DOI 10.18019/1028-4427-2017-23-1-63-70

Corrective femoral osteotomy in the complex treatment of children with Legg-Calve-Perthes disease

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Objective Improve outcomes of complex treatment of children with Legg-Calve-Perthes disease. **Material and methods** Pre- and postoperative assessment of 90 patients with Legg-Calve-Perthes disease and severe epiphyseal involvement was reviewed. The age of the patients ranged from 6 years to 14 years. Corrective femoral osteotomy was performed for the patients who were followed up for 10 years. The patients were subdivided into two groups depending on the extent of bone coverage (EBC) of the femoral head straight after the surgery: group I (n = 60), EBC ≥ 1.0; group II (n = 30), EBC < 1.0. **Results** Regardless of the type of corrective femoral osteotomy group I showed positive clinical and radiological dynamics, and improved capital improvement, in particular; group II (archive material, cases who underwent surgery until 1998) demonstrated negative dynamics with considerably deformed femoral head. **Conclusion** Corrective femoral osteotomy remains the procedure of choice for patients with LCP disease, and femoral head remodeling can be provided with the extent of bone coverage index measuring one and over.

Keywords: Legg-Calve-Perthes disease, coxarthrosis, femoral head remodeling, corrective femoral osteotomy

INTRODUCTION

Remodeling surgical interventions are essential for improving treatment of children with Legg-Calve-Perthes disease (LCPD) and severe epiphyseal involvement. The surgery included in the plan of complex treatment can facilitate more effective femoral head reshaping, elimination of the subluxation in the involved joint and reduced length of pathological process [1, 2, 3, 4, 5].

Procedures with remodeling effect on the femoral head include corrective femoral osteotomy, the Salter or innominate osteotomy, combination of the two techniques and triple pelvic osteotomy. The above interventions involve a similar mechanism of therapeutic effect due to containment and decreased compression of the surrounding group of muscles [6, 7, 8, 9, 10].

The majority of reports suggest that surgical remodeling of the femoral head can be advocated only in severe capital femoral epiphyseal involvement being in place or expected (Catterall groups III or IV, Salter-Thompson group B) when lateral pillar is involved in necrotic 'sequester'. Some prognostic factors and adverse effects among which the subluxated femoral head is the most meaningful should be considered while identifying indications [11, 12, 13, 14, 15, 16].

Corrective (varus, detorsion-varus and detorsion) femoral osteotomy is relatively simple and less time-consuming as compared to the above mentioned procedures and just as effective. Femoral head fitting inside the acetabulum (extent of bone coverage (EBC) measuring 1.0) is provided due to decrease in the neck-to-shaft angle (NSA) and/or anteversion angle (ATA) and decrease in muscular compression with decreased NSA and/or appropriate fascio- and tenotomies performed during the procedure [17, 18, 19, 20, 21].

The disadvantages of the procedure include increased height of the greater trochanter that can aggravate gluteal muscle function, and additional shortening of the operated limb (with decreased NSA), as well as decreased amplitude of internal rotation of the femur (with decreased ATA). For all the drawbacks most surgeons would opt for corrective femoral osteotomy rather than innominate osteotomy in all clinical cases when initial values of NSA and ATA allow for appropriate correction of the femoral head in the acetabulum [22, 23, 24, 25].

Currently, corrective femoral osteotomy remains a most rewarding procedure among interventions used for the femoral head remodeling in patients with LCPD.

Purpose of the study: improve outcomes of the complex treatment of children with LCPD.

Barsukov D.B., Krasnov A.I., Baskov V.E., Pozdnikin I.Yu., Voloshin S.Yu., Baskaeva T.V., Bortulev P.I., Aleksandrenko I.P. Corrective femoral osteotomy in the complex treatment of children with Legg-Calve-Perthes disease. *Genij Ortopedii*. 2017. T. 23. No 1. pp. 63-70. DOI 10.18019/1028-4427-2017-23-1-63-70.

