Lateral shelf acetabuloplasty in treatment of residual hip dysplasia

Hossam E.D. Mohamed Gad[a], Mohammed M. Abdelaaty Ahmed[a], Mohammed O. Hegazy[b], Mahmoud I. Kandil[b]

[a]Department of Orthopedic Surgery and Traumatology, Kafr El-Sheikh University, Kafr El-Sheikh, Egypt, [b]Department of Orthopedic Surgery and Traumatology, Benha University, Benha, Egypt

Correspondence to Mohammed M. Abdelaaty Ahmed, MSc, Department of Orthopedic Surgery and Traumatology, Kafr El-Sheikh University, Kafr El-Sheikh 33511, Egypt Tel: +0020 1099 325 593; fax: +0020473109591;
e-mail: mohamed_moaaz@med.kfs.edu.eg

Received: 23-Oct-2023
Revised: 03-Nov-2023
Accepted: 04-Nov-2023
Published: 08-Mar-2025

The Egyptian Orthopaedic Journal 2024, 59:667–673

Background
To evaluate the functional and radiological outcomes of the shelf acetabuloplasty procedure in patients with residual hip dysplasia.
Patients and methods
Thirty hips with residual hip dysplasia were treated by lateral shelf acetabuloplasty. The mean age was 10.5 years (range: 8–15years).
Results
Eighteen patients (60%) had a poor score according to the modified Sundt criteria while 12 patients (40%) had a fair score preoperatively. At the end of 1 year follow-up 20 patient (66.7%) had good score, 8 patients (26.7%) had fair score while 2 patients (6.6%) had 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:
acetabuloplasty, DDH, shelf

Egypt Orthop J 2024, 59:667–673

1110-1148

Introduction

The abnormal acetabular and femoral development that occurs in developmental dysplasia of the hip (DDH) patients often results in alteration in both shape and/or position of the acetabulum, which progressively leads to inadequate coverage of the femoral head or mismatch of femoral head and acetabulum. Accordingly, hip biomechanics and stability changes in the way that makes the femoral head prone to lateral displacement and secondary subluxation. These alterations in the native anatomy of the hip result in residual dysplasia which leads to decrease in the weight-bearing area of the hip with concentration of the loading forces and shear stresses on the 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 unilateral or bilateral 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].

Shelf acetabuloplasty was established by several pioneers in the early 1900s, It was introduced first by König in 1891 then modified and become popular by Gill in 1926. Afterwards, Wiberg improved the technique and the results of the procedure [3–5] long-term follow-up of the shelf procedure have shown numerous favorable results in treatment of DDH. The reported advantages of shelf acetabuloplasty are as follows: it is a simple and less invasive surgery; it does not deteriorate the natural progression of osteoarthritis (OA) [6]; and it encompasses a very low risk of vascular injury when compared with periacetabular osteotomies additionally, evidence supporting the superiority of the peri-acetabular osteotomy (PAO) over shelf arthroplasty is lacking [7]. With the rising focus on redirectional pelvic osteotomies, the role of the shelf acetabuloplasty now needs to be re-evaluated.

Hip shelf acetabuloplasty is a procedure that aims at correcting residual acetabular dysplasia. The goal is to enhance hip stability and avoid worsening of residual dysplasia, therefore preserving hip motion and congruity, avoiding head deformation and delaying the occurrence of secondary hip OA. Also, eliminate or decrease hip pain in patients who have such symptoms [8,9].

The aim of the current study was to explore the clinical and radiological effectiveness of shelf procedure in patients with 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 sideaffection and 12 cases (40%) had right-sided affection. Twelve patients (40%) underwent previous surgical intervention, 11 patients (36.7%) had previous nonsurgical 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.

