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ORIGINAL ARTICLE

Reshaping Pelvic Osteotomies In Management Of Developmental Dysplasia Of The Hip in Younger Children Aged Between 11 to 35 Months: Short-Term Comparative Study

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ABSTRACT

Keyword: pelvic osteotomy, Developmental dysplasia of the hip, high trans-iliac incomplete bi-cortical osteotomy, HTIBO

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Background: Pelvic osteotomies are often necessary during the surgical treatment of Developmental dysplasia of the hip (DDH). This study aims to analyze the short-term outcomes of Dega pelvic osteotomy (DPO) and high trans-iliac incomplete bi-cortical osteotomy (HTIBO) in managing DDH. **Patients and Methods**; This prospective study included 41 patients (51 hips) aged 11 to 35 months with DDH (Tönnis grade III and IV). The patients were divided into two groups: Group A (26 hips), managed with DPO, and Group B (25 hips) with HTIBO. The patients were assessed clinically and radiologically according to Severin classifications. **Results**: With a minimum follow-up of 8 months, both groups significantly improved the acetabular index (AI) ($p < 0.001$). Postoperative AI was significantly better in Group B ($p < 0.001$). The clinical evaluation and complication rates were insignificant between the groups. There were no reported cases of bone-crushing or graft slippage in the HTIBO group; in contrast, there were two cases under 18 months old within the DPO group. **Conclusion**: HTIBO is a safe and effective alternative to DPO in the treatment of DDH and achieves better results in children under 18 months old.

INTRODUCTION

Developmental dysplasia of the hip (DDH) is a spectrum of pathological changes affecting the developing hip joint, ranging from mild to severe forms frequently associated with newborn hip instability (1). As the most prevalent hip disorder in pediatric populations, DDH affects approximately 1 in 1,000 children (0.1%) at birth, with a notable predominance in females, who account for 80% of cases. Furthermore, the left hip is more frequently involved, occurring in 60% of affected individuals (2).

The fundamental goal of the treatment of DDH is to attain stable and concentric reduced hip joints to facilitate normal joint growth. Surgical intervention is typically indicated for two groups of children: those who do not respond to initial splinting and those diagnosed later who are unsuitable for non-surgical treatment. The likelihood of requiring extensive surgical procedures increases with the child's age (3). Such procedures may include open reduction with soft tissue stabilization followed by casting. In children over 18 months, pelvic and /or femoral osteotomies may be added to restore a typical anatomical hip joint configuration (4).

Controversies persist regarding the optimal management strategies for DDH, particularly concerning the types of pelvic osteotomies employed. The choice among various osteotomy techniques is often not definitive Commonly utilized pelvic osteotomies include Salter, Pemberton, San Diego, and Dega pelvic osteotomy (DPO) (5–8) and, recently, High Trans-iliac Incomplete Bi-cortical Osteotomy (HTIBO) (9). The primary goals of pelvic osteotomy are to enhance coverage of the femoral head and achieve reduction stability of the hip joint (10,11).

The selection of an appropriate pelvic osteotomy is generally influenced by the patient's age (5,11), the degree of correction required (11–13), and the surgeon's preference (11,14,15). Pelvic osteotomy is typically performed after 18 months (6,8,11) to avoid crushing soft, thin bones in younger ages (16,19). However, some authors advocate for earlier intervention before one year of age, specifically at six months (16), twelve months (17), and fourteen months (18,19). The timing of pelvic osteotomy in this younger demographic remains a topic of considerable debate (16).

HTIBO is a novel reshaping pelvic osteotomy described by H. Amin et al. that increases head coverage and improves the acetabular index in treating DDH. The osteotomy line starts at the iliac crest proximal to the anterior superior iliac spine (ASIS) in a straight line. It ends just above the triradiate cartilage's posterior limb, leaving the posterior column intact and acting as a reshaping pelvic osteotomy (9).

Meanwhile, the results of HTIBO still need more multicentric studies and longer-term results to evaluate the magnitude of acetabular coverage, complications, AVN rate, and age limits. Furthermore, we hypothesize that HTIBO may entitle the surgeon to perform it in a younger age group (below 18 months), as the sizeable distal osteotomized bone fragment supports manipulating the soft iliac bone in this age group.

The current study aims to analyze the short-term clinical and functional results of HTIBO compared to DPO in managing DDH in pediatric patients, especially those under 18 months of age. We hypothesize that HTIBO will demonstrate preliminary superior acetabular index improvement and a lower complication rate than DPO in different age groups.

PATIENTS AND METHODS

This prospective cohort multicenter study included 41 patients with 51 involved hips with DDH between March 2022 and August 2024 at Aswan university hospital (Aswan University) and Abo El-Resh Hospital of Children (Cairo University). The sample size was calculated based on the effect size of previous studies.