MATERIAL AND METHODS

The study reviewed 90 children with unilateral LCPD and severe epiphyseal involvement. Patients' age ranged from 6 to 14 years. The study included our own 60 observations and 30 cases from archive material. Surgical intervention suggested corrective femoral osteotomy, deformity correction (varus, detorsion-varus or detorsion alone) depending on initial anatomical condition of the hip joint. The ratio of boys to girls was 3:1; there were 41 children (45.6 %) aged from 6 to 8 years at the time of operation, 32 (35.6 %), from 9 to 11 years, and 17 (18.8 %), from 12 to 14 years. No treatment was performed for 68 patients (75.6 %) before surgical containment, and the rest could ambulate with crutches bearing no weight on the leg involved. Clinical, radiological (conventional radiography and arthrography) and ultrasonographic assessments were performed for all children pre- and postoperatively.

An extent of major symptoms of LCPD was seen through physical examination. Gait pattern and Trendelenburg sign were assessed preoperatively in 68 patients who had no previous treatment. Fifty two patients showed slightly disturbed gait pattern, however evident limping was observed in 16 patients with severe pains. Trendelenburg sign was either weakly positive or negative in 58 patients (85.3 %) and severe in 10 cases (14.7 %). Maximum value of relative shortening of the involved limb was observed at fragmentation and reconstitution stages and measured 1.8 ± 1.1 cm and 1.5 ± 1.2 cm, correspondingly. Other clinical manifestations included limited abduction and internal rotation of the femur, and 35 (38.9 %) children presented with thigh pain at extreme points of the amplitude.

The Reinberg classification was used to evaluate the stage and severity of the disease using anteroposterior and Lauenstein views of the hip joint. Schertlein chart was applied to accurately measure NSA and ATA.

Severity of LCPD and the sequelae can be mostly predicted by extent of the deformity of the femoral neck as the course of the disease is complete, and by subchondral fracture line and location (assessed by Salter-Thompson classification), and further on by dimensions and location of necrotic 'sequester' (assessed by Catterall classification) in the involved epiphysis. The above parameters of subchondral fracture line can be assessed at early stage of impression fracture when necrotic 'sequester' is not evident yet, and parameters of the latter are visible at stages of impression fracture except for subchondral fractures and fragmentation. The extent of the severity of pathological process can be assessed by degree of the deformity of the femoral head at stage of reconstitution.

Perthes patients of our group were staged as follows, impression fracture, 33 (36.7 %); 41 (45.6 %), fragmentation; 16 (17.7 %), reconstitution. Six patients 6 (6.7 %) from 33 children with impression stage were Salter-Thompson group B with subchondral fracture line viewed in the involved epiphysis. Well contoured necrotic 'sequester' could be visualized in 63 patients (70.0 %). Thirty nine cases (62.0 %) were classified as Catterall group III, and 24 (38.0 %) as Catterall group IV.

Anterolateral and Lauenstein arthrographs of the hip joints were used to assess the extent of the femoral head extrusion out of the acetabulum (if there is subluxation or not) and congruency of articular surfaces. Cartilaginous outline of the femoral head and the extent of bone coverage (EBC) of the femoral head were identified with this purpose. Cartilaginous outline of the femoral head was measure as a ratio between minimal and maximal radius in a concentric circle template with each circle separated by 2 mm. Template was placed over an arthrography so that a matching circle of minimal diameter got circumscribed about cartilaginous outline. The ratio of more than 0.95 indicated to sphericity; 0.95 to 0.86, to grade I deformity; 0.85 to 0.76, to grade II deformity; 0.75 and less, to grade III deformity.

Severe deformity of cartilaginous outline of the femoral head (grades II and III) seen in most of the patients (71% and 78.9 %, correspondingly) was commonly observed at stages of fragmentation and reconstitution with grade III reported in 48 cases (53.3 %) and grade III, 33 patients (36.7 %). Normal (spherical) shape of cartilaginous outline and mild grade I deformity were normally seen at the stage of impression fracture and detected in 3 (3.3 %) and 6 (6.7 %) children, correspondingly. Progressive femoral head deformity was accompanied by reduction in FHC and other stability parameters in all age groups (**Fig. 1**). A greater deviation in the mean EBC value from age norm was observed with grade III deformity. The latter was 0.55 ± 0.02 at the age of 6 to 8 years; 0.61 ± 0.01, 9 to 11 years; 0.60 ± 0.01, 12 to 14 years. Functional athrography of the femur was used in addition to standard views.

