ORIGINAL ARTICLE

Early Results of Femoral Head Reduction Osteotomy in Late Perthes Disease

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Abstract

Background: ***In LCPD, the femoral head usually deforms because of the failure of the acetabulum to contain the soft head, which finally results in an abnormal morphology that causes FAI in adult life.***

Aim of the Work: ***The purpose of our research was to assess the early clinical and radiological results after femoral head reduction osteotomy(FHRO) of a severely deformed head in late stages of LCPD.***

Patients and Methods: ***Our prospective study was conducted at Al-Azhar University Hospitals, Cairo, Egypt, on 15-cases with a severely deformed femoral head.***

Results: ***The mean age of the studied cases was 10.87±1.96 years and ranged between 9 and 14, and the BMI mean was 22.33±3.96 and ranged from 17 to 29 kg/m2. 10-cases(66.7%) males and 5(33.3%) females. All patients had open femoral physis; the affected side was right in 7(46.7%) and left in 8(53.3%). Concomitant surgeries done were PAO in 1(6.7%), triple pelvic osteotomy in 6(40.0%). Relative neck lengthening in 14(93.3%), anterior offset trimming in 7(46.7%), adductor tenotomy in 3(20.0%), and Subsequent surgery needed was hardware removal in 6(40.0%). The complications were minimal, with only one patient having AVN.***

Conclusion: ***FHRO is an appropriate treatment for a severely deformed head in LCPD.***

Keywords: FHRO; LCPD

1. Introduction

Legg-Calve-Perthes' disease (LCPD) is characterized by idiopathic avascular osteonecrosis (AVN) of the capital femoral epiphysis.[1]

LCPD's course and prognosis are unpredictable and rely on a number of factors, including range of motion (ROM), lateral pillar height, femoral head configuration and congruency, and age at presentation.[2]

The frequency of an aspherical femoral head and an incongruent hip joint after late diagnosis or improper treatment of LCPD is high.[3]

Complete collapse of the femoral epiphysis in the normal acetabulum causes limb shortening, high-standing greater trochanter, claudication with weakening of the abductor muscles, and chronic pain from hinge abduction. Limited hip joint range of motion was accompanied by the development of progressive flexion and adductor contractures. Acetabular dysplasia and femoroacetabular impingement cause changes in hip biomechanics, which limit function and cause hip discomfort and early joint deterioration.[4,5]

Anteroposterior (AP), lateral, false profile, and Dunn views are among the several radiographic views that can be used to evaluate the deformed hip.[6] To better plan, computed tomography (CT) is used to understand the abnormality[7] and labral injury exclusion using magnetic resonance imaging (MRI).[8]

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Hip containment can be assessed by the use of the extrusion index,[9] the lateral center-edge angle (LCEA), the acetabular index, and the Shenton line. Additionally, the neck shaft angle (NSA) is utilized to evaluate varus or valgus alignments.[10]

The treatment of these deformities most commonly included valgus extension osteotomies,[11] distal transfer of the greater trochanter,[12] cheilectomy,[13] and pelvic osteotomies.[5]

This results in partial correction for intracapsular head deformities because the correction is not performed at the site of the deformity.

With a better understanding of the femoral head's vascular supply, head reduction osteotomy, a treatment that allows for femoral head contouring and downsizing to improve containment and head sphericity, as well as perhaps improve function and reduce hip pain, was developed.[14,15]

In 2002, Ganz did the first FHRO. The goal of the surgery is to restore the femoral head's sphericity as much as feasible. The head is divided by the osteotomies into a stable medial portion, a central necrotic portion, and a movable lateral piece. The lateral piece is meticulously reduced, and the pathologically enlarged central portion is removed.[14,15]

In certain instances, periacetabular osteotomy (PAO) is required to concurrently realign the acetabulum in order to restore joint stability and containment.[16]

This study aimed to evaluate the early clinical and radiological outcomes of late LCPD after FHRO of a severely deformed head.