Table 1 Demographic data and results of the study

No. of patients	30 patients
Age	Mean 10.5 ± 2.3 years (range: 8–15years)
Sex	28 female 2 males
Side	Left side 18 cases (60%) Right side 12 cases (40%)
Previous interventions	Previous surgical intervention 12 cases (40%) Previous nonsurgical interventions 11 cases (36.7%) No previous surgical interventions 7 cases (23.3%)
Laterality	All cases unilateral (100%)
CEA	Preoperative: 7.3 ± 8.1° range (–2.4° to 20.6°) 6 months postoperative: 40.32°±11.83° range (26–54°) 12 months postoperative: 34.6 ± 3.7° range (24–39°)
AI	Preoperative: 50.8 ± 11.7° range (37.4 –64.6°) 6 months postoperative: 32.6 ± 7.54° range (23.12–43.86°) 12 months postoperative: 28.2 ± 5.7° range (18.3–35.8°)
Score	Preoperative: 60% (18 patients) had a poor score: 40% (12 patients) had a fair score. 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)

Exclusion criteria

Patients with acetabular dysplasia due to Perthe disease, septic, spastic, paralytic hip disorders, and also DDH cases with frank hip dislocation [10].

The study was approved by the Committee of Medical Ethics and the institutional review boards of Benha University Hospitals. Written informed consents were obtained from all the parents of the patients 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 preoperatively and postoperatively regarding gait, degree of local pain or tenderness, active and passive range of movement (ROM), limb length discrepancy and hip flexion deformity. Functional outcomes were determined using modified Sundt criteria [11] where good represent no pain and full ROM, fair represent restricted range and/or occasional pain, and poor represent pain and hip motion markedly restricted.

The following radiographic views were obtained: plain radiography of pelvis in anterior-posterior and frog lateral views to assess the acetabular index (AI) and center edge angle (CEA) of Wiberg preoperatively, postoperatively, 6 weeks later after removal of cast then every 3 months till the end of follow-up.

Surgical technique

All children were operated by lateral shelf acetabuloplasty procedure using the Spitzy technique. Surgery was performed in supine position with a bump under the operated hip to elevate it. Anesthesia protocol was in the form of general anesthesia and caudal analgesia for postoperative pain control.

A bikini incision was made below the iliac crest, reaching 1.5 cm underneath the anterior superior iliac spine to avoid injury of the lateral cutaneous nerve of the thigh. The abductors were elevated from the outer table of the ilium, and the reflected head of the rectus femoris was dissected free from the joint capsule and displaced posteriorly.

A trapezoidal unicortical bone graft was obtained from the concave inner iliac table to mimic the concave acetabulum (~4 cm base and 4 cm length). After identification of the true capsular attachment to the ilium, a bone slot was made just above the subchondral bone of the acetabulum. It was important to place the slot for the graft just above the capsule with no space in between by reaching the true capsule and not to be deceived by any tissue above.

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 impacted into the slot with the slightly concave cortical side downwards. The graft is sutured to the underlying capsule using absorbable sutures to make good contact between the graft and capsule.

Some cancellous bone is harvested from the iliac bone and packed above the previous shelf graft after shingling of the outer iliac table just above the shelf by an osteotome to enhance union. The graft was then maintained in position by reattachment of the reflected head of rectus femoris above the graft or compressing it by bone wax. The periosteum and glutei were closed to maintain the grafts in place.

Patients were immobilized in a bilateral above knee abduction cast with bar for 6 weeks and protective weight-bearing was then continued for 4 additional 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.

Statistical analysis was done using SPSS software package version 25 (SPSS, Chicago, IL, USA). Quantitative data were expressed using range, mean, standard deviation, and median while qualitative data were expressed in frequency and percent. Qualitative data were analyzed using χ^2 test.

Results

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

Preoperatively the mean AI angle was 50.8°±11.7° (range: 37.4–64.6°). the mean CEA was 7.3 ± 8.1° (range: –2.4 °to 20.6°).