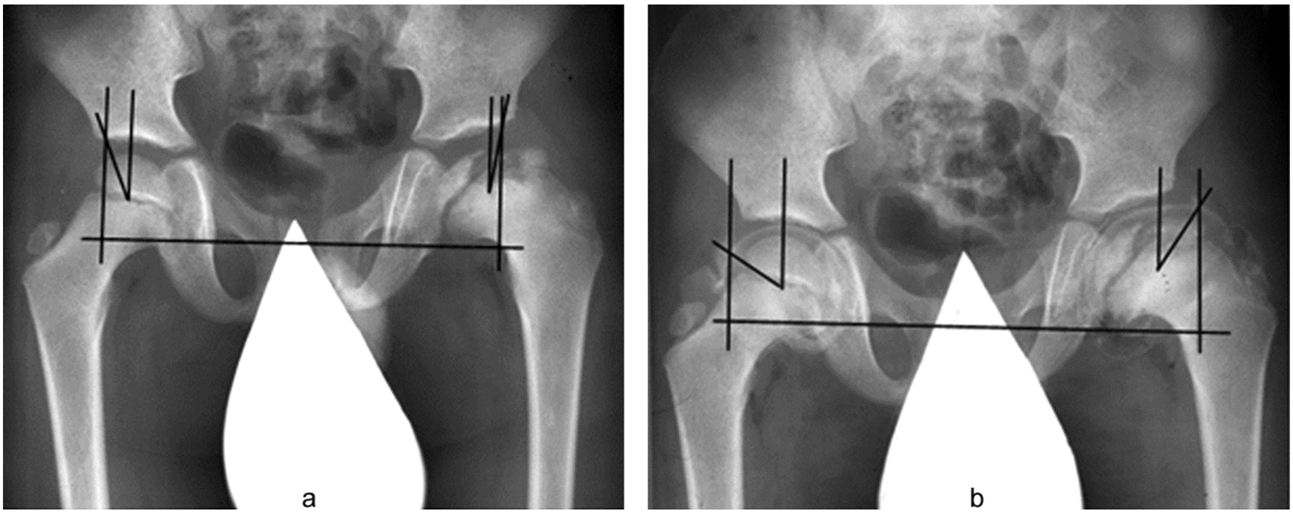

Fig. 1 Anteroposterior radiological (*a*) and arthrographic (b) views of pelvis in a 6-year-old patient A. diagnosed with Catterall group III Legg-Calve-Perthes disease at the stage of fragmentation, left side, showing reduction in bone and cartilage coverage, and Wiberg angle measured by bone and cartilage landmarks

In 2012, we reviewed radiological findings of 120 patients with LCPD and severe epiphyseal involvement (Catterall group III and IV and Salter-Thompson group B) aged from 6 years to 14 years and identified 11 variants of radioanatomical disorders in the involved joint that facilitated the choice of optimal surgical technique for an individual clinical case. The identified radioanatomical manifestations differed in the height of greater trochanter relative to the femoral head and EBC of the femoral head on anteroposterior radiograph, and in the EBC of the head alone on functional arthrograph. They also differed in measures of true ATA of the femoral neck (**Table 1**). The height of greater trochanter relative to femoral head was measured as a ratio between the apex of greater trochanter (AGT) and ‘O’ point that was shown to coincide with the centre of the femoral head in patients aged 9 years and older (**Fig. 2a**), and be located at the boundary of the upper and middle third of the radius of the femoral head connecting the centre and lower pole in patients aged 6 to 8 years (**Fig. 2b**). Concentric circle template was used to find the location of ‘O’ point.

Table 1

Variants of radioanatomical disorders in the hip joint of children with LCPD and severe epiphyseal involvement

№ variant	Radioanatomical manifestations			Description of functional arthrograph
	Location of AGT and EBC on AP view	True anteversion angle	EBC on functional arthrograph	
1	AGT levelled with ‘O’ point or above it EBC ≥ 2/3	> 5º	≥ 1	with internal rotation
2	AGT levelled with ‘O’ point or above it EBC ≥ 2/3	> 5º	< 1	with internal rotation
3	AGT levelled with ‘O’ point or above it EBC < 2/3	> 5º	< 1	with internal rotation
4	AGT below ‘O’ point EBC ≥ 2/3	≤ 5º	≥ 1	with abducted femur
5	AGT below ‘O’ point EBC ≥ 2/3	≤ 5º	< 1	with abducted femur
6	AGT below ‘O’ point EBC < 2/3	≤ 5º	< 1	with abducted femur
7	AGT below ‘O’ point EBC ≥ 2/3	> 5º	≥ 1	with abducted femur and internal rotation
8	AGT below ‘O’ point EBC ≥ 2/3	> 5º	< 1	with abducted femur and internal rotation
9	AGT below ‘O’ point EBC < 2/3	> 5º	< 1	with abducted femur and internal rotation
10	AGT levelled with ‘O’ point or above it EBC ≥ 2/3	≤ 5º	–	N/A
11	AGT levelled with ‘O’ point or above it EBC < 2/3	≤ 5º	–	N/A

