18	37	10	44	+	-	10	-3	16	105	140	43	100	

Data was presented as a mean

FU = follow-up; TDB = Trendelenburg 's sign; LG = length gained; ATD = articulo-trochanteric distance: ATD is negative if the tip of greater trochanter lies above the upper border of femoral head and positive if it is below; CCD = femoral neck-shaft angle; HHS = Harris Hip Score: 1 = preoperative, 2 = last follow-up; FL= femoral lengthening; TL = tibial lengthening

to the femoral shaft, and the third one for insertion of a seating chisel. Insertion of the K-wire guide for plate blade (seating chisel) is crucial and the authors developed a geometric formula: Y = 40-X for fixation with the 130-degree-angle blade plate. Y = 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).

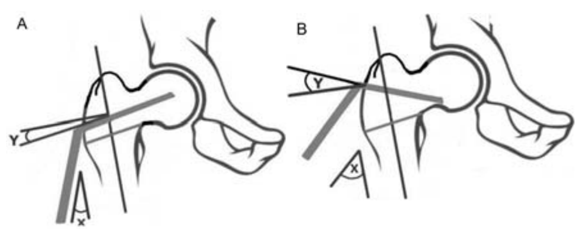

Fig. 2 (A) Diagram shows the technique of using 130-angle blade plate (ABP) for correction and fixation of the coxa vara associated with short femoral neck. Y = 40-x: Y = angle between the seating chisel and line perpendicular to the femoral shaft. X = correction angle or angle between plate and the femoral shaft. If y is positive: for example X = 30, Y = 40-30, Y = +10, the blade of the ABP should be inserted 10° below the line perpendicular to the femoral shaft. (B) If y is negative: for example X= 50, Y = 40-50, Y = -10, the blade of the ABP should be inserted 10° above line perpendicular to the femoral shaft