2. Patients and methods

A prospective study was conducted at Al-Azhar University Hospitals, Cairo, Egypt, from January 2022 to July 2024, on fifteen patients with severe head deformities. This study aimed to evaluate the early clinical and radiological outcomes after FHRO of a severely deformed head in LCPD (Figure 1).

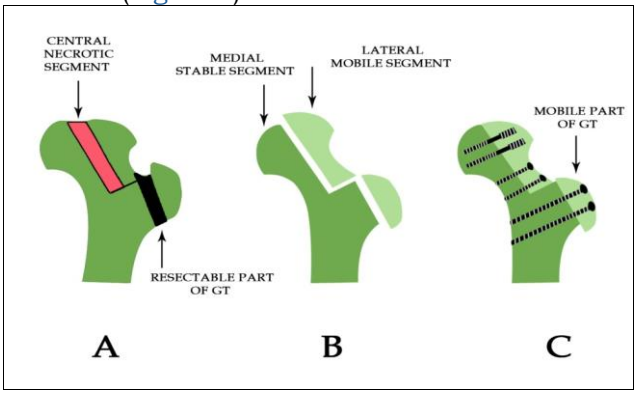


Figure 1. Modified form of Fig. 9 in the work by Ganz et al.,[14] Panels A-C show the planning for femoral cuts and implementation of FHRO.

Our Inclusion criteria were Painful hip, non-arthritic hip, after stage 3A modified Waldenstrom, with Intact lateral pillar of aspherical, oversized femoral head and Normal muscle power, whether

Exclusion criteria include stages before 3A modified Waldenstrom, Osteonecrosis of the lateral pillar of the femoral head in MRI, Hip osteoarthritis and neuromuscular insults.

Administrative issues were done before beginning of the study. Ethical issue was considered such as written Informed consent from parents and Confidentiality and benefitiality were considered.

All cases were subjected to a full history taking (from the patients or their relatives), clinical examination (both general and local hip examinations), laboratory investigations, hip x-ray, CT, and MRI hip before the procedure.

All cases were evaluated Clinically by Pain, mobility, and ability to walk were measured by the Merel de'Aubigne postel scoring system (PMA score) and ROM and radiologically by femoral head shape, head size percent, sphericity index, femoral head extrusion index, LCEA, acetabular index and evaluation of varus or valgus alignments by NSA.

The follow-up visits were planned for two weeks, six weeks, three months, and twelve months, followed by an annual visit. A clinical assessment and a radiological evaluation are completed at every appointment.

Surgical Technique:

Anaesthesia, Positioning and Draping: All patient operated under general anesthesia, a urinary catheter is inserted, then the patient is placed with the operative leg raised in the lateral decubitus position.

Incision, superficial and deep dissection: An incision centered over the GT, measuring about 10-15 cm and opening the fascia Lata, proximally located gap between the gluteus Medius muscle and the piriformis tendon, and distally elevating vastus lateralis off the femur.

GT osteotomy: Marking the posterior border of the GT with the use of cautery, then trochanteric ridge osteotomy from posterior to anterior, the thickness of the mobile GT is about 10-15mm.

Capsulotomy: Opening the capsule after good exposure by a Z-shape for the right side and a reversed Z for the left side.

Dislocating the hip: After cutting the ligamentum teres with long, curved scissors.

Templating and Sizing: Use a spherical template to assess the sphericity of the femoral head in different parts.

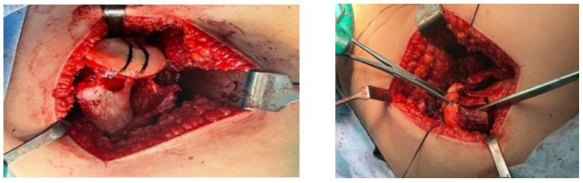
Development of an extended retinacular flap: a periosteal flap of the proximal femur that contains branches of the medial circumflex femoral artery(a safe surgical dislocation of the hip(SHD) as

mentioned by Reinhold Ganz).[14]

Head osteotomy: Mark 2 vertical osteotomies (medial and lateral) and one horizontal baseline Osteotomy (Figures 2A&B). Remove the intercalary segment after osteotomy(Figure 3A), then mobilize the lateral segment to achieve the best feasible posterior congruency. (Figure 3B).