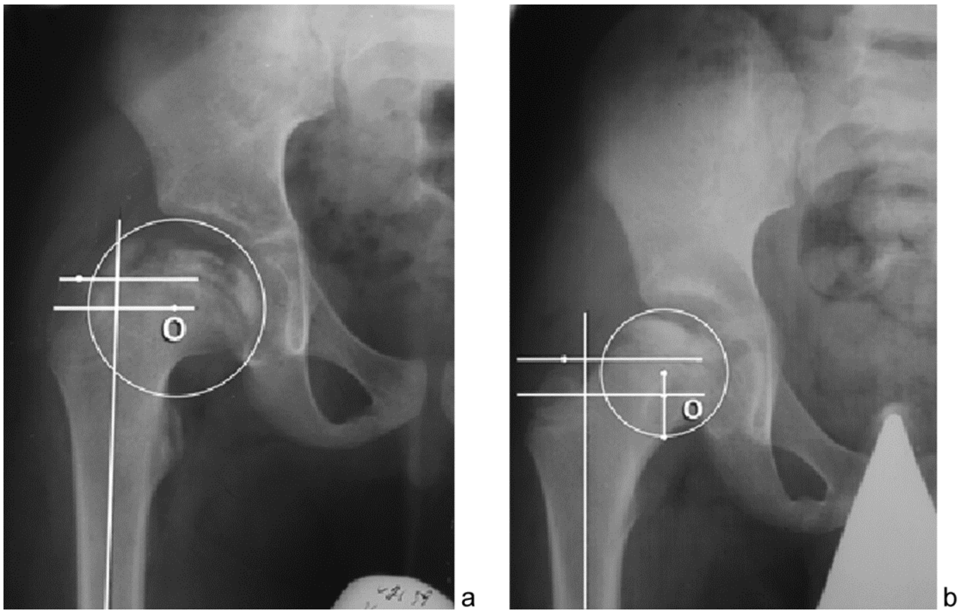

Fig. 2 Technique for measuring the height of greater trochanter relative to femoral head (described in the text)

"AGT levelled with 'O' point" position with femoral neck being in coronal plane was created by femoral abduction and/or internal rotation of the femur on a functional arthrography. However, if AGT was at the level with 'O' point or above it on anteroposterior radiograph this position was not changed in in arthrography.

Ultrasonographic assessment was performed shortly before surgical intervention to evaluate an extent of inflammation in the hip joint. Excessive synovial fluid was observed in 19 cases (21.1 %) at the stage of impression fracture. US scans showed mild synovitis or none at stages of fragmentation and reconstitution.

In our opinion, indications to surgical treatment aimed at remodeling of the femoral head in children with LCPD aged 6 years and older can include patients at stages of impression fracture and fragmentation with evident necrotic 'sequester' in the epiphysis corresponding to Catterall groups III and IV. In the early stage of impression fracture when necrotic 'sequester' is incomplete surgical remodeling can be indicated to patients with subchondral fracture line in the epiphysis corresponding to Salter-Thompson group B. At the stage of reconstitution when dimensions and location of necrotic 'sequester' could not be identified operative treatment was performed to the patients with deformity of the femoral head grade III only with impaired joint stability. Surgical remodeling was never produced for children aged less than 6 years and was considered a contraindication at stages of osteonecrosis and outcome, and also for Catterall groups I and II, and Salter-Thompson group A. The intervention was not advocated at the stage of reconstitution with the deformity of the femoral head grades I and II with no impairment to the joint stability.

