Osteochondroplasty and relative neck lengthening in the treatment of late sequelae of Perthes disease

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Purpose
The goal was to evaluate the short-term results of femoral head osteochodroplasty and trochanteric advancement in the treatment of late sequelae of Perthes disease associated with aspherical head and hinged abduction.
Patients and methods
The authors carried out a prospective study to evaluate the clinical and radiological results of 15 patients with late sequelae of Perthes disease treated by osteochodroplasty of the head neck junction with distal advancement of the greater trochanter through a surgical hip dislocation approach.
Results
The mean age of the patients was 20 years, with a mean follow-up of 36 months. We achieved a mean improvement of harris hip scores (HHS) from 65.6 preoperatively to 87.6 postoperatively, with a marked improvement in range of motion, especially for abduction (from 13.8° preoperatively to 30.3° postoperatively) and internal rotation (from 16.4° preoperatively to 28.6° postoperatively). The mean center trochanteric distance (CTD) improved from −18 to 0.26 mm postoperatively. Seven cases progressed one grade of osteoarthritis (OA); two of them required total hip replacement.
Conclusion
Combined osteochondroplasty and distal advancement for the treatment of late sequel of Perthes disease improve hip function, decrease pain, and improve radiological parameters of the hip.

Keywords:
femoral head reshaping, hinged abduction, late Perthes, osteochondroplasty of the femoral head, relative neck lengthening, trochanteric advancement

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Introduction

Femoral head deformities due to sequelae of Legg–Calves–Perthes disease (LCPD) are often enlarged (Coxa magna) and nonspherical (Coxa plana), with a short femoral neck (Coxa breva) and varus neck (Coxa vara) and high-riding greater trochanter [1].

The shape of the femoral head ranged from an enlarged spherical shape to an ovoid or flattened shape, which leads to abnormal mechanical function of the hip [2].

Complex proximal femoral deformities can cause both intra-articular impingement [(femoroacetabular impingement (FAI)] resulting from aspherical femoral head and extra-articular impingement resulting from greater and lesser trochanter, which abut against the ilium and ischium, respectively, which leads to restricted range of movement (ROM), degenerative hip disease and impaired function of the hip abductors [3].

According to the Stulberg classification, femoral head shape is considered the most important predictor factor for development of osteoarthritis (OA) in the hip following Perthes disease and required a hip-preserving surgery to postpone the need for total hip replacement (THR) [4,5]

With the introduction of the novel approach for the hip by Ganz *et al.* [6] with preservation of the blood supply of the femoral head called the safe surgical hip dislocation method (SHD), this approach opens the field for treatment of sequelae of LCPD by two different methods: one is osteochondroplasty of the head–neck junction with simultaneous relative femoral neck lengthening by trochanteric advancement [3,7,8] and the other is femoral head reduction osteotomy (FHRO) with resection of the central third of the femoral head. Then, the lateral third is advanced to the medial third with preservation of the vascular pedicle to the medial third [5,8,9].

Our prospective study raises the following question: does femoral head osteochondroplasty and trochanteric advancement relieve hip pain, improve hip function and radiographic parameters and prevent OA progression in patients with sequelae of LCPD associated with aspherical head and hinged abduction?

Patients and methods

Informed consent was obtained from all participants included in the study after obtaining approval of the Ethical Committee of our university.

Between January 2009 and January 2015, we prospectively treated 15 hips in 15 patients with complex proximal femoral deformity due to sequelae of LCPD with osteochodroplasty of the head neck junction and relative neck lengthening by distal advancement of the greater trochanter through SHD to treat both intra-articular and extra-articular FAI.

Ten patients were males and five were females, with a mean age of 20.1 years (range: 14–26 years). Indications for surgery were pain, restricted ROM, impaired hip function (limping and positive impingement test) and abductor weakness. We excluded patients with advanced OA of the hip (more than Tonnis grade 2) [10].

Hip deformity was classified according to the Stulberg classification [4] as follows: grade II (enlarged but spherical head) in three patients, grade III (nonspherical head) in eight patients and grade IV (flat head) in four patients. Patients had received previous treatment in the form of Arthrodiastasis of the hip in three cases, Salter?s osteotomy in two cases and drilling and core decompression in two cases.