Evaluation of epiphyseal perfusion by inspection of bleeding from osteotomized cancellous bone of the head.

Reduction and Fixation of the femoral head: head fixed by two headless 2.7 or 3.5mm screws, and Fixation of the femoral neck also with 2or 3 screws (Figure 3B,4).



A B

Figure 2. A-Intraoperative photographs showing the Vertical and Horizontal Baseline Osteotomy Lines. B-Intraoperative photographs showing Removal of the Intercalary Segment(the middle segment).

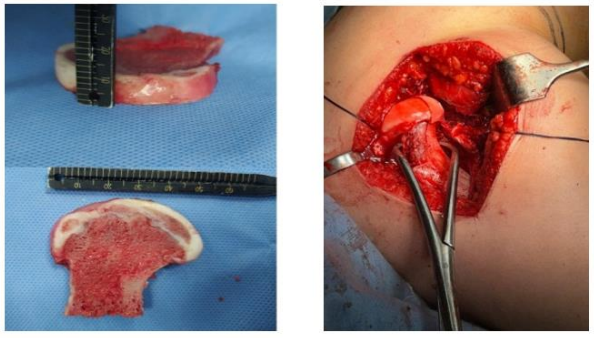
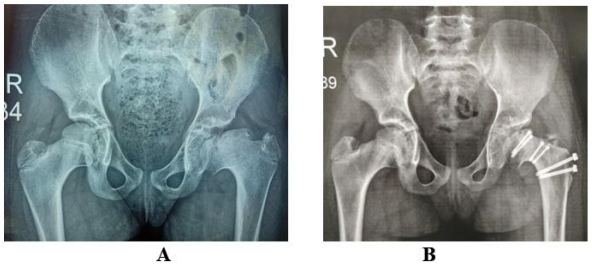


Figure 3. A-The resected part showing central necrosis. B-Reduction of the Femoral Head making the posterior congruity is as perfect as possible.

Osteochondroplasty: for incongruous anterior aspects of the femoral head, followed by capsular repair with some redundancy to prevent subluxation.

GT Fixation: The GT is then reduced, translated distally, and fixed with two 4.5mm cannulated screws into the lateral aspect of the femur (Figure 4).



A B

Figure 4. A-Preoperative x ray of 12-years old girl show left coxa magna, coxa breva, and varus neck. B-After FHRO and Fixation of the femoral head and neck with headless screws and fixation of the GT by 4.5mm cannulated screws

Assessment of hip stability and containment: by clinical examination and image intensifier, concomitant pelvic osteotomy only if gross instability was present. (Figure 5).

A B C

Figure 5. (A) preoperative radiographs of 12-year-old boy with show right coxa magna, coxa breva, overriding trochanter. (B)Immediate postoperative radiograph show FHRO, RNL and simultaneous a triple osteotomy. (C)after removal of iliac screws 24-months after the index surgery.

Statistical Analysis:

Data was gathered, edited, coded, and entered using SPSS version 27. The mean, standard deviations, and ranges for parametric or median data are provided, as well as the interquartile range(IQR) when the quantitative data is found to be non-parametric. Qualitative features were also represented using figures and percentages.

3. Results

Our study was conducted at Al-Azhar University Hospitals on 15-cases with the age range from 9–14 years, the mean (10.87±1.96) and the cases were 10(66.7%) males and 5(33.3%) females. The affected hips were right in 7(46.7%) and left in 8(53.3%), All had open proximal femoral physis, with mean follow up in months 20.4±8.44 (Table.1).

Table 1. Demographic data and characteristics of the studied cases.