Surgical intervention endeavoured to be performed for the involved joint as early as possible was delayed in presence of clinical and ultrasonographic signs of evident synovitis until anti-inflammatory therapy was completed. A straightforward surgical technique was employed to provide EBC being equal to 1.0 without expressed deformity of articular components. Innominate osteotomy and combined procedures were never employed for anatomical situations that would confine to corrective femoral osteotomy.

The choice of optimal surgical remodeling technique to be applied to a particular clinical case was based on a variant of radioanatomical disorders and patient's age as presented in **Table 2**.

Corrective femoral osteotomy was performed for patients aged 6 to 14 years having radioanatomical disorders variants 1, 4 and 7: detorsion produced for variant 1 (n = 20), varus, for variant 4 (n = 20) and detorsion-varus, for variant 7 (n = 20).

Varus and detorsion-varus procedures included oblique intertrochanteric osteotomy of the femur followed by wedged fragment excision creating NSA so that the apex of greater trochanter and 'O' point got levelled out. Detorsion surgery involved transverse intertrochanteric osteotomy of the femur without wedged fragment excision creating ATA of 5º. Distal femoral fragment was medialized by one-third of the diameter with any type of intervention.

Table 2

Indications to reconstructive (remodeling) surgical interventions for LCPD and severe epiphyseal involvement

Technique of treatment	Indications	
	Variant of radioanatomical disorders	age, years
Corrective (detorsion) osteotomy of the femur	1	6–14
Corrective (varus) osteotomy of the femur	4	6–14
Corrective (detorsion-varus) osteotomy of the femur	7	6–14
Salter innominate osteotomy	2, 5, 8, 10	6–8
Salter innominate osteotomy and corrective (detorsion) osteotomy of the femur	3	6–8
Salter innominate osteotomy and corrective (varus) osteotomy of the femur	6	6–8
Salter innominate osteotomy and corrective (detorsion-varus) osteotomy of the femur	9	6–8
Triple pelvis osteotomy	2, 3, 5, 6, 8, 9, 10	9–14
	11	6–14

RESULTS AND DISCUSSION

Clinical and radiological results of treatment were assessed 10 years after surgical intervention. Patients were subdivided into two groups depending on EBC of the femoral head straight after the surgery:

group I (*n* = 60), corrective femoral osteotomy, EBC ≥ 1.0;

group II (*n* = 30), corrective femoral osteotomy, EBC < 1.0.

Patients of group I had radioanatomical disorders in the hip joint variants 1, 4 and 7; group II, variants 1, 2, 3, 5, 6, 7, 8 and 9 variants.

Whatever a corrective femoral osteotomy, group I showed positive clinical and radiological dynamics, improved shape of the femoral head, in particular; group II (patients who underwent surgery prior to 1998, archive material) demonstrated negative dynamics with considerable deformity of the femoral head.

Radiographs were essential in detecting coxarthrosis in 20 patients (66.7 %) group II that appeared as hyperpressured focus due to shear stress from anterosuperior rim of acetabulum to articular surface of the femoral head, and sclerotic subchondral areas in the head and acetabulum being more expressed in the focus. The patients developed progressive coxarthrosis over the next years. No impairment of bone tissue structure of articular components, decrease in articular space and other arthritic changes were radiologically seen in 55 patients (91.7 %) group I. The shape of femoral head and indices of joint stability (EBC, Wiberg angle and acetabular inclination) were normal or close to normal in patient group I and gradually declining in group II. None of the patients group I developed subluxation in the involved joint.

Treatment performed for group I resulted in greater number of patients with spherical femoral head and grade I deformity (n = 10 (16.7 %) and n = 29 (48.3 %), correspondingly) and less cases with deformity grades II and III (n = 12 (20.0 %) and n = 9 (15.0 %), correspondingly) (**Fig. 3**). Group II showed a greater number of patients with deformity grade III (n=25 (83.3 %)), less cases with deformity grade II (n = 5 (16.7 %)) and no patients with deformity grade I and spherical femoral head (**Fig. 4**).