The current study included children between 11 and 35 months old with unilateral/bilateral DDH Tonnis classification grades III and IV (20). We excluded cases of previous hip septic arthritis, arthrogryposis, ligamentous hyperlaxity, neuromuscular disorders, femoral shortening osteotomy, or revision surgery.

The patients were divided into two groups based on surgeon preference and awareness of the new HTIBO osteotomy: Group A, composed of 20 patients (26 hips) with DDH treated by DPO, and Group B, composed of 21 patients (25 hips) with DDH treated by HTIBO.

Surgical technique

All hips (both groups) received operative treatment in the form of Open reduction, capsulorrhaphy, and pelvic osteotomy; DPO in group A and HTIBO in group B, followed by immobilization in a hip spica cast for 10 weeks.

All surgeries were performed in the supine position on a radiolucent table while under general anesthesia. Placing a roll under the ilium lifted the affected side somewhat. The whole lower extremity and pelvis were prepped and draped. The initial step was to perform an adductor tenotomy. Then, the bikini-incision of the hip anterior approach was performed, advancing between the sartorius and tensor fascia lata muscles.

(2).

The lateral femoral cutaneous nerve has been found and preserved. The iliac apophysis was separated with subperiosteal dissection on both sides of the iliac bone, followed by intra-muscular tenotomy of the iliopsoas tendon and release of the direct head of rectus femoris muscle. The superior and anterior regions of the hip capsule were accessed by lifting the hip abductors muscles and iliocapsularis. The capsulotomy was done in a line parallel to the iliac and superior pubic bone. The intracapsular reduction obstacles are removed (the ligamentum teres, the transverse acetabular ligament, the tight inferior capsule, and the pulvinar fatty tissue).

Direct vision determined the best hip position for reducing the head and achieving concentric reduction. Sutures were placed initially before attempting pelvic osteotomy. After removing the unnecessary superolateral portion of the capsule, the lateral flap was sutured to the periosteum of the superior pubic ramus and inferior iliac spine using PDS sutures to move the capsule inferomedially just after performing the pelvic osteotomy and before inserting interposition bone graft inside the osteotomy gap.

DPO in group A

The planned osteotomy direction was marked on the outer iliac table just proximal to the AIIS and directed posterior-medial reaching 1.5 cm away from the greater sciatic notch. The osteotomy's uppermost point corresponded to the acetabular roof's center. Then, a k wire was inserted and guided by fluoroscopic control from the lateral starting point of the osteotomy in the outer iliac cortex and with oblique direction toward the inner cortex medially and exits above the horizontal limb of the triradiate cartilage. The osteotome was inserted medially and inferiorly in the same direction as this k wire. The inner cortex was osteotomized from the anterior and middle sides, keeping intact the posterior part (1-2cm) as a hinge while distal leverage by the osteotome to open the osteotomy. One or two flakes of a bicortical iliac graft kept the osteotomy site open. (Fig.1).

A B

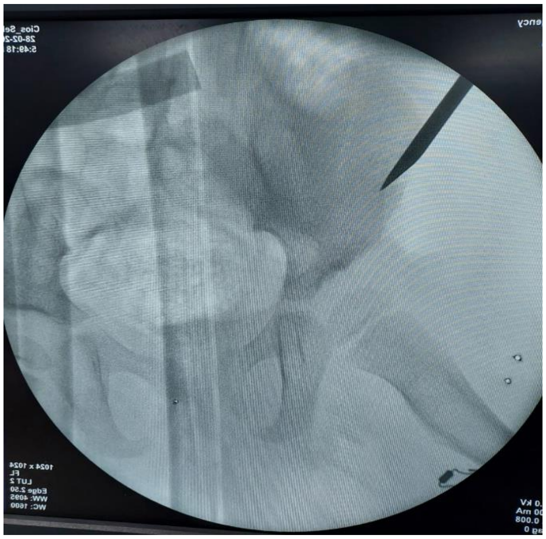
Fig 1: the intra-operative trajectory of the k wire insertion as a guide for DPO (A) surgical field photo, (B) fluoroscopy image of the osteotomy line.

