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**Aly Aly Ibrahim Attia Alaswad**
Orthopedics Specialist, Al Ahrar Teaching Hospital and Banha University Hospitals, Egypt

**Mohamed Abobakr Atia Eldayasty**
Orthopedic Surgery, Shebin El-Kom Teaching Hospital, Menoufia, Egypt

**Esayed Said Esayed Abdou**
Orthopedic Surgery, Shebin El-Kom Teaching Hospital, Menoufia, Egypt

**Abdel-Nasser Ahmad Saleh**
Orthopaedic Specialist, Al-Ahrar Teaching Hospital, Egypt

**Corresponding Author:**
**Abdel-Nasser Ahmad Saleh**
Orthopaedic Specialist, Al-Ahrar Teaching Hospital, Egypt

# Lateral shelf acetabuloplasty: Surgical outcomes in patients with residual hip dysplasia

**Aly Aly Ibrahim Attia Alaswad, Mohamed Abobakr Atia Eldayasty, Esayed Said Esayed Abdou and Abdel-Nasser Ahmad Saleh**

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**Abstract**
In treating developmental dysplasia of the hip (DDH), the goal is to realign the femoral head with its native acetabulum, which can occur at any age. In older children, concentric reduction is challenging especially with flattened femoral head or dysplastic acetabulum that make open reduction and some acetabuloplasty procedures difficult to be applied due to the risk of incongruence, arthritis beside vascular serious complications,. Another barrier that hinders anatomic reduction is soft tissue contracture which, may increase the incidence of some complications, such as the femoral head avascular necrosis. Shelf acetabuloplasty can be a good option for those cases avoiding vascular risks of other reorientation osteotomies, In order to prevent or postpone the development of arthritis, it is necessary to distribute stress evenly over the acetabular cartilage and provide adequate coverage of the femoral head.
**Objective:** To assess both the functional outcomes and radiological impacts of the shelf acetabuloplasty procedure in patients who have residual hip dysplasia.
**Patients and Methods:** 30 hips with residual hip dysplasia were treated by lateral shelf acetabuloplasty. The mean age was 10.5 years (range: 8-15 years).
**Results:** 18 patients (60%) had a poor score according to modified Sundt criteria while 12 patients (40%) had a fair score preoperatively. At the one-year follow-up, 20 patients (66.7%) had a good score, 8 patients (26.7%) had a fair score, and 2 patients (6.6%) had a poor score.
**Conclusion:** Lateral shelf acetabuloplasty can be a good option for children with residual hip dysplasia and have a favorable short term outcome at 1 year follow up.

**Keywords:** Lateral Shelf acetabuloplasty: surgical outcomes in patients with residual hip dysplasia

## Introduction
Patients with DDH often have aberrant acetabular and femoral development, which can change the form and location of the acetabulum. As a result, the acetabulum may not provide adequate coverage for the femoral head, or it May and femoral head to not match. As a result, the femoral head becomes more susceptible to lateral displacement and subsequent subluxation due to changes in hip kinematics and stability. Due to these changes in the hip's natural architecture, residual dysplasia develops, reducing the hip's weight-bearing area and putting an excessive amount of stress on the relatively small articular surface area [1].
In older children with DDH and in addition to the previous anatomical and biomechanical changes, the degree of acetabular anteversion and the power of remodeling is markedly affected. The shape of the pelvis differs according to uni-or bi-lateral affection. Furthermore, because of the related changes in the surrounding muscles, capsule, ligaments and bone, the treatment should be tailored according to the complexity of the problem as the outcome may be affected by age and laterality [2].
Several trailblazers in the early 20th century constructed shelf acetabuloplasty. König put it out there in 1891, and by 1926, it had been refined and had come to notoriety owing to Gill. Shortly after, Wiberg improved the method and the procedure's results [3-5]. Many good outcomes in treating hip developmental dysplasia have been shown by long-term follow-up of the shelf acetabuloplasty procedure (DDH). Its capacity to not impede the normal evolution of osteoarthritis is one of the procedure's advantages, along with its simplicity and minimally invasive nature [6]; and in comparison to peri-acetabular osteotomies, it carries a

little danger of vascular damage. Additionally, shelf acetabuloplasty and peri-acetabular osteotomy (PAO) have not been proven to be better [7]. Shelf acetabuloplasty has to have its function reevaluated because re-directional pelvic osteotomies are getting more and more attention.