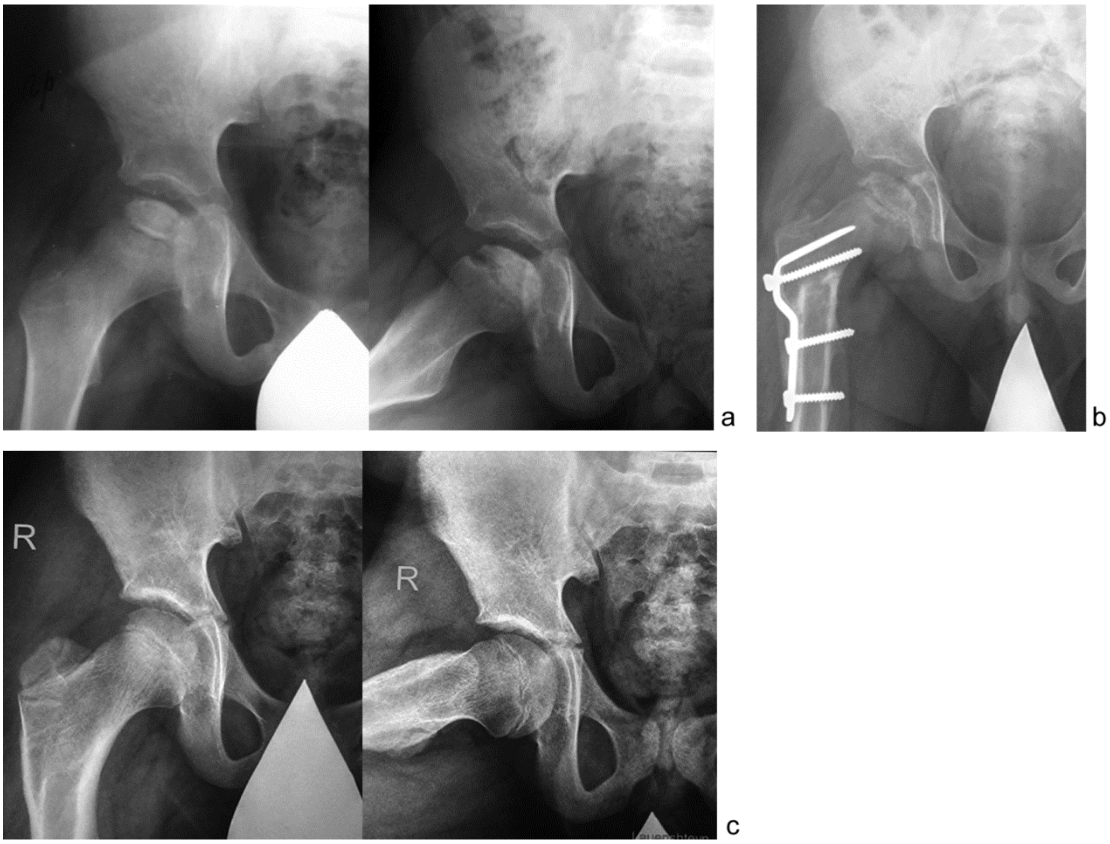

Fig. 3 Anteroposterior radiograph of the right hip joint of a 8-year-old patient R. diagnosed with Catterall group III Legg-Calve-Perthes disease at the stage of impression fracture showing (a) preoperative view, (b) six months after the surgery, and (c) four years after the surgery