		TOTAL NO.=15
AGE	Mean±SD	10.87±1.96
	Range	9-14
SEX	Female	5(33.3%)
	Male	10(66.7%)
OPEN FEMORAL PHYSIS	Open	15(100.0%)
SIDE	Right	7(46.7%)
	Left	8(53.3%)
FOLLOW UP IN MONTHS	Mean±SD	20.4±8.44
	Range	6-31
BMI(KG/M^2)	Mean±SD	22.33±3.96
	Range	17-29

Concurrent surgeries were performed: PAO in 1(6.7%), triple pelvic osteotomy (TPO) in 6(40.0%) relative neck lengthening (RNL) in 14(93.3%), anterior offset trimming in 7(46.7%) and adductor tenotomy in 3(20.0%).

Subsequent surgery needed was hardware removal in 6(40.0%), and final head morphology was spherical, contained in 12(80.0%), not spherical, contained in 2(13.3%), and deformed,

not contained in 1(6.7%). The complications were minimal, where only one patient had Avascular necrosis (AVN) of the femoral head.

Regarding radiographic outcome measures (Figure 6), we found that the mean head size percent (Table 2) showed improvement from 125.67±8.63 preoperative (range from 110-140) to 101.0±4.71 postoperative (range from 95-110). Head sphericity improved from 61.6% (range, 47%–75%) to 89.8% (range, 80%–98%), and on follow-up, it was 87.5% (range, 68%–98%). The mean extrusion index decreased from 50% (range, 30%-60%) to 15% (range, 9% to 20%). The mean LCE angle increased from 5(range, -10-15) to 30(range, 25-35). The mean acetabular index (°) decreased from 29.53(range, 20-40) to 23.8 (range, 14-38), and on follow-up, it was 24.27(range, 15-45) only in the seven cases underwent triple osteotomies and PAO. The mean NSA increased from 128.4(range, 120-135) preoperatively to 131.3(range, 120-138) postoperatively (Table 3).

Table 2. Head size percent pre and post among the studied cases.

HEAD SIZE PERCENT	PRE	POST	TEST VALUE	P-VALUE	SIG.
MEAN±SD	125.67±8.63	101±4.71	10.017•	<0.001	HS
RANGE	110-140	95-110			

•:Paired t-test

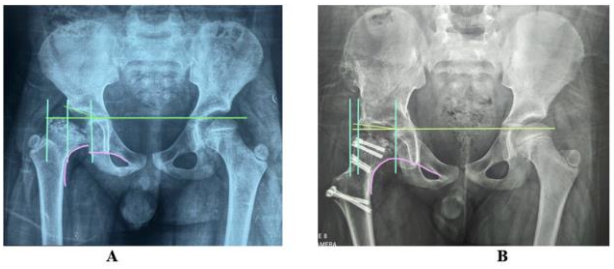


Figure 6. A-Preoperative and B-Follow up x ray show a well-contained femoral head with improvement of femoral head size and improvement of acetabular index between 32°-10°; extrusion index between 45% -10%, sphericity index between 83%-99%; and intact Shenton's line after previous disruption.

Table 3. Radiographic data among the studied cases.

		PRE	POST	LAST FOLLOW UP	TEST VALUE	P-VALUE	SIG.
HEAD SPHERICITY INDEX(0%)	Mean±SD	61.6±10	89.8±5.93	87.53±9.71	2902.182•	<0.001	HS
	Range	47-75	80-98	68-98			
EXTRUSION INDEX(%)	Median(IQR)	50(35-55)	15(11-15)	15(10-19)	20.491≠	<0.001	HS
	Range	30 -60	9-20	10-47			
LCEA(°)	Median(IQR)	5(-8-10)	30(27-33)	30(30-33)	20.857≠	<0.001	HS
	Range	-10-15	25-35	-2-35			
ACETABULAR INDEX(0)	Mean±SD	29.53±6.89	23.8±6.99	24.27±9.29	218.496•	<0.001	HS
	Range	20-40	14-38	15-45			
CENTRUM-COLLUM DIAPHYSEAL ANGLE(°)	Mean±SD	128.4±4.78	131.33±5.07	131.6±5.21	10665.412•	<0.001	HS
	Range	120-135	120-138	120-138			

•:Repeated Measures ANOVA test; ≠:Friedman test

Concerning the improvement of functional scores, PMA score, improved from 14.4(range, 13–16) preoperatively to 17.4(range, 9–18) postoperatively (Table 4).