HTIBO in group B

HTIBO technique was described by H. Amin et al., where the osteotomy started at a point over the iliac crest, 1 to 2 cm behind to the ASIS. With A straight osteotome, under direct vision, the osteotomy started at that point and was directed caudally and medially, cutting the outer and inner table of the iliac bone. The osteotomy stopped at a point located posteriorly just proximal to the horizontal limb of the triradiate cartilage and lateral to the greater sciatic notch, leaving 1 cm of the posterior column intact. The osteotome was used to spread out the osteotomy site (Fig 2). This osteotomy was done under fluoroscopic control (Fig 3). Then, after confirmation of the AI correction and optimal femoral head coverage inside the acetabulum, we inserted the harvested iliac bone graft into the osteotomy held by the osteotomy site's recoil. (9). (fig 2)

a **b** **c**

Fig 2: intra-operative image demonstrating HTIBO A: osteotomy line using a straight osteotomy under direct vision away from the greater sciatic notch and towards a point just proximal to the posterior limb of the triradiate cartilage. B: opening the osteotomy. C: impaction of the bone graft into the osteotomy.



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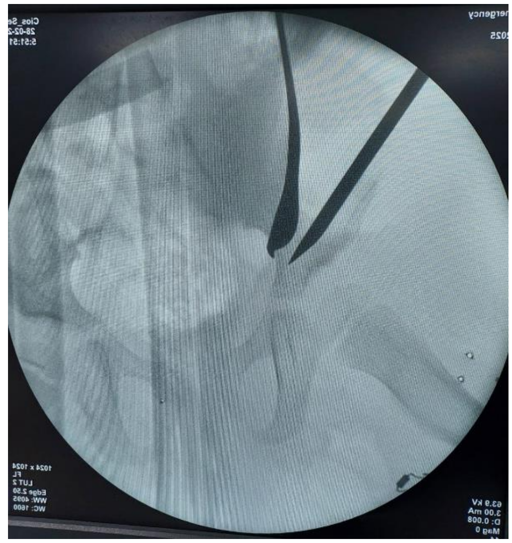

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Fig 3: intra-operative fluoroscopic image demonstrating HTIBO a): starting point of the HTIBO posterior to ASIIS using a straight osteotome, b) the direction of the osteotomy toward the posterior limb of and away from the greater sciatic notch.

The wound was closed in layers, starting with the split iliac apophysis, which was sutured anatomically (Fig 4). Postoperatively, the patients were immobilized in a hip spica cast for 8-10 weeks, with the hip in 30^0 flexion, 10^0 internal rotation, and 40° abduction.

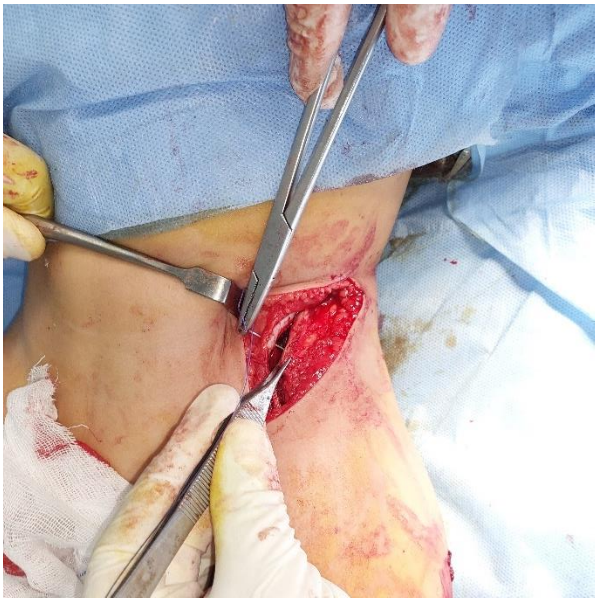


Fig 4: anatomical closure of the split iliac apophysis.

The follow-up protocol: The pelvis and both hips were x-rayed on the first day and after one month postoperatively and then every 3 months postoperatively to assess hip reduction, AI, Shenton line continuity, and AVN according to the Kalamaci classification (20). Clinical and radiological assessments were performed according to the modified Severin and radiological Severin classifications, respectively (21, 22). Other clinical recorded data: Hip range of motion (ROM), leg length discrepancy (LLD), hip pain and limping

Ethical consideration

The Ethical Committee of the Faculty of Medicine at Aswan University (No: aswu /661/9/22) performed in line with the principles of the Declaration of Helsinki.

Each participating patient's parents or guardians provided written informed permission, which included a thorough description of the operation procedure and potential problems. All patients' parents or guardians had the right to refuse participation in the study without impacting the service or clinical care. They were also permitted to ask questions about the study.

Statistical Analysis

The data was loaded into the computer and analyzed with SPSS version 21. Numbers and percentages were used to present qualitative data, whereas means, standard deviations, medians, and interquartile ranges were used for quantitative data. Significance tests were performed (chi-square for qualitative, student t-test, and Mann Whitney for quantitative parametric and non-parametric, respectively), with a significance threshold of p equal to or less than 0.05.