Acetabular dysplasia that persists after hip shelf arthroplasty can be treated with this procedure. The goal of the surgery is to stabilise the hip joint and stop dysplasia from getting worse. This will keep the hip joint mobile and in alignment, stop the femoral head from getting deformed, and postpone the start of secondary hip osteoarthritis (OA). If a patient is also suffering from hip discomfort, it aims to lessen or eliminate that pain [8, 9].

This study aim to determine if the shelf treatment was beneficial in terms of clinical outcomes and imaging findings for individuals suffering from residual hip dysplasia.

## Patients and Methods

This study included 30 patients with residual hip dysplasia treated via lateral shelf acetabuloplasty between September 2021 and August 2022 at Kafr El Sheikh and Benha University Hospitals. Cases were followed up for a minimum of 1 year postoperatively.

A prospective therapeutic case series study in which patients were subjected to clinical and radiological examination to collect the data needed for analysis of the results.

### Demographic data

The mean age for patients was 10.5±2.3 years (range: 8-15years). It included 28 female and 2 males. Eighteen cases (60%) had left side affection 12 cases (40%) had right sided affection. 12 patients (40%) underwent previous surgical intervention, 11 patients (36.7%) had previous non-surgical interventions and 7 patients had no previous surgical interventions (23.3%). All cases had unilateral affection. (Table 1)

### Inclusion criteria

Patients with late sequels of DDH who had acetabular dysplasia with or without hip subluxation with age more than 8 years.

### Exclusion criteria

Patients with acetabular dysplasia due to Perthe's disease, septic, spastic, paralytic hip disorders and also DDH cases with frank hip dislocation.

The study received approval from the Committee of Medical Ethics and the institutional review boards at Benha University Hospitals. Written informed consent was obtained from all patients' parents before participation.

Patients and their parents were investigated for full history taking regarding analysis of the main complaint (Pain, limping, limited movement, etc.) and history of previous hip surgeries. All patients were clinically assessed pre and postoperatively regarding gait, degree of local pain or tenderness, active and passive ROM, Limb length discrepancy and hip flexion deformity. The modified Sundt criteria were used to evaluate the functional results [10]. In which "Good" implies complete freedom of movement and absence of discomfort, "Fair" suggests some limitation of movement and/or occasional pain, and "Poor" indicates severe pain and severely limited hip mobility.

Both anterior and posterior (AP) plain X-rays (PXR) of the pelvis, as well as lateral (frog) views, were acquired for radiographic analysis. The Acetabular Index (AI) and the Center Edge Angle of Wiberg (CEA) were measured using these instruments before surgery, immediately after the operation, at 6 weeks post-cast removal, and every 3 months thereafter until the conclusion of the follow-up period.

### Surgical technique

All children underwent the lateral shelf acetabuloplasty using the Spitzy technique. A bump was used to elevate the operated hip while the patient was in a supine posture during the procedure. The anesthesia protocol included general anesthesia combined with caudal analgesia for postoperative pain management.

In order to avoid damaging the lateral cutaneous nerve of the thigh, a bikini incision was created 1.5 cm below the anterior superior iliac spine, lying immediately below the iliac crest. With great care, the abductors were elevated away from the ilium's outer table, and the reflected head of the rectus femoris was detached from the joint capsule and shifted posteriorly.

In order to mimic the acetabulum's concave form, a trapezoidal uni-cortical bone graft measuring around 4 cm in base and 4 cm in length was taken from the inner iliac table. Once the actual capsular connection to the ilium was located, a bone slot was cut right above the acetabulum's subchondral bone. It was crucial to place the slot for the graft directly above the capsule with no intervening space, ensuring that the slot reached the true capsule and was not misled by any tissue above it.