Regarding radiological measurements at 6 months follow-up, the mean AI angle was 32.6 ± 7.54° (range: 23.12–43.86°). The mean CEA at the end of the follow-up period was 40.32°±11.83° (range: 26–54°). The difference between the results of preoperative and 1 year postoperative radiological measurements was statistically significant (P<0.05).

Regarding radiological measurements at 1 year follow-up, the mean final AI angle was 28.2 ± 5.7° (range: 18.3–35.8°). The mean final CEA at the end of the follow-up period was 34.6 ± 3.7° (range: 24–39°). The difference between the results of preoperative and 1 year postoperative radiological measurements was statistically significant (P<0.05). also the difference between the results of radiological measurements at 6 months follow-up and 1 year follow-up was statistically significant (P<0.05)

At the end of the follow-up period (1 year), 66.7% (20 patient) had good score while 26.7% (8 patients) had fair score and 6.6% (2 patients) had poor score. The difference between the results of preoperative and postoperative scores was statistically significant (P<0.05).

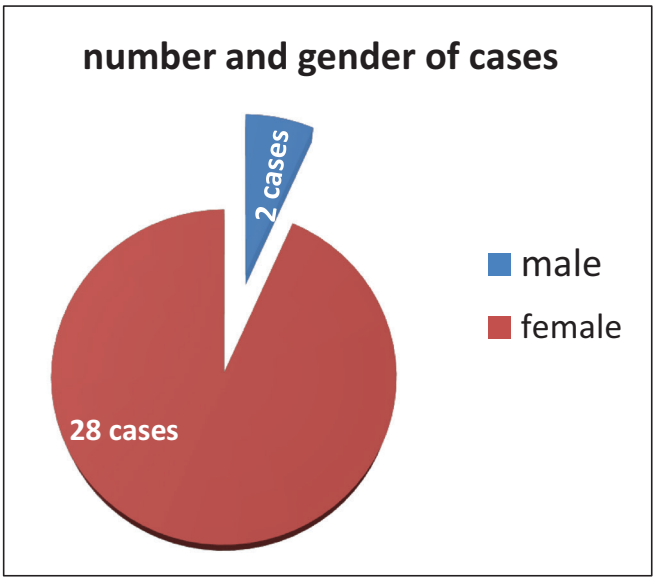
There was no statistically significant correlation between the age of the patients and the final score (P>0.05). There was no statistical significance between previous intervention and postoperative final score (P>0.05). There was no statistically significant relation between postoperative final score and patient's sex or affected side (P>0.05).

There were two 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).

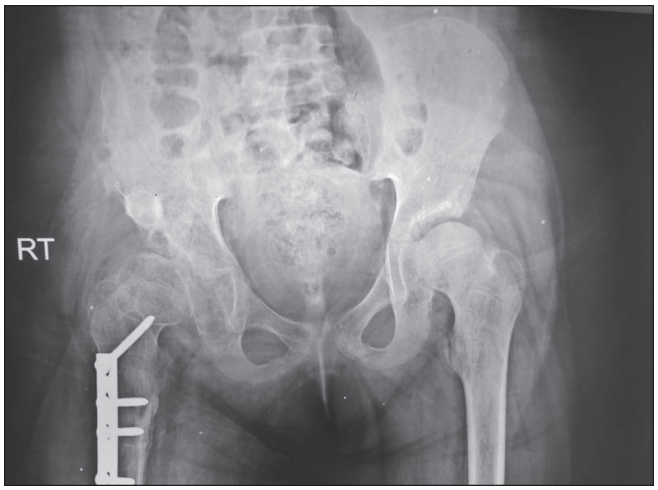
Shape 1

Shape 1



Number and gender of cases

Figure 1



Preoperative radiography shows residual hip dysplasia at right side.

Figure 2

Intraoperative c-arm photo shows the shelf osteotomy.

Figure 3

Postoperative radiography of the shelf osteotomy.

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 derotation osteotomy at age of 8 years for right side untreated DDH.