Hip ROM (Figure 7) flexion improved from 104.33(range, 70-120) to 116.53(range, 15-130). Internal rotation in hip flexion 90 improved from 10.67(range, 0-15) to 25.67(range, 0-35). External rotation in hip flexion 90 improved from 26.67(range, 5-45) preoperatively to 36(range, 0-45) postoperatively. Abduction has improved from 16.33(range, 0-30) to 32.2(range, 0-45) postoperatively, and adduction has improved from 13.33(range, 5-20) preoperatively to 25.33(range, 0-30) postoperatively (Table 4).

Table 4. Clinical results pre and postoperative among the studied patients.

		PRE	POST	TEST VALUE	P-VALUE	SIG.
MERLE DE'AUBIGNE´-POSTEL SCORE(18–0)						
THE PMA SCORE(18–0)	Mean±SD	14.4±0.99	17.4±2.32	-4.801•	0.000	HS
	Range	13-16	9-18			
PAIN(6–0)	Mean±SD	3.73±0.7	5.67±0.82	-9.374•	0.000	HS
	Range	3-5	3-6			
MOBILITY(6–0)	Mean±SD	5.27±0.7	5.73±1.03	-1.974•	0.068	NS
	Range	4-6	2-6			
WALKING ABILITY(6–0)	Mean±SD	4.87±0.35	5.8±0.56	-14.000•	0.000	HS
	Range	4-5	4-6			
ROM						
FLEXION	Mean±SD	104.33±16.13	116.53±28.6	-1.856•	0.085	NS
	Range	70-120	15-130			
INTERNAL ROTATION IN HIP FLEXION 90°	Mean±SD	10.67±4.58	25.67±9.23	-5.521•	0.000	HS
	Range	0-15	0-35			
EXTERNAL ROTATION IN HIP FLEXION90°	Mean±SD	26.67±12.91	36±11.83	-4.404•	0.001	HS
	Range	5-45	0-45			
ABDUCTION	Mean±SD	16.33±6.94	32.2±13.9	-4.332•	0.001	HS
	Range	0-30	0-45			

ADDUCTION	Mean±SD	13.33±4.08	25.33±7.67	-4.431•	0.001	HS
	Range	5-20	0-30			
	Range	65-88	60-98			

•:Paired t-test. P-value>0.05:non-significant(NS);
P-value<0.05:significant(S);P-value< 0.01:highly significant(HS).

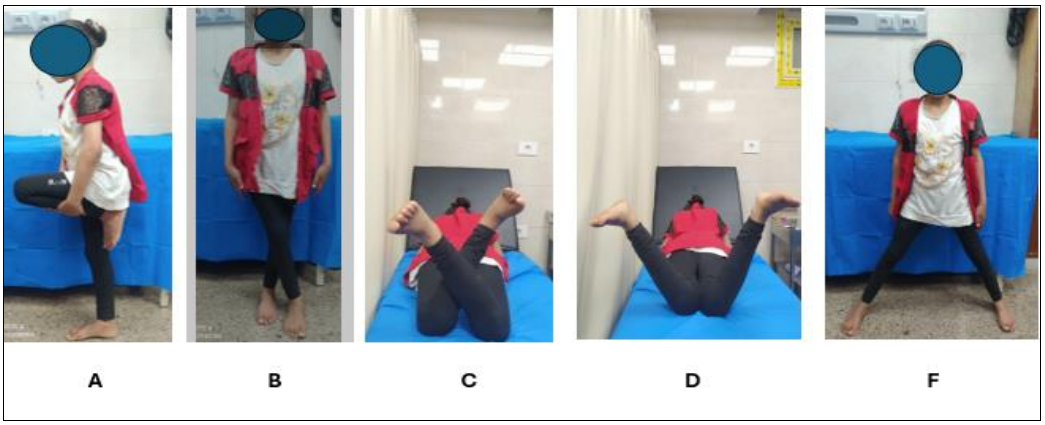


Figure 7. ROM 9-months postoperative for a girl in(figure7) A-Flexion, B-Adduction, C-External rotation, D-Internal rotation, E-Abduction respectively. FHRO is an appropriate treatment for severely deformed head in LCPD.