The slot was directed upward to make the direction of the graft in line with the C shaped articular surface of the acetabulum as much as possible. The trapezoidal bone graft was then inserted into the slot with the slightly concave cortical side facing downwards. The graft was secured to the underlying capsule with absorbable sutures to ensure a good fit and proper contact between the graft and the capsule.

The iliac bone was removed and filled with cancellous bone above the shelf graft that had been previously implanted. The outer iliac table was shingled just above the graft using an osteotome to promote better union. After that, the graft might be made more stable by compressing it with bone wax or by reattaching the reflected head of the rectus femoris over it. The last step in securing the grafts was to seal the periosteum and gluteal muscles.

Patients were immobilized in a bilateral above-knee abduction cast with a bar for 6 weeks. Following this, protective weight-bearing was maintained for an additional 4 weeks. The patients were encouraged to perform gentle progressive passive and active ROM of their hips then a physiotherapy program includes gluteal and thigh muscle strengthening is started.

The statistical analysis was carried out using the SPSS software package, version 25. (SPSS, Chicago, IL, USA). Range, mean, standard deviation, and median were used to represent quantitative data, whereas percent and frequency were used to convey qualitative data. We used the Chi-square test to examine the qualitative data.

## Results

Preoperative clinical examination results according to modified sundt criteria were 60% (18 patients) had a poor score while 40% (12 patients) had a fair score.

Preoperatively the mean acetabular index angle (AI) was 50.8º±11.7 (range: 37.4 º to 64.6 º). The mean center edge angle (CEA) was 7.3º±8.1 (range: - 2.4 º to 20.6 º).

The mean acetabular index angle (AI) during the 6-month follow-up was 32.6°±7.54°, ranging from 23.12° to 43.86°. The mean centre edge angle (CEA) at the conclusion of the follow-up period was 40.32°±11.83°, with a range of 26° to 54°.The difference between the results of pre and 1 year postoperative radiological measurements was statistically substantial ($p< 0.05$).

The mean final acetabular index angle (AI) during the one-year follow-up radiological examination was 28.2o±5.7. (Range: 18.3o to 35.8o). A final centre edge angle (CEA) of 34.6o±3.7 was recorded at the conclusion of the follow-up period (range: 24o to 39o). A statistically significant difference ($p< 0.05$) was seen between the pre- and one-year post-operative radiological measurement data. also the difference between the results of radiological measurements at 6 months follow up and 1 year follow up was statistically substantial ($p< 0.05$) At the conclusion of the one-year follow-up period, 66.7% (20 patients) had good scores, 26.7% (8 patients) had acceptable scores, and 6.6% (2 patients) had bad scores. There was a significant statistical difference ($p< 0.05$) between the pre- and post-operative ratings.

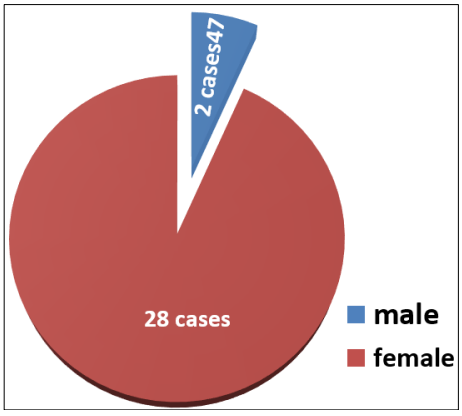
The age of the patient did not correlate significantly with their final score ($p> 0.05$). Similarly, there was no statistically significant relationship between preoperative treatments and the final score after surgery ($p> 0.05$). Additionally, no statistically substantial association was observed among the postoperative final score and the patient's sex or the affected side ($p> 0.05$).

There were 2 patients who had poor results at end of follow up both were females one of them had previous false track pelvic osteotomy which ended by arthritis preoperatively and the other one was complicated by deep infection which was treated by aggressive debridement and antibiotic therapy, but hip stiffness was the end result.

The rest of the patients were able to perform well and get back to normal activities after a mean period of 7.2±1.5 months (range: 5-9 months).

