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General

Shelf osteotomy improves pain and stulberg outcome in Legg–Calve´– Perthes disease (LCPD)

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Keywords: Legg-Calvé-Perthes disease, shelf osteotomy, early disease.

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Objective

Our ideal objective was to assess clinically and radiologically the efficacity of shelf osteotomy in early LCPD with epiphyseal extrusion without hinge-abduction and/or severe stages.

Patients and Methods

A prospective case study conducted at Al-Hussein Hospital, Cairo, Egypt on 20 children with unilateral LCPD, were treated with shelf acetabuloplasty. 14 boys and six girls shared , with 20 hips involved (11 right hip and 9 left hip).

Results

The mean follow-up was 4.9 years (3-6 years). No cases complained of disability or activity limitation. ROM has greatly improved. Internal rotation improved from an average of 15° to 35.9°. Radiographic non union of the shelf was achieved in zero case.

Conclusion

Shelf acetabuloplasty in early extruded femoral head and before extrusion improves and restores pain-free hip movements and improves sphericity of the femoral head and in turn stulberg functional outcome in children with perthes disease.

Level of evidence

IV

INTRODUCTION

Still the treatment of Perthes disease is challenging with multiple modalities and tailored according to multiple factors in each patient with no consnsus on the appropriate modality of treating child with perthes disease.[1]

The most important determining factors in the prognosis of the perthes disease are age, gender and the stage of the disease. But the femoral head deformity is the most crucial and determinant of outcome so the treatment of perthes depends predominantly on decreasing and or avoidance of Femoral head (FH) deformity to eliminate or decreasing degenerative hip joint disease.[2]

Therefore , the surgical treatment of perthes disease usually is targeting to modulate the forces exerted on the head and acetabulum, which can be done by improving the coverage of the acetabulum by pelvic osteotomy including shelf acetabuloplasty that it supports the labrum and stimulates growth of the acetabulum and therefore decreases the load on the soft head.[2-4]

Still, shelf osteotomy counted by some authors as salvage procedure in late stages of perthes disease.[5-8] While others have endorse the use of a shelf as a labral support osteotomy to contain the extruded portion of the femoral head in the earlier stages of the perthes disease.[2,9-16] Some use shelf acetabuloplasty in treating patients with hinged abduction,[7-9,12,14,15] others endorse shelf augmentation contraindicated in the presence of hinge abduction.[10-12,16] In our study we exclude patients with hinged abuction because of it may affect the results.

In our hospital we start using shelf acetabuloplasty in perthes disease in sporadic cases with no statistical collection of these cases but from 2017, march we start to do the technique with follow up the children and assessing the results of the shelf on the course of the head deformity resulting from perthes disease.

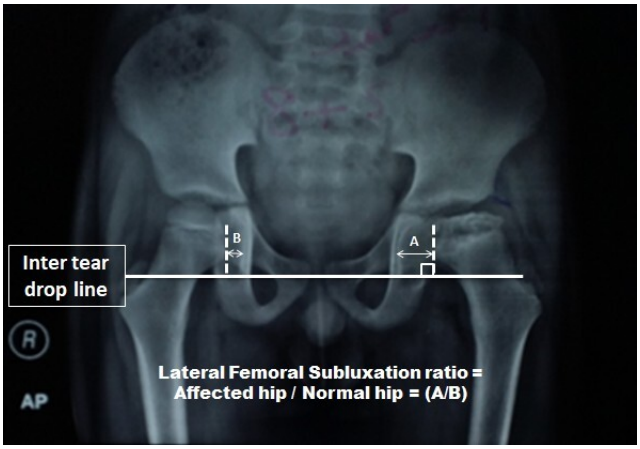

Figure 1. Lateral femoral subluxation ratio in patient 8 (the quotient of the distance from the deepest point of the teardrop to the medial femoral head in affected hip over normal hip)