She had poor score according to modified sundt criteria preoperatively. The preoperative AI of the right hip was 38° while CEA was 17°. She was treated by shelf acetabuloplasty and the final follow-up at 1 year postoperative was good score according to the modified Sundt criteria. The 1 year postoperative AI of the right hip was 30° while CEA was 33.5° (Figs. 1–5).

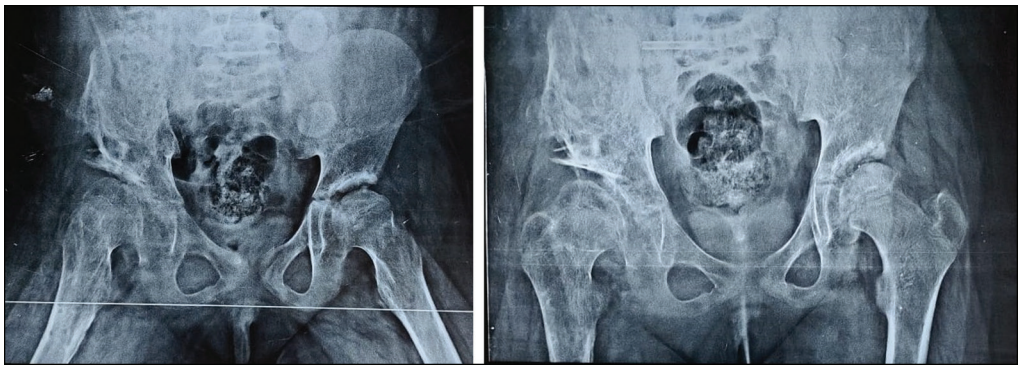
Discussion

The reorientation osteotomies in cases of nonspherical femoral head, would result in an incongruent joint which may aggravate symptoms and accelerate the process of arthritis [12]. Consequently, shelf acetabuloplasty is considered more appropriate solution for such cases. Acetabular augmentation procedures are based on the hypothesis that uneven distribution of the weight on the joint surface is the main cause of OA [13], the weight can be better distributed through increasing femoral head coverage and the occurrence of OA can be delayed. Bouyer *et al.* [14], found a strong association between OA and dysplasia of the hip supporting the hypothesis, Lievense *et al.* [15], found similar associations just among young patients. Therefore, management of the dysplasia of the hip among young patients gains importance.

The main goal of the shelf procedure is to increase stability of the femoral head by widening the surface area exposed to weight-bearing and decreasing the 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 fibrocartilagenous metaplasia with some hyaline-like cartilage near the joint surface [16,17].

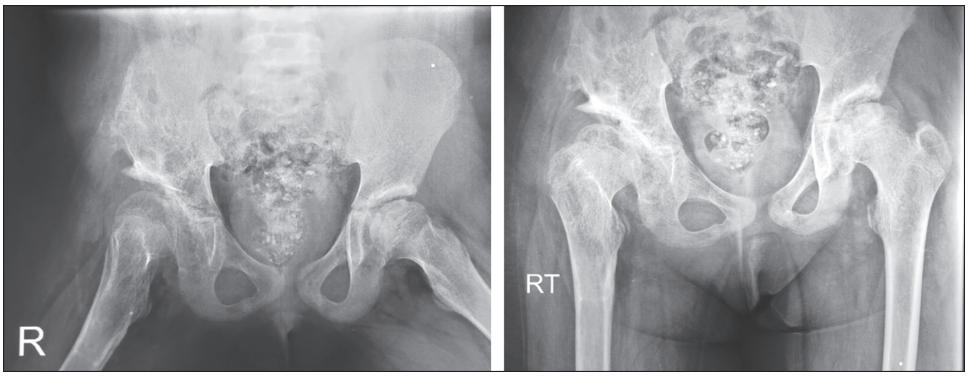
The biomechanics of the shelf acetabuloplasty does not depend on reorientation of the acetabulum, also it does not change the hip joint center regardless of femoral head subluxation. Yet, there is no risk of unexpected deterioration; unlike reorientation and curved peri-

Figure 4



Follow up radiographies 6 months postoperatively show healing of right-sided shelf osteotomy.