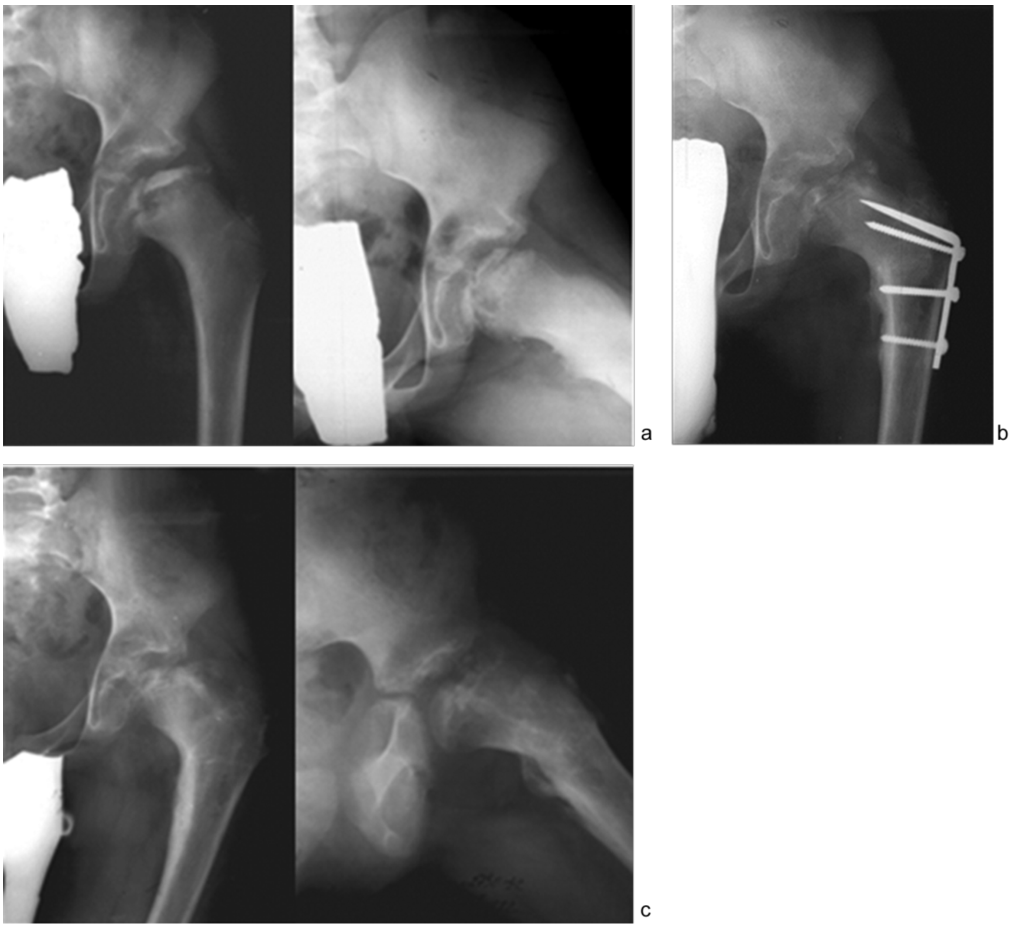

Fig. 4 Anteroposterior radiograph of the left hip of a 10-year-old patient Z. diagnosed with Catterall group IV Legg-Calve-Perthes disease at the stage of fragmentation showing (a) preoperative view, (b) six months after the surgery, and (c) two years after the surgery

Clinical assessment of patients group II showed painful motion in the involved joint that resulted in expressed limping in 14 (46.7 %) cases, positive Trendelenburg symptoms in 15 (50 %) cases, and greater number of patients with severe coxarthrosis over the following years. Whereas group I demonstrated slightly disturbed pain-unrelated gait in 7 (11.7 %) patients and weak positive Trendelenburg symptoms in 11 (18.3 %) cases.

Poor outcomes in most patients of group II could be associated with corrective femoral osteotomy performed for radioanatomical disorders variants 2, 3, 5, 6, 8 and 9 that failed to provide complete hip containment. These cases are currently considered to be an indication to innominate osteotomy.

It should be noted that none of the patients showed high standing greater trochanter at long-term follow-up and there was no need to bring it down.

The results obtained are in line with multiple reports [4, 8, 18, 20, 22, 23, 24, 25], and our previous findings [1, 17] that confirmed high efficacy of corrective femoral osteotomy for LCPD and severe epiphyseal involvement provided that EBC measuring at least one.

CONCLUSIONS

1. Corrective (varus, detorsion-varus and detorsion) femoral osteotomy can be advocated for children with LCPD and severe epiphyseal involvement in the presence of radioanatomical disorders variants 1, 4 and 7 that would facilitate expressed remodeling effect on the femoral head and prevent/eliminate subluxation in the involved joint.

2. Femoral head shape in patients with LCPD at a long-term follow-up would be dependent on EBC measure following corrective femoral osteotomy rather than a type of osteotomy performed. Remodeling of the femoral head can occur with EBC≥ 1 to be created intraoperatively, otherwise a deformity will be progressing with EBC < 1.

3. Corrective femoral osteotomy is the procedure of choice for LCPD among remodeling surgical interventions, easy to perform and less time-consuming as compared with innominate osteotomy. Innominate osteotomy should be used in the anatomical situations when corrective femoral osteotomy is contraindicated.

4. Position of greater trochanter relative femoral head and value of femoral neck anteversion angle offered as maximum permissible for corrective femoral osteotomy are helpful to avoid high-standing greater trochanter at a long-term follow-up and do not affect the patient’s gait.

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Received: 07.07.2016

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