**Table 1:** Demographic data and results of the study

| No of patients | 30 patients |
|---|---|
| Age | Mean 10.5±2.3 years |
| | (range: 8-15 years) |
| Gender | 28 female |
| | 2 males |
| Side | Left side 18 cases (60%) |
| | Right side 12 cases (40%) |
| Previous interventions | Previous surgical intervention 12 cases (40%) |
| | Previous non-surgical interventions 11 cases (36.7%) |
| | No previous surgical interventions 7 cases (23.3%) |
| Laterality | All cases unilateral (100%) |
| CEA | Preoperative : 7.3º±8.1 range (- 2.4 º to 20.6 º) |
| | 6 months postoperative : 40.32º±11.83º range (26º to 54º) |
| | 12 months postoperative : 34.6º±3.7 range (24º to 39º) |
| AI | Preoperative : 50.8º±11.7 range (37.4 º to 64.6 º) |
| | 6 months postoperative : 32.6º±7.54 range (23.12º to 43.86º) |
| | 12 months postoperative : 28.2º±5.7 range (18.3º to 35.8º) |
| Score | Preoperative: 60% (18 patients) had a poor score: 40% (12 patients) had a fair score.<br>12 months postoperative : 66.7% (20 patient) had good score : 26.7% (8 patients) had fair score : 6.6% (2 patients) had poor score |
| Complications | 1 case : infection and stiffness |
| Return to normal activity | 7.2±1.5 months (Range: 5-9 months) |




**Shape 1:** Number and gender of cases

**Case presentation**

An 11 years female child presented with residual right hip dysplasia, the past surgical history included open reduction, capsulorraphy, dega pelvic osteotomy, femoral shortening and de-rotation osteotomy at age of 8 years for right side untreated DDH.

She had poor score according to modified sundt criteria preoperatively. Prior to the operation, the right hip had an acetabular index (AI) of 38° and a centre edge angle (CEA) of 17°. She was treated by shelf acetabuloplasty and the final follow up at 1 years postoperative was good score according to modified sundt criteria. Right hip acetabular index at 1 year postoperatively was 30 degrees, with a CEA of 33.5 degrees. (Fig 1-5)


**Fig 1:** Pre-operative x-ray shows residual hip dysplasia at right side

**Fig 2:** Intra-operative c- arm photo shows the shelf osteotomy

**Fig 3:** Post-operative x-ray of the shelf osteotomy

**Fig 4:** Follow up x-rays 6 months post-operatively show healing of RT sided shelf osteotomy

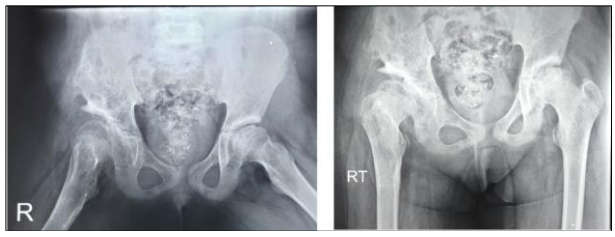



**Fig 5:** Follow up x-ray 9 months postoperatively show healed RT sided shelf osteotomy

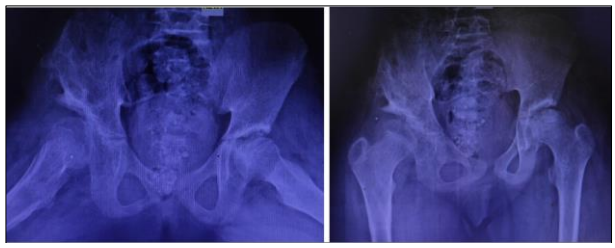


**Fig 6:** Follow up x-ray 12 months postoperatively show healed RT sided shelf osteotomy

## Discussion

The reorientation osteotomies in cases of non-spherical femoral head, would result in an incongruent joint which may aggravate symptoms and accelerate the process of arthritis [11]. Consequently, Shelf acetabuloplasty is considered more appropriate solution for such cases. According to the theory behind acetabular augmentation operations, one of the main causes of osteoarthritis is an unequal distribution of weight over the joint surface [12], By increasing femoral head coverage, weight distribution can be improved, which may help delay the onset of osteoarthritis. Hip dysplasia and osteoarthritis are strongly associated, according to Bouyer *et al*. [13] Supporting this hypothesis, Similar correlations were seen among younger patients by Lievense *et al*. [14]. A study conducted by Lievense *et al*. also found similar relationships in patients who were younger.