Clinical evaluation included medical history, hip pain, limping, ROM (degree of flexion/extension, internal/external rotation, and abduction/adduction), impingement test and preoperative and postoperative harris hip scores (HHS) [11,12]

Preoperative standard radiographs including anteroposterior view (AP) pelvis and cross-table lateral views of the hip [13] reveal a short femoral neck with varus deformity with an enlarged flat and mushroom-shaped head and overgrowth of the trochanter, and sometimes, shallow acetabulum and up-sloping of the acetabular roof with varying degrees of anterior and lateral deficiencies are observed.

Standard measurements of preoperative and postoperative radiograph for the femoral side were performed including the following.

Trochanteric height center trochanteric distance (CTD), recorded in millimeters, positive or negative, indicates whether the tip of the trochanter is above or below the femoral head center, respectively [14], the alpha angle in axial view [15] and neck shaft angle (centrum–collum–diaphysis angle) [16]. For the acetabular side, the lateral center edge angle (LCE angle) was determined [16]. Finally, Tonnis grading for OA progression was performed [10]. Three-dimensional computed tomography was performed to observe the whole morphology of the femoral head (Fig. 1b).

Operative technique

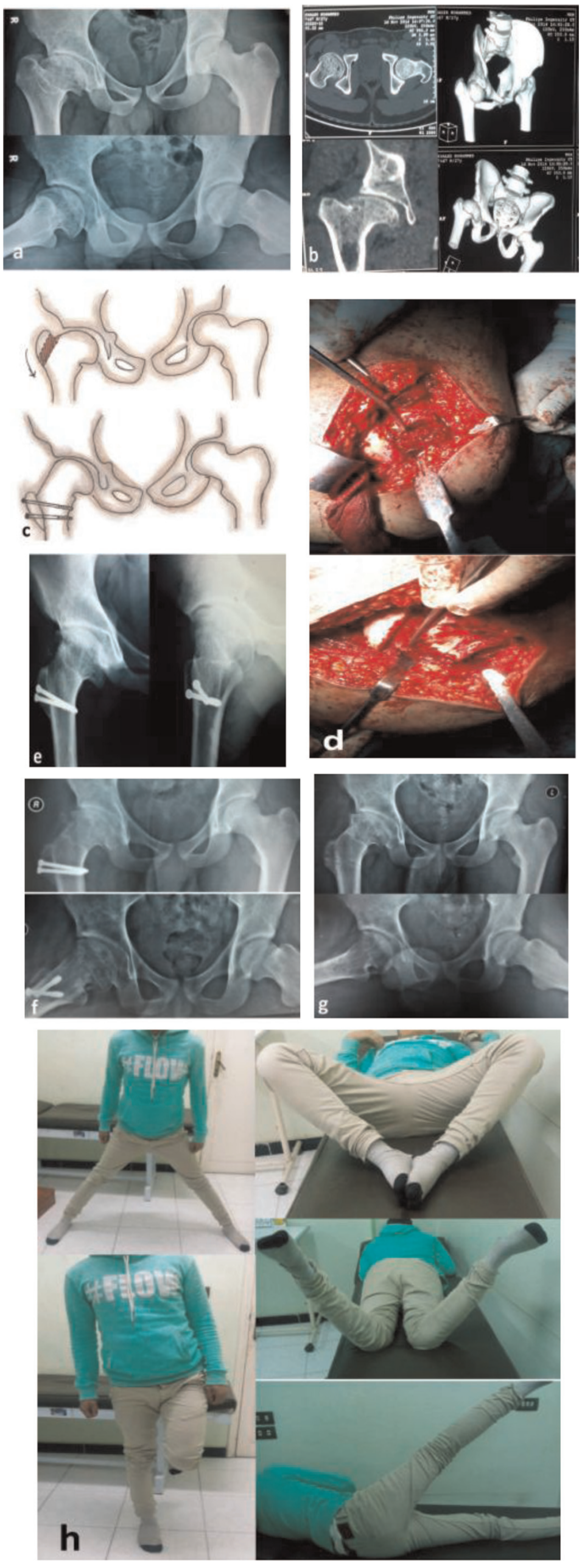
We approach the hip through a SHD approach as described by Ganz *et al.* [6], with development of an extended retinacular soft tissue flap [8]. Flat trigastric trochanteric osteotomy is performed and then a Z-shaped capsulotomy is performed; after this, the hip can be surgically dislocated [17]. We subperiosteally resect the stable part of the greater trochanter (Fig. 1c) with preservation of the periosteal flap of the posterior aspect of the proximal femur (extended retinacular soft tissue flap), which contains a deep branch of the medial circumflex femoral artery [8]. Then, the femoral head is reduced into the acetabulum to detect the area of impingement of the femoral head by assessment of the range of motion (flexion, flexion–internal rotation and abduction in flexion and extension) [18].