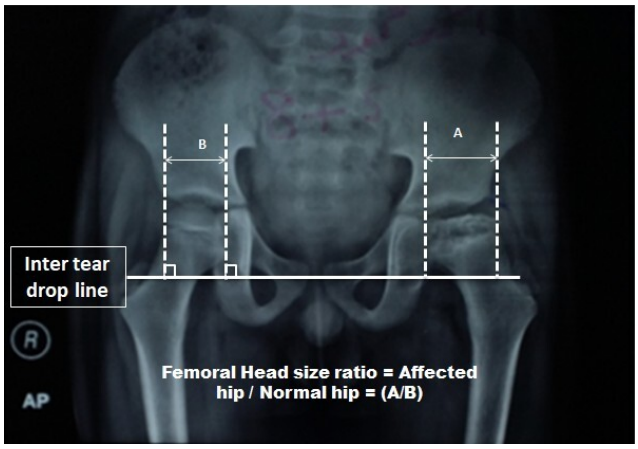

Figure 2. Femoral head size ratio in patient 8 (the quotient of the distance from medial femoral head to the lateral femoral head in affected hip over normal hip)

MATERIAL AND METHODS

A prospective case series study was performed From March 2017 to March 2023 and was handled 20 cases (20 hips, 11 right and 9 left) with unilateral LCPD were treated with shelf osteotomy in the stage fragmentation. The 20 patients were operated from March 2017 to 2021 and follow up was up to March 2023.

Inclusion criteria include child under 12 years, perthes hip whatever the stage. Child with hinge abduction are excluded from this study .

We estimated all cases clinically preoperatively and at final follow-up for pain (using VAS score) ROM, hip disfigurement, and LLD, also radiographically measuring subluxation ratio [Figure 1], Size of femoral head (FH) [Figure 2], Reimer migration percentage (MP) represents acetabular coverage [Figure 3] and sharp's angle [Figure 4]. Postoperatively and at the final check-up we measured the acetabular size (acetabular length relative to shelf) [Figure 5], Shelf cap (the length of the acetabulum and shelf relative to the femoral head) [Figure 6] and sharp's acetabular angle.

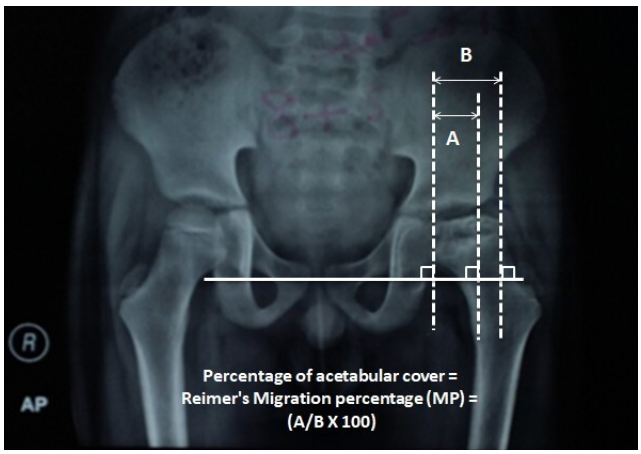

Figure 3. Reimer Migration percentage (Acetabular coverage) in patient 8 (the percentage of the covered part of the femoral head over the total head size)

SURGICAL TACTICS

Modified bikini cut, Tensor-sartorius interval, Splitting of the apophysis of the iliac crest with a knife, elevation of gluteal muscles from ileum subperiosteal was done up to the capsule of the hip joint. Z-shaped cut of The reflected head of the rectus. Recession of the iliopsoas at pelvic border to drcrease pressure on FH. A curvilinear slot is produced in the subchondral bone of the anterolateral aspect of the acetabular roof, 3–3.5 cm in length, 2–3 mm in height, and 1–1.5 cm in depth, in an ascending direction from lateral to medial and from distal to proximal. One or two cortical grafts are harvested from the iliac wing, tightly inserted in the slot, with an extrusion of 1–1.5 cm lying on the hip capsule after its exposure and incision of the outer layer of the capule ("filleting" with a scalpel), and secured with the reflected head of the rectus femoris. This is sutured back to its origin on the direct head, keeping 5– 6 mm of the most lateral aspect of the graft, exposed in such a way as to be in contact with the cancellous and cortical graft harvested from the same iliac wing, and put on top of it . In 7 out of 20 patients an adductor tenotomy was also performed these seven patient had limited abduction of the hip. All kids were kept in hip spica for 1 month then allowed for full weight bearing after a month

STATISTICAL ANALYSIS

Data were coded & entered using Graph Pad InStat version 3 program . Quantitative variables are presented as mean ± SD, while qualitative variables as percentages. Qualitative variables were compared among groups using the Chi-square test ($\chi 2$) test, whereas continuous variables were compared with the analysis of variance test [e.g., paired T-test]. P value < 0.05 was considered statistically significant whereas P value > 0.05 was considered statistically non-significant.