Figure 5



Follow-up radiography 9 months postoperatively show healed right-sided shelf osteotomy.

acetabular osteotomies which may accelerate the expected natural sequence of OA progression and increase the incidence of iatrogenic complications as chondrolysis and avascular necrosis [18].

In order to facilitate fibrocartilagenous metaplasia of the underlying capsule, the shelf graft orientation need to be in the same continuity of the curve of the acetabulum. This was supported by Aota and Hakozaki who reported that the height of the acetabular slot for bone grafting is very influenced by the morphology of the acetabular edge and the thickness of the joint capsule. The fear from violation of the joint during osteotomy might be a main cause of high seated shelf [19].

Shingling of the outer table of the ilium above the graft, compression of cancellous bone graft against the shelf graft by suturing the reflected head of rectus femoris or covering it by bone wax that maintain cancellous graft in position. Both help the biomechanical properties of the cancellous grafting and enhance shelf graft union.

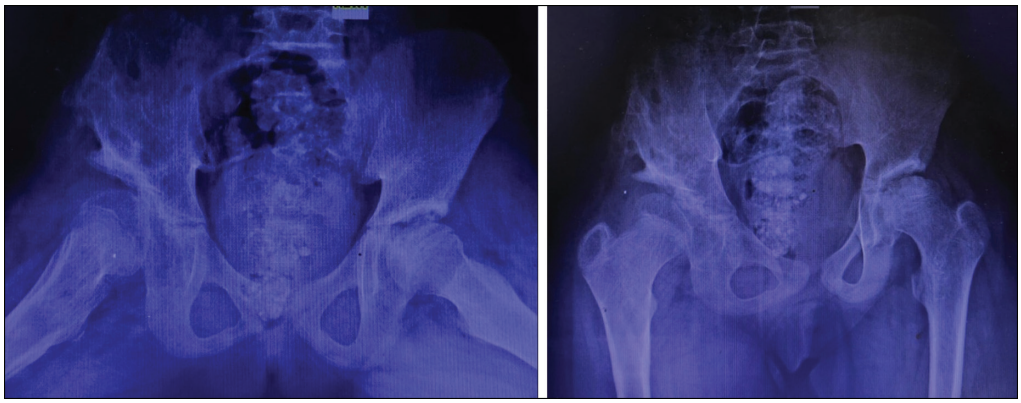
It is important also to increase coverage of femoral head by the shelf graft beyond normal values as always and after strict precautions to minimize resorption of the graft, the results of the current study show changes in radiological measurements between 6 and 12 months follow-up (P<0.05) which means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

The results of this study showed good improvement in both clinical and radiological outcome of the included children. The physical performance regarding ROM and hip pain were better than preoperative values also, the AI and CEA values shows good coverage of the femoral head minimizing residual dysplasia to the least values at the end of follow-up (P<0.5).

The results of the shelf procedure is remarkably high when less patients with severe OA are included, Hirose *et al.* [20] and Tanaka *et al.* [21] reported good short-term and long-term results. the total hip arthroplasty-free survival percentage were ~72% at 35 years of follow-up. Similar results were reported by Holm *et al.* [17] who reported a total hip arthroplasty-free survival percentage of 100% at 20 years, 83% at 30 years, and up to 22% at 50 years in children and adolescents.

Clohisy and colleagues reported a survival analysis of the shelf acetabuloplasty for residual dysplasia

Figure 6



Follow-up radiography 12 months postoperatively show healed right-sided shelf osteotomy.

at 20 years follow-up using joint replacement as an 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 [22].