Osteochondroplasty of the femoral head neck junction is performed to improve the offset using a small osteotome and a high-speed burr. We assess the improvement in impingement by reducing the head and examine the range of motion [17].

The mobile fragment of the greater trochanter is reattached to the proximal femur in a distal position with the tip at the level of the center of the femoral head to improve abductor muscle function and fixed by two cancellus screws, which was confirmed by fluoroscopic examination till satisfactory positions were achieved [3] (Fig. 1c).

Cartilage flaps were debrided and osteochondral lesions were treated by the microfracture technique, while labral tears were debrided and repaired by anchor suture if necessary.

Figure 1



(a) Preoperative AP and Frog lateral views in a 20-year-old male with Stulberg type III with limited abduction and internal rotation. (b) Computed tomography with 3 D shows an enlarged mushroom-shaped head, Coxa Breva and high-riding greater trochanter. (c) Preoperative planning. (d) Intraoperative picture shows surgical hip dislocation approach with trochanteric osteotomy and osteochodroplasty of the head neck junction. (e) Postoperative radiographs show resection of the stable trochanteric part and distal advancement of the greater trochanter. (f) One-year follow-up. (g) Two-year follow-up after removal of screws. (h) Clinical follow-up with full range of motion.

Early continuous passive motion of the hip and early partial weight bearing were advised, while full weight bearing and active abductor exercises were advised after healing of the greater trochanter (2 months on average), with regular clinical and radiographic follow-up at 2 months, 6 months, and 1 year postoperatively.

Complications were classified into five grades according to the type of treatment required and long-term morbidity [19]:

(1) Grade I, which requires no change in postoperative care.
(2) Grade II, which requires treatment on an outpatients care.
(3) Grade III, which requires an invasive (surgical or radiological) procedure.
(4) Grade IV, which includes potentially life-threatening or high-morbidity complications.
(5) Grade V, which includes death.

Results

The mean Harris hip scores [11,12] improved from 65.6 preoperatively (range: 53–74) to 87.6 postoperatively (range: 58–98) (Table 1), with a mean follow-up of 36.1 (range: 12–60 months) (P<0.001).

Pain and limping decreased from 86.6% (13 of 15 hips) and from 100% (15 of 15 hips) preoperatively to 13.3% (2 of 15 hips) and to 20% (3 of 15 hips) postoperatively, respectively. Positive anterior impingement test decreased from 93.3% (14 of 15 hips) preoperatively to 26.6% (4 of 15 hips) at the last follow-up.

There were marked improvements in the range of motion of the hip, especially for abduction and internal rotation (Fig. 1h), with a mean improvement from 13.8° (range: 0–27°) and from 16.4° (range: 0–32°) preoperatively to 30.3° (range: 10–43°) (P<0.001) and 28.6° (range: 0–42°) (P<0.001) postoperatively, respectively (Table 2).

Abductor muscle strength was improved, with 80% (12 out of 15 hips) regaining full muscle strength (M5).

The mean CTD [14] (center trochanteric distance=trochanteric height relative to the center of the femoral head) improved from −18.1 mm (range: −33 to −5 mm) preoperatively to 0.26 mm (range −10 to

Table 1 Demographic data

Case	Age	Sex	Stulberg classification	Harris hip score		Tonnis grading		FU Months	Complication
				Pre	Post	Pre	Post		
1	18	♂	II	74	97	0	1	24	
2	22	♂	III	67	95	1	1	18	
3	14	♀	IV	53	66	2	3	50	Stiff hip
4	26	♂	III	64	91	1	2	45	
5	19	♂	IV	58	58	2	3	36	Stiff hip
6	24	♀	III	65	92	0	1	12	
7	16	♂	III	70	94	1	1	60	
8	23	♂	IV	68	83	1	2	44	
9	17	♂	III	71	89	1	1	52	
10	19	♀	II	73	98	0	1	38	
11	20	♀	III	56	84	2	2	28	
12	25	♂	III	69	92	1	1	18	
13	21	♂	II	72	96	0	1	52	
14	18	♀	IV	55	86	2	2	43	
15	20	♂	III	70	93	1	2	22	