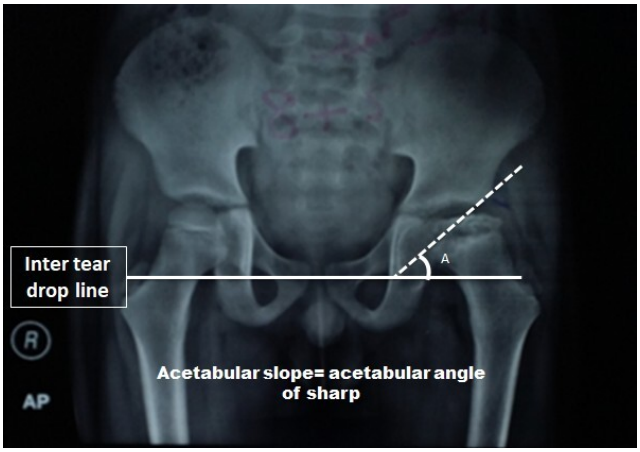

Figure 4. Acetabular angle of sharp's in patient 8 (acetabular inclination angle lateral margin of the acetabulum to the bottom of tear drop in relation to intertear drop line)

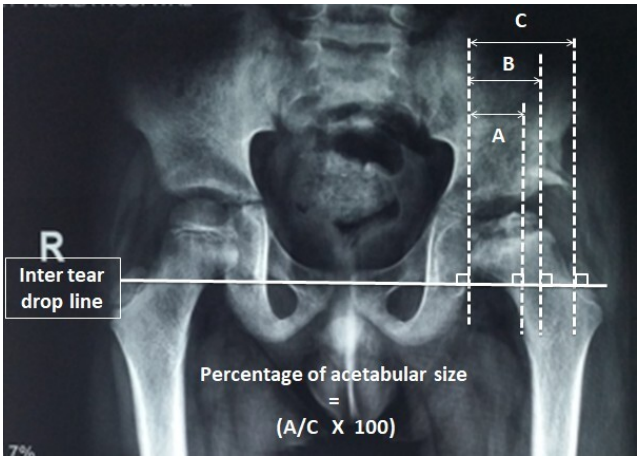

Figure 5. percentage of acetabular size postoperative ratio in patient 8 = A/C100 (The distance between two vertical lines through the most lateral point of the acetabulum and the most medial point of the femoral metaphysis (A) expressed as a percentage ratio of the distance from the most lateral point of the shelf to the most medial point of the femoral metaphysis (C))

RESULTS

Our patients' ages were ranging 5-11 years old with average 8.6 ± 2.1years old. 12 cases were over 8 years while 8 cases under 8 years. These cases followed up 4.9 ±0.82 years old (3-6 years).

3 cases were Catterall II, 7 cases were Catterall III and 10 cases were Catterall IV, according to Herring Lateral pillar 2 cases were B while 7 cases were B/C and 11 cases were C [Table 1].

Hip pain was observed in Four patients the pain score was 4/10 in 2 cases and 6/10 in 2 cases and treated by NSAIDs and physiotherapy, the pain might be attributed by the shelf was done in a deformed head. The hip ROM is improved especially the internal rotation from 15±3.2 to 35.9

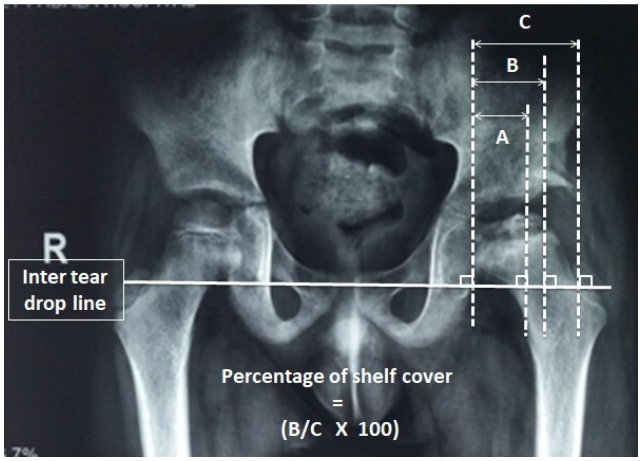

Figure 6. Percentage of shelf cover in patient 8 = B/C100. (The distance between two vertical lines through the most lateral point of the femoral metaphysis and the most medial point of the femoral metaphysis (B) expressed as a percentage ratio of the distance from the most lateral point of the shelf to the most medial point of the femoral metaphysis (C).)