Terjesen [6] reported a survival of 100% at 20 years, 72% at 30 years, and 32% at 40 years of follow-up for the age group above 12 years (average age 16.1 years). The statistics of Schramm *et al.*, Hasegawa *et al.*, and Lerch *et al.* showed the shelf survival values are equal or are even better than PAO survival in the long term [23–25].

In conclusion, the shelf procedure is a relatively simple and safe surgery that could successfully correct residual hip dysplasia without disruption of the pelvic ring structure, consequently, it is a good option for young children above 8 years of age with residual hip dysplasia or subluxation with nonspherical head or noncongruent acetabulum whenever reorientation osteotomies is not suitable, achieving good stability, ROM and function at 1 year follow-up [22–26].

The limitation of this study is the small number of cases and the need for longer time of follow up for better evaluation and comparison of results.

Acknowledgements
There is no funding source.

Informed consent was obtained from all individual participants included in the study.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1 Ito H, Tanino H, Yamanaka Y, Minami A, Matsuno T. Intermediate to long-term results of periacetabular osteotomy in patients younger and older than forty years of age. J Bone Joint Surg Am 2011; 93:1347–1354.

2 Wen Z, Wu YY, Kuang GY, Wen J, Lu M. Effects of different pelvic osteotomies on acetabular morphology in developmental dysplasia of hip in children. World J Orthop 2023; 14:186–196.

3 König F. Osteoplastische behandlung der kongenitalen hueftgelensluxation (mit demonstration eines pareparates). Verh Dtsch Ges Chir 1891; 20:75–80. quoted from: Bashti K, Navab I, Result of shelf acetabuloplasty in adults: 20 years of follow-up. Acta Med Iran. 2011;49(8):536–542.

4 Gill B. Operation for old congenital dislocation of the hip. Surg Clin North Am 1926; 6:147–153. quoted from: Bashti K, Navab I, Result of shelf acetabuloplasty in adults: 20 years of follow-up. *Acta Med Iran*. 2011;49(8):536–542.

5 Wiberg G. Shelf operation in congenital dysplasia of the acetabulum and in subluxation and dislocation of the hip. J Bone Joint Surg [Am] 1953; 35-A:65–80. quoted from: Bashti K, Navab I. Result of shelf acetabuloplasty in adults: 20 years of follow-up. *Acta Med Iran*. 2011;49(8):536–542.

6 Terjesen T. Residual hip dysplasia: is there a place for hip shelf operation?. J Child Orthop 2018; 12:358–363.

7 Otani T, Kawaguchi Y, Fujii H, Hayama T, Marumo K. Indications for Shelf Acetabuloplasty and Rotational Acetabular Osteotomy for Developmental Dysplasia of the Hip. In: Hirose S (eds). Revival of Shelf Acetabuloplasty. Singapore: Springer; 2018.

8 Willemsen K, Doelman CJ, Sam ASY, Seevinck PR, Sakkers RJB, Weinans H, van Der Wal BCH. Long-term outcomes of the hip shelf arthroplasty in adolescents and adults with residual hip dysplasia: a systematic review. Acta Orthop 2020; 91:383–389.

9 Berton C, Bocquet D, Krantz N, Cotten A, Migaud H, Girard J. Shelf arthroplasties long-term outcome: influence of labral tears. A prospective study at a minimal 16 years' follow-up. Orthop Traumatol Surg Res 2010; 96:753–759.

10 Holm AGV, Reikerås O, Terjesen T. Painless period after Spitzy shelf operation for residual hip dysplasia-A long-term study of 47 children and young adults. J Orthop 2018; 15:196–200.

11 Sundt H. Malum coxae Calve-Legg-Perthes with special regard to the prognosis and treatment. Acta Chirur Scand Suppl 1949; 148:1–101. quoted from: Elbarbary HM, Abdel-Ghani H, Ali MY and Okasha KI, Spitzy shelf acetabuloplasty for perthes disease. *Eur J Mol Clin Med* 2020; 7:2515–8260.