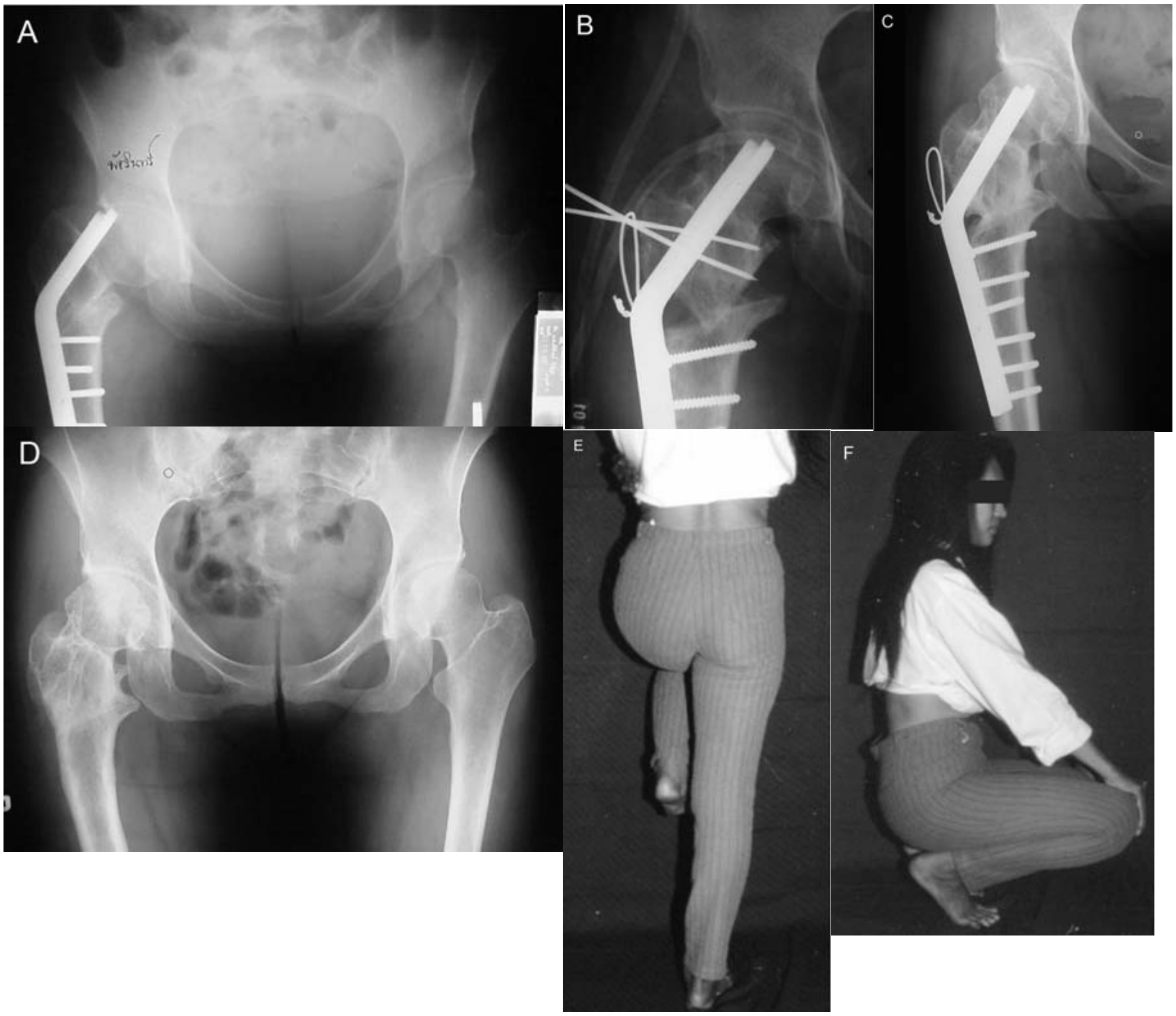

Fig. 3 (A) Radiograph of a 28-year-old woman with malunion of intertrochanteric fracture right hip two years after motorcycle accident. She had pain, limping gait and adductor contracture. Percutaneous adductor tenotomy and Ratchaprasong Osteotomy were performed. (B) Radiograph immediate after surgery shows valgization of proximal fragments lateral and distal displacement of proximal femur, which was fixed with a 130° 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

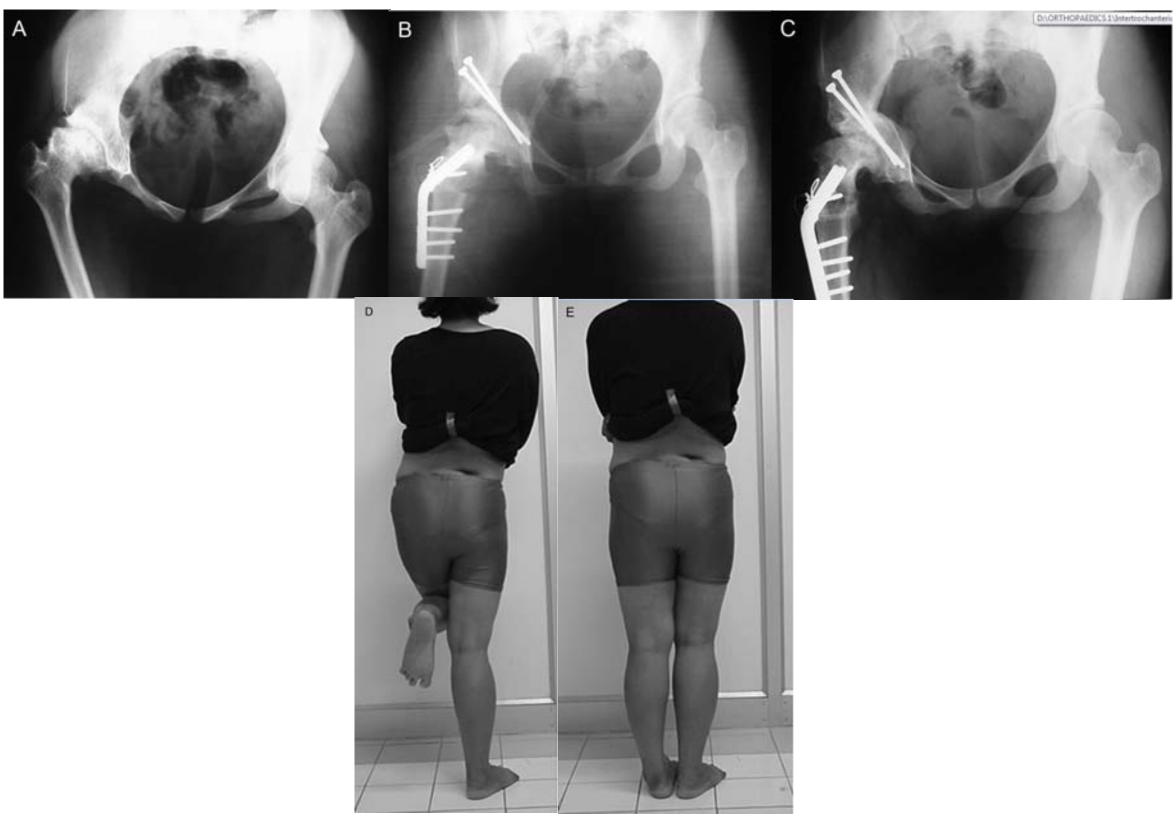

Fig. 4 **(**A) Radiogaph of a 24-year-old woman with early osteoarthritis of the hip as a results of ischaemic necrosis of femoral head secondary to DDH. Anterior pelvic tilt as a result of hyper-lordosis is noted. (B) Radiograph after valgus extension osteotomy, femoral neck lengthening and trochanteric 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.