± 4.1 degrees, the abduction range improve from 20 ±2.1 preoperative to 40 ±3.1 degrees postoperative . None of our patients has limping at the last follow up. Seven of our patients had LLD about 3.2± 0.1 mm averge .

Non union of the shelf is zero in our cases [Figure 7 A-K]. Subluxation ratio of the FH decreased from 1.45±0.02 preoperative to 1.22±0.03 postoperative (at final follow up) (P<0.0001). The size of FH increased from 1.13 ± 0.1preoperative to 1.30 ± 0.04 postoperative (P=0.002) and the coverage of the shelf decreased from 145.7 ± 3.1% early postoperative to 105.5 ± 2.6 % at final follow up (P<0.0001) which attributed by the the increase of the size of the FH. There were decrease in Acetabular angle of sharp from 46.6±3.5 preoperative to 43.9±2.4 postoperative (P=0.0002). the acetabular coverage of the femoral head increased from 66.6 ±2.1 % preoperative to 74.2 ± 3.2 % postoperative (P<0.0001 which means, with time the shelf has shrunk while the acetabular growth is stimulated [Table 2].

In younger children than 8 years, the acetabulum continued to grow and so the size of the acetabulum increased from 48.8 ± 2.6 % to 69.9 ± 1.6 % while in older children than 8 years, the size of the acetabulum increased from 55.8 ± 2.8% to 69.5 ± 1.7% [table 3], so there is significant increase the acetabular coverage in relation to the shelf in younger children (P<0.02) than older ones which is attributed by the formation of coxa magna so the coverage decreases in older children.

The final outcome depending on Stulberg grading shown in Table 4 as follows, 4 cases categorized as stulberg 1, 12 cases categorized as stulberg 2, 3 patients categorized as stulberg 3 while 1 patient only as stulberg 4 and zero patient as Stulberg 5. The difference between Stulberg groups 2 and 4 was significant (P<0.001) and it was also significant between Stulberg groups 3 and 4 (P<0.001).

Table 1. Demographic criteria of the patients

Demographic criteria of the patients			
Age	Mean age (yrs) 8.6 (5 – 11)	< 8 years	8
		> 8 years	12
sex	Male	14	
	Female	6	
side	Right hip	11	
	Left	9	
Caterall stages	Stage II	3	
	Stage III	7	
	Stage IV	10	
Herring stages	Stage B	2	
	Stage B/C	7	
	Stage C	11	

In younger children less than 8 yrears, the predictive value of the Catterall and Herring grades to Stulberg was significant (P<0.01) while it was non significant in older kids.

DISCUSSION

Deformity of the FH is primarily depend up on the extrusion, so the main indication of doing surgery in this study was the extrusion of the femoral head. We did adductor tenotomy and iliopsaos recession in all patients to reduce the irritability of the hip after surgery and decrease extrusion and improve hip ROM which is also supported by many surgeons.[1,5,6,10-13,15]

In the study of Dimitriou et al[16] 12 cases of perthes aged 9-12 years after shelf showed good results with averge follow-up of 4 years. Kadhim et al[17] perform as meta-analysis comparing Stulberg in children in early and late stages of perthes treated by shelf the results were good (stulberg I,II,III) in early (85%) than late stages (69%). Near results observed in study done by carsi et al[1] (84.4%). Also good results observed in 22 of 27 hips after shelf in the study of Daly et al.[10] In this study the results of shelf in early stages were excellant 95% (stulberg I,II,III) than late stages 5% (stulberg 4).

In this study, the femoral head subluxation improved from 1.45 to 1.22 following shelf acetabuloplasty also the size of the femoral head improved from 1.13 to1.30 while shelf cap decreased and the coverage of the acetabulum improved.