12 Migaud H, Chantelot C, Giraud F, Fontaine C, Duquennoy A. Long-term survivorship of hip shelf arthroplasty and Chiari osteotomy in adults. Clin Orthop Relat Res 2004; 418:81–86.

13 Shapira J, Chen JW, Bheem R, Lall AC, Rosinsky PJ, Maldonado DR, Domb BG. Radiographic factors associated with hip osteoarthritis: a systematic review. J Hip Preserv Surg 2020; 7:4–13.

14 Bouyer B, Mazieres B, Guillemin F, Bouttier R, Fautrel B, Morvan J. Association between hip morphology and prevalence, clinical severity and progression of hip osteoarthritis over 3 years: the knee and hip osteoarthritis long-term assessment cohort results. Joint Bone Spine 2016; 83:432–438.

15 Lievense AM, Bierma-Zeinstra SM, Verhagen AP, Verhaar JA, Koes BW. Influence of hip dysplasia on the development of osteoarthritis of the hip. Ann Rheum Dis 2004; 63:621–626.

16 Rajakulendran K, Strambi F, Buly J, Field RE. A shelf procedure at a follow-up of 75 years. J Bone Joint Surg Br 2011; 93-B:108–110.

17 Holm AG, Reikerås O, Terjesen T. Long-term results of a modified Spitzy shelf operation for residual hip dysplasia and subluxation. A fifty-year follow-up study of fifty-six children and young adults. Int Orthop 2017; 41:415–421.

18 Fu M, Xiang S, Zhang Z, Huang G, Liu J, Duan X, *et al*. The biomechanical differences of rotational acetabular osteotomy, Chiari osteotomy and shelf procedure in developmental dysplasia of hip. BMC Musculoskelet Disord 2014; 15:47.

19 Aota S, Hakozaki M. Shelf acetabuloplasty in comparison with curved periacetabular osteotomy: an opinion based on the perspective of experienced surgeons with limited experience with shelf acetabuloplasty. In: Hirose S (eds) Revival of Shelf Acetabuloplasty. Singapore: Springer; 2018.

20 Hirose S, Otsuka H, Morishima T, *et al*. Long-term outcomes of shelf acetabuloplasty for developmental dysplasia of the hip in adults: a minimum 20-year follow-up study. J Orthop Sci 2011; 16:698–703.

21 Tanaka H, Chiba D, Mori Y, Kuwahara Y, Baba K, Yamada N, *et al*. Long-term results of a modified Spitzy shelf operation for developmental dysplasia of the hip in adults and adolescents. Eur J Orthop Surg Traumatol 2018; 28:1341–1347.

22 Clohisy JC, Schutz AL, John LS, Schoenecker PL, Wright RW. Periacetabular osteotomy: a systematic literature review. Clin Orthop Relat Res 2009; 467:2041–2052.

23 Schramm M, Hohmann D, Radespiel-Troger M, Pitto RP. Treatment of the dysplastic acetabulum with Wagner spherical osteotomy: a study of patients followed for a minimum of twenty years. J Bone Joint Surg 2003; 85:808–814.

24 Hasegawa Y, Iwase T, Kitamura S, Kawasaki M, Yamaguchi J. Eccentric rotational acetabular osteotomy for acetabular dysplasia and osteoarthritis: follow-up at a mean duration of twenty years. J Bone Joint Surg 2014; 96:1975–1982.

25 Lerch TD, Steppacher SD, Liechti EF, Tannast M, Siebenrock KA. One-third of hips after periacetabular osteotomy survive 30 years with good clinical results, no progression of arthritis, or conversion to THA. Clin Orthop Relat Res 2017; 475:1154–1168.

26 Selberg CM, Chidsey B, Skelton A, Mayer S. Pelvic osteotomies in the child and young adult hip: indications and surgical technique. J Am Acad Orthop Surg 2020; 28:e230–e237.