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การผ่าตัดเปลี่ยนแนวรับน้ำหนักข้อสะโพกและยืดกระดูกคอสะโพกให้ยาวขึ้นในผู้ป่วยที่กระดูกคอสะโพกงุ้มและสั้นผิดปกติ

ชาญชิต แสงแก้ว, พีรพงษ์ ปิยพิทยานันต์

วัตถุประสงค์: *เพื่อศึกษาผลการรักษาภาวะกระดูกคอสะโพกงุ้ม (coxa vara) ร่วมกันกับกระดูกคอสะโพกสั้น (femoral neck shortening) และกระดูกส่วน greater trochanter อยู่สูงด้วยการทำผ่าตัดเทคนิคใหม่ด้วยการแก้ปรับมุมกระดูกคอสะโพก (valgus osteotomy) ร่วมกับการผ่าตัดยืดคอกระดูกสะโพกให้ยาวขึ้น (femoral neck lengthening) และเลื่อนตำแหน่งส่วน greater trochanter ให้กลับลงมาด้านข้าง (trochanteric lateralization)*

วัสดุและวิธีการ: *การศึกษาแบบย้อนหลังในผู้ป่วย 12 ราย จากจำนวน 15 ราย ที่ได้รับการผ่าตัดด้วยเทคนิคดังกล่าว ซึ่งในผู้ป่วย 12 รายนี้ 7 ราย มีสาเหตุของภาวะผิดปกติของข้อสะโพกดังกล่าวจากการบาดเจ็บ (กระดูกติดผิดรูป 4 ราย, กระดูกไม่ติด 2 ราย และกระดูกคอสะโพกหักตั้งแต่ยังเป็นเด็ก 1 ราย) และ 5 รายมีสาเหตุจากความผิดปกติตั้งแต่เด็ก (กระดูกข้อสะโพกเสื่อม 3 ราย และ กระดูกคอข้อสะโพกมีการเจริญเติบโตผิดปกติ 1 ราย ซึ่งทั้งสองประเภทนี้มีสาเหตุจากกระดูกเบ้าสะโพกมีความผิดปกติ นอกจากนี้มีหัวกระดูกสะโพกแบน 1 ราย) ได้ติดตามผลการรักษาเฉลี่ย 34.3 เดือน (พิสัย 12-106 เดือน) เพศชาย 5 ราย เพศหญิง 7 ราย อายุเฉลี่ย 26.6 ปี (พิสัย 13-50 ปี) เทคนิคการผ่าตัดประกอบด้วยการผ่าตัดยกคอกระดูกสะโพกขึ้น (opening wedge intertrochanteric valgus osteotomy) ยืดคอกระดูกสะโพกโดยการตัดและเลื่อนกระดูกต้นขาออกด้านข้าง และตัดเลื่อนกระดูกส่วน greater trochanter ออกด้านข้างโดยไม่มีการปลูกถ่ายกระดูก (bone grafting) หรือกระดูกเทียมเลย (bone substitute)*

ผลการศึกษา: *จากการติดตามผลการรักษาพบว่าคะแนนการทำงานของข้อสะโพก (Harris hip score) ดีขึ้นกว่าก่อนการผ่าตัดรักษาอย่างมีนัยสำคัญ กล่าวคือก่อนการรักษามีค่าคะแนนเฉลี่ย 51.8 (พิสัย 32-67) หลังการรักษามีค่า 94.8 (พิสัย 60-100) (p = 0.002) และหลังการรักษามีความยาวของขาเพิ่มขึ้นเฉลี่ย 12.3 มม. (พิสัย 8-29) ไม่พบมีผลแทรกซ้อนที่สำคัญเช่น กระดูกไม่ติดหรือติดช้า และการบาดเจ็บของหลอดเลือดและเส้นประสาท*

สรุป: *เทคนิคการผ่าตัดข้อสะโพกที่นำเสนอนี้ สามารถแก้ไขภาวะกระดูกคอสะโพกงุ้มที่เกิดร่วมกับกระดูกคอสะโพกสั้นและกระดูกส่วน greater trochanter อยู่สูงอย่างได้ผลเป็นวิธีการที่ปลอดภัยและเชื่อถือได้*