There was a statistically significant difference regarding the PMA score, pain, walking ability and ROM.

4. Discussion

Typically, in LCPD, the femoral head enlarges and flattens, making it impossible for the acetabulum to contain it.[17] This leads to central osteonecrosis, aberrant greater trochanter development, coxa magna, coxa breva, and coxa Vara, among other complex hip abnormalities.[18]

An innovative rebirth in the treatment of such deformities provoked by the development of the SHD method because it made the treatment possible without resulting in AVN.[19, 20]

Consequently, the middle necrotic part of head was removed, then two spherical lateral sections joined together.[21,22] This procedure allowed for the femoral head to be reshaped into a more spherical shape.[23,24] The AP view provides the best view of the frontal plane, where femoral head sphericity and confinement were evaluated.

Our findings concurred with those of Siebenrock et al., who reported that 11 patients (11 hips) had LCPD(10 hips) or developmental dysplasia(one hip). The median age of the studied cases was 13 years; five hips had concomitant pelvic osteotomies, including 2 TPO, 2 PAOs, and one Colonna procedure. All cases(100%) had RNL; there were 4 anterior head-neck trimmings, and there was one rim trimming.[25] Radiologically the head sphericity increased from 72%(range 64%–81%) preoperatively to 86%(74%–95%) postoperatively. The mean extrusion index dropped from 47(25–60) to 21(12–36). The mean LCEA increased from 1(- -10-16) preoperatively to 20(-2-35) postoperatively clinically. Clinically The pain sub score increased from 3.5(range, 1–5) preoperatively to 5.0(range, 3–6) at the latest follow-up(p=0.026); however, the PMA score declined from 14.5(range, 12–16) preoperative to 15.7±1.8(range, 12–16) at the last follow-up(p=0.072).[25]

According to Eltayeby et al., the mean age of 22 patients was 15.8 years(range: 9.2-23.9). Out of the 22-patients, only 5(22.7%) received TPO. Two of those were secondary procedures, and three were performed with the FHRO. Heterotrophic ossification, one infection, and two AVN were among the consequences. However, there was a noticeable rise in LCEA, from 14.6°-25.1° on average. The average extrusion index decreased from 32.4 to 16.8.[26] The sphericity index increased from 0.71 to 0.79 on the AP view and from 0.69 to 0.78 on the lateral view. The head size percentage decreased from a mean of 122.7-105.9% on the AP view and from 121.0%-108.0% on the lateral view. The HHS statistically improved from 62.0 to 81.6 in the clinical setting. In the most recent follow-up, five patients had HHS values below 70.[26]

Paley et al. stated that 21 cases with misshapen femoral heads underwent FHRO. One case suffered a femoral neck fracture, leaving 20 patients. At a mean follow-up of 2.7 years(range, 1–5 years). 3 simultaneous Wagner osteotomies and 2 later PAOs. To maintain stability, five patients utilized an external fixator during the first six weeks after surgery. One of the 21 hips with AVN of the head in an 11-year-old boy had a femoral neck fracture, and three had been converted to a THA.[27]

Paley et al. reported a decrease in head sphericity from 133%(range, 115%–160%) to

96%(range, 91%–100%) after surgery.[27]

Furthermore, because this classification may be utilized to forecast long-term results, the Stulberg classification was not provided in our study to recognize the sphericity and congruency of the hip. [28]

Limitations:

The short-term follow-up period, limited sample size, and focus of the study on the femoral head frontal plane deformity only. To validate our findings and the technique's effectiveness, further research with longer follow-up periods is still required.

4. Conclusion

FHRO is a good and safe way to preserve the native hip in patients with aspherical, enlarged, and misshapen femoral heads. Preoperative ROM is the key clinical factors influencing prognosis following FHRO; better outcomes are observed in cases with good ROM conversely.

Disclosure

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Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

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