Table 2 Clinical and radiological results

Case No.	Flexion		Extension		Internal rotation pre post		External rotation pre post		Abduction		Adduction		CTD		CCD angle		Alpha angle		LCE angle	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	115	120	4	8	30	42	25	32	15	35	4	7	−18	−2	114	121	48	33	10	20
2	110	115	3	6	20	40	18	30	10	30	6	10	−−30	−10	108	116	66	40	15	23
3	95	95	0	0	0	10	15	20	5	15	5	5	−20	−5	116	125	56	30	30	40
4	115	115	6	10	25	36	30	35	10	35	10	15	−25	−5	112	127	92	42	25	25
5	90	95	0	0	0	0	17	25	0	10	4	8	−20	−2	114	132	88	46	15	25
6	110	120	5	5	23	33	33	35	25	38	12	15	−15	+5	130	136	102	66	18	27
7	113	118	8	10	18	42	35	35	22	36	12	15	−12	+2	121	128	86	41	8	18
8	85	88	0	0	5	13	17	25	5	15	5	10	−5	+16	130	140	93	44	17	28
9	103	110	6	10	14	30	28	32	20	34	13	15	−12	−2	121	130	76	36	12	32
10	105	120	10	10	30	38	30	35	27	40	14	15	−8	+4	118	133	68	29	13	25
11	95	100	7	10	15	25	24	30	10	36	10	12	−22	0	113	131	84	41	23	38
12	105	115	8	10	16	32	26	30	15	32	12	15	−20	−5	115	126	94	50	27	40
13	110	129	5	5	32	42	29	33	18	43	10	15	−17	+5	114	135	57	38	18	22
14	85	95	0	0	0	12	14	28	5	15	5	18	−33	−7	106	118	49	34	8	23
15	110	120	10	10	18	35	32	35	20	40	12	15	−15	+10	122	141	66	44	15	26

CCD, centrum–collum–diaphysis; CTD, center trochanteric distance; LCE, lateral center edge.

+16 mm) postoperatively ($P<0.001$), with 40% (6 out of 15 hips) showing a preoperative normal variation according to Omeroglu (>+7 or >−17 mm). The mean alpha angle on axial view [20] improved from 75° (range: 48–102°) to 40.9° postoperatively (range: 29–66°) ($P<0.001$). The mean LCE angle [16] improved from 16.9° preoperatively (range: 8–30°) to 27.4° postoperatively (range: 18–40°) ($P<0.001$) (Tables 2 and 3).

Seven cases progressed by at least one grade of OA; two of them progressed to grade III OA according to To?nnis [10]. Both were Stulberg [4] type IV with a flat head and a type III osteochondral lesion in the femoral head according to the Outerbridge classification, with marked limitation of the hip motions, and was scheduled for THR.

One patient with small peripheral labral tear was treated by debridement.

Complications were minor, including two cases with stiffness due to intra-articular adhesions that required manipulation under anesthesia (grade III complication), no avascular necrosis or deep infection or trochanteric nonunion.

Two patients with acetabular dysplasia required further surgery including periacetabular osteotomy (PAO) to improve femoral head coverage.

Table 3 Correlation between preoperative and postoperative Harris hip score and clinical and radiological parameters

	(Pre) Harris hip score		(Post) Harris hip score	
Items	*r*	*P*	*r*	*P*
Stulberg classification	–0.791	0.002*	–0.885	≤0.001**
Tonnis grading	–0.804	≤0.001**	–0.799	≤0.001**
CTD	0.627	0.012*	0.158	0.575
CCD angle	0.336	0.220	–0.044	0.877
Alpha angle	0.001	0.997	0.011	0.968
LCE angle	–0.382	0.160	–0.380	0.163
Flexion	0.639	0.010*	0.762	0.001*
Extension	0.570	0.027*	0.669	0.006*
Internal rotation	0.676	0.006*	0.920	≤0.001**
External rotation	0.628	0.012*	0.808	≤0.001**
Abduction	0.686	0.005*	0.700	0.004*
Adduction	0.416	0.123	0.564	0.029*

CCD, centrum–collum–diaphysis; CTD, center trochanteric distance; LCE, lateral center edge.

Discussion

Complex proximal femoral deformities include Coxa vara, mushroom-shaped head and trochanteric overgrowth that lead to a combined intra-articular and extra-articular FAI and early degenerative joint disease [3,21].