The main objective of the shelf operation is to increase the weight-bearing surface area of the femoral head in order to make it more stable and reducing shear forces; those are accomplished through the added shelf graft. The previous literature revealed that interposition of the capsular tissue under the shelf results in fibrocartilage nous metaplasia with some hyaline-like cartilage near the joint surface [15-16].

The biomechanics of the shelf acetabuloplasty doesn't depend on reorientation of the acetabulum, also the hip joint's centre remains unaffected, even in instances of femoral head dislocation. There is also zero chance of unanticipated degradation; unlike reorientation and curved peri-acetabular osteotomies which may accelerate the expected natural sequence of OA progression and increase

the incidence of iatrogenic complications as chondrolysis and AVN [17].

The direction of the shelf graft should be parallel to the acetabulum curve to promote fibro-cartilagenous metaplasia of the subcutaneous capsule. Aota *et al*. found that the joint capsule thickness and the architecture of the acetabular edge significantly affect the height of the acetabular slot for bone grafting, lending credence to this idea. One possible reason for high sitting shelf is the worry of joint violation during osteotomy [18].

Suturing the reflecting head of the rectus femoris or covering it with bone wax to preserve the position of the cancellous graft, which causes the ilium's outer table to shimmer above the graft, and compressing the graft against the shelf graft. Both help the biomechanical properties of the cancellous grafting and enhance shelf graft union.

It is important also to increase femoral head coverage by the shelf graft beyond normal values as always and after strictprecautions to minimize resorption of the graft, the results of the current study show changes in radiological measurements between 6 and 12 months follow up ($p< 0.05$) which means reduction in length of the shelf that become smaller with union and consolidation of the graft.

The results of this study showed good improvement in both clinical and radiological outcome of the included children. Results postoperatively were better than those before surgery in terms of range of motion and hip discomfort. Furthermore, by the conclusion of the follow-up period, the Acetabular Index (AI) and Center Edge Angle (CEA) values demonstrate adequate covering of the femoral head, resulting in little residual dysplasia. ($p<0.5$)

The outcomes of the shelf procedure are notably better when fewer patients with severe osteoarthritis are included. Hirose *et al*. and Tanaka *et al*. reported favorable short- and long-term results, with THA-free survival rates of approximately 72% at 35 years of follow-up [19-20] Similar results were reported by Holm *et al*., who observed THA-free survival rates of 100% at 20 years, 83% at 30 years, and 22% at 50 years in children and adolescents [16].

A survival analysis of the shelf acetabuloplasty for residual dysplasia was reported by Clohisy *et al*. at a 20-year follow-up utilising joint replacement as the endpoint. Showed 83–93%, and good hip joint function was attained in 87% at 25 years. These results is comparable to those of the PAO with less subjection to major complications [21].

The survival rates for patients over the age of 12 were 100% at 20 years, 72% at 30 years, and 32% at 40 years of follow-up, with an average age of 16.1 years, according to Terjesen *et al*. [6] According to Schramm *et al*., Hasegawa *et al*., and Lerch *et al*., stats show that shelf procedures have long-term survival rates that are comparable to or higher than peri-acetabular osteotomy (PAO) [22-24].

In conclusion, Successfully correcting residual hip dysplasia without disrupting the pelvic ring structure is possible with the shelf operation, a safe and relatively straightforward surgical procedure, consequently, it is a good option for young children above 8 years of age with residual hip dysplasia or subluxation with non-spherical head or non-congruent acetabulum whenever reorientation osteotomies is not suitable, achieving good stability, ROM and function at 1 year follow up.

The study's limitations include the need for a larger sample size and further follow-up time to provide a more precise evaluation and comparison of results.

**Conflict of Interest:** Not available

**Financial Support:** Not available

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