Shelf osteotomy does not destroy the acetabular epiphysis but could stimulate growth as evidenced by increase of the acetabular coverage in our study and other studies[2,7-13, 15,18]

The stulberg grouping done in our study is demonstrative as none of our patient reach the skeletal maturity but all were in remodeling stage.

Limitations of this study include a relatively small number of cases, no nonoperative control group, and a relatively short follow-up, which may make the statistical analysis unreliable.

CONCLUSION

shelf acetabuloplasty in early extruded femoral head and before extrusion improves and restores pain-free hip movements improves sphericity of the femoral head and stulberg outcome in children with perthes disease .

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Informed consent was obtained from all legal substitute decision makers of individual participants included in the study.

CONSENT FOR PUBLICATION

Informed consent was obtained from all legal substitute decision makers individual participants included in the study to publicate the results.

AVAILABILITY OF DATA AND MATERIAL

all data and materials are available

COMPETING INTERESTS

The authors declare that they have no conflict of interest.

CONFLICT OF INTEREST

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FUNDING

There is no funding source.

Figure 7. Preoperative and postoperative and follow up x rays in patients No 10, 8 yrs and 2 months old, Herring LP grade C with pain and limping, shelf osteotomy was done although it is a little bit high it gave its benefit which supports the labrum and decreases the forces exerted on the lateral acetabular epiphysis so stimulating its growth and contain the femoral head to be ended up stulberg 1after 5 years, the patient fully satisfied with pain-free hip motion. A and B preoperative. C and D immediate post-op, E and F 1 year post-operative, G and H 3 years post-operative, I, J, and K 5 years post-operative.

AUTHORS' CONTRIBUTIONS

1. Mohammed Elmarghany, M.D (Surgeon, manuscript preparation, performed measurement, statistical analysis)
2. Tarek M. Abd El-Ghaffar M.D (review the manuscript, help in surgery)
3. Ahmed Elgeushy, M.D (manuscript preparation, performed measurement)
4. Yehia Hasanin, M.D (performed measurement)
5. Ehab Elzahed , MD (performed measurement)
6. Mohammed I Abulsoud, M.D (measurements and statistical analysis)
7. Ahmed M. Khairy, MD (collecting data, assist in surgery)
8. Mohamed N.Akl, M.D1 (collecting data, assist in surgery)

Table 2. Radiographic parameters postoperative and at final follow-up.

		Subluxation ratio	Acetabular angle of sharp	FH size ratio	Acetabular cover(%)	Acetabular size (%)	Shelf cover (%)
postoperative	Mean	1.45	46.6	1.13	66.6	49.9	145.7
	Range	1. - 2.55	39 - 55	0.82- 1.45	49.2 – 90.3	38.2 – 69.8	98.4 - 200
Final Follow up	Mean	1.22	43.9	1.3	74.2	70.1	105.5
	Range	0.88- 2.00	36 -56	0.65- 1.62	45.1 – 92.3	45.3 -100	82.2 -149.3
P- value		< 0.0001	0.0002	0.0002	<0.05	<0.0001	<0.0001

Table 3. Radiographic parameters in children with LCPD treated with a shelf acetabuloplasty

			Acetabular angle of sharp(°)	Acetabular cover(%)	Acetabular size (%)
< 8 yrs (n = 6)	postoperative	Mean	47.6	65.7	48.8
		Range	37 -55	45-87.6	36.1-62.4
	Follow up	Mean	43.4	75.2	69.9
		Range	42.2 -53.4	43.7-91.1	44.6- 100
>8 yrs (n = 14)	postoperative	Mean	45.0	74.4	55.8
		Range	40.1 – 52.3	54.3- 93.1	44.3 -66.6
	Follow up	Mean	44.3	72.6	69.5
		Range	33 -49	58.8-84.4	54.88- 83.0

Table 4. Stulberg grading at the final follow-up.

Stulberg	Mean Age (years)	Caterall 4	Herring C
Stulberg 1 *(n=4)*	4.6	2/10	2/11
Stulberg 2 *(n=12)*	5.2	4/10	5/11
Stulberg 3 *(n=3)*	7.2	3/10	3/11
Stulberg 4 *(n=1)*	11	1/10	1/11

9. Mohammed Adel, M.D1 (collecting data, assist in surgery)
10. Jorge Knorr, MD2 (collecting data, assist in surgery, revise the manuscript)

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