Options of treatment for such deformities associated with hinge abduction include Cheilectomy [22], valgus intertrochanteric osteotomy [23–25] or greater trochanter advancement [26,27]. Cheilectomy does not address extra-articular impingement and, in most of the cases, does not prevent early OA, with the need for hip arthroplasty in young adults [22]. Valgus intertrochanteric osteotomy is best indicated in early stages of LCPD and contraindicated in late stages and fails to correct deformity when the major aspherical part of the head is located more anterior than lateral [25,28]. Isolated greater trochanter transfer can correct extra-articular impingement and improve abductor weakness, but it does not correct intra-articular impingement [26].

Restoration of the spherical shaped head, which is a major determinant for prognosis, alters the natural history of Perthes disease as reported by Stulberg *et al*. [4] and Mose [29].

Surgical dislocation of the hip [6] combined with extended retinacular soft tissue flap [8] enables identification of area of impingement and represents a new treatment option for patients with complex proximal femoral deformities [3], this approach introducing two new major strategies for the treatment of such deformities: FHRO [5,9] and osteochodroplasty with trochanteric advancement [3,17,21]. FHRO can restore the spherical shape of the femoral head by resection of the central necrotic segment and is best indicated in elliptical or saddle-shaped femoral heads with good flexion and extension and limited acetabular degeneration, with high potential risk of avascular necrosis and possible recurrence of the femoral head deformity when performed in children with open proximal femoral physis [5,9]. However, the second strategy that we used is osteochodroplasty of the head neck junction and relative neck lengthening by trochanteric advancement with possible advantages of addressing the intra-articular and extra-articular impingement and improve hip abductor strength [3,17,21].

Therefore, we asked whether this procedure improves hip function and pain, and radiographic parameters of the hip and decreases progression of the OA of the hip.

Our study had several limitations; we had a small number of cases and we did not have a control group, but we compared the preoperative and postoperative status. There was bias in our patient selection due to the heterogeneity of previous surgery. Finally, we had a short follow-up.

The surgical dislocation approach allowed us to address the whole morphology of the femoral head and acetabulum and identify the exact site of the intra-articular and extra-articular impingement of the hip; with this approach, we performed osteochodroplasty of the femoral head neck junction and relative neck lengthening in all cases.

We observed a mean decrease in pain and limping to 13.13 and 20%, respectively, and this was consistent with other studies where limping decreased to 20% in a study carried out by Albers *et al*. [30] and to 9% in a study carried out by Albers *et al*. [3], while 50% of patients in a study carried out by Eijer *et al.* [31] were pain free at 33 months of follow-up. We observed an improvement in HHS from 65.6 preoperatively to 87.6 postoperatively, with a mean follow-up of 36.1 months, and this was comparable to the study carried out by Anderson *et al*. [17], where HHS improved from 66 to 87 postoperatively with 45 months of follow-up. Also, we observed a significant improvement in whole ROM in abduction and internal rotation, which is consistent with the study of Albers *et al*. [3], where the ROM increased, namely, abduction, internal rotation and external rotation.

Radiographic parameters improved; the mean CTD improved from −18.1 to +0.26 mm postoperatively, which is consistent with other studies. In Albers *et al*. [3], restoration of normal trochanteric height occurred in 80% of cases, while Anderson *et al*. [17] reported an improvement from −20 to ±1.3 mm postoperatively The mean alpha angle in axial view improved from 75 to 40.9° postoperatively, which is consistent with Albers *et al*. [3], who reported an improvement from 77±18° to 42±10°.

Two patients (13.3%) with hip stiffness were Stulberg type IV with a flat head and OCD lesion type III; they were treated by manipulation under anesthesia and were scheduled for THR, which is comparable with the study of Anderson *et al.* [17], where 4 out of 14 hips had osteochondral defects of the femoral head treated by an autograft with a mean postoperative HHS of 94, with a mean follow-up of 57 months. Seven cases progressed at least one grade of OA according to To?nnis grading; two of them required THR, which is comparable to the study of Anderson *et al.* [17], where 4 out 14 hips (28.5%) deteriorated one grade according to To?nnis and 1 out of 14 hips needed THR, while 3 out of 29 cases (10%) required THR according to Shore *et al.* [21].

In two patients, subsequent surgery (PAO) was required to correct the acetabular dysplasia and improve head coverage, where the LCE angle was 8°.

We conclude that the combined approach of osteochondroplasty and distal trochanteric transfer through the SHD approach enables safe management of intra-articular pathology and decreases pain and improves hip function and biomechanics.

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Conflicts of interest
There are no conflicts of interest.

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