RESULTS

The study included 41 patients (51 hips) with DDH aged between 11 and 35 months. We divided the patients into two groups: Group A, composed of 20 patients (26 hips) treated by DPO, and Group B, composed of 21 patients (25 hips) treated by HTIBO.

In group A, the mean follow-up was 17.4 ± 4.98 months, ranging from (8 to 24) months, and in group B. The mean follow-up was 19.5 ± 5.07 months, ranging from (12 to 30) months. In group A, the age ranged from 11 months to 35 months (mean ± SD = 19.75 ± 7.69). Five children of dislocated hips were males, while 15 were females. Six patients with bilateral DDH and 14 unilateral. The left side was affected in 10 patients and the right side in 4 patients. As regards to the Tönnis classification, four hips were grade III, while 22 were grade IV. The mean ± SD pre-operative acetabular index (AI) was 40.96 ± 6.98 ranging from 26 to 52 degrees.

In group B, the age ranged from 12 months to 34 months (mean ± SD = 22.1 ± 6.74). Six children of dislocated hips were males, while 15 were females. Four patients had bilateral DDH, and 17 patients had unilateral hip involvement. Twelve patients had the left side affected, and five had the right side affected. As regards to the Tönnis classification, six hips were grade III, while 19 were grade IV. The mean ± SD pre-operative AI was 38.6 ± 3.26, ranging from 32 to 45 degrees.

Follow-up, pre-operative classification, and demographic data (age, gender, and side) did not show a statistically significant difference between the HTIBO and DPO groups.

. (Table 1)

Table 1: Demographic data distribution and Tonnis classification between the two groups.

	Group A (patients=20) (hips=26)	Group B (patients =21) (hips=25)	P value
Age (months)			
Mean ± SD	19.75 ± 7.73	21.76 ± 6.72	0.379
Median (min-max)	18 (11-35)	20 (12-34)	
less than 18 months	9 (45%)	6 (28.6%)	0.274
18 months and more	11 (55%)	15 (71.4%)	
Gender			
Male	5 (25%)	6 (28.6%)	0.795
Female	15 (75%)	15 (71.4%)	
Side			
Right	4 (20%)	6 (28.6%)	0.662
Left	10 (50%)	11 (52.4%)	
Bilateral	6 (30%)	4 (19%)	
Follow up (months)			
Mean ± SD	17.4±4.98	19.5±5.07	0.142

Median (min-max)	18 (8-24)	20 (12-30)	
Tonnis grade			
III	4 (15.4%)	6 (24%)	0.438
IV	22 (84.6%)	19 (76%)	

P value >0.05: non-significant, P value <0.05; statistically significant, p<0.001; highly significant., SD: standard deviation.

According to the modified Severin classification, in group A (n=26 hips), there were 21 hips grade 1 (Excellent), three hips grade 2 (good), and two hips grade 3 (fair). In contrast, in group B (n=25 hips), there were 22 hips grade 1 (Excellent), two hips grade 2 (good), and one hip grade 3 (fair), with no statistically significant difference.

According to radiological Severin's classification, there was no statistically significant difference between the two groups. In group A, 22 hips were grade I (normal), two hips were grade II (mild dysplasia), one hip was Grade III (moderate dysplasia), and one hip was grade IV (subluxation) (n=26 hips). In contrast, in group B, 22 hips were grade I (normal), one hip was grade II (mild dysplasia), and two hips were grade III (moderate dysplasia) (n=25 hips). In group A, the Shenton line was intact in 23 hips and broken in three hips; in contrast, in group B, it was intact in 23 hips and broken in two hips, with no statistically significant difference. (Table 2)

Table 2: clinical and radiological Results between the studied groups

	Group A (patients=20) (hips=26)	Group B (patients =21) (hips=25)	P value
Clinical Severin classification			
I	21(80.8%)	22(88%)	0.76
II	3(11.5%)	2(8%)	
III	2(7.7%)	1(4%)	
Radiological modified Severin's classification			
I	22(84.6%)	22(88%)	0.63
II	2(7.7%)	1(4%)	
III	1(3.8%)	2(8%)	
IV	1(3.8%)	0	
Shenton line alignment			
Intact	23(88.5%)	23(92%)	0.67
Broken	3(11.5%)	2(8%)	

P value >0.05: non-significant, P value <0.05; statistically significant, p<0.001; highly significant., SD: standard deviation.

Regarding preoperative AI, it was insignificant statistically between groups A and B. The improvement was significant in the AI at the final follow-up in group B with AI regression with a P value < 0.001m compared to preoperative AI. Regarding post

Statistically, there was no significant difference between groups A and B regarding Postoperative AI after 6 months and the last follow, with significant improvement in group B rather than group A, especially in children under 18 months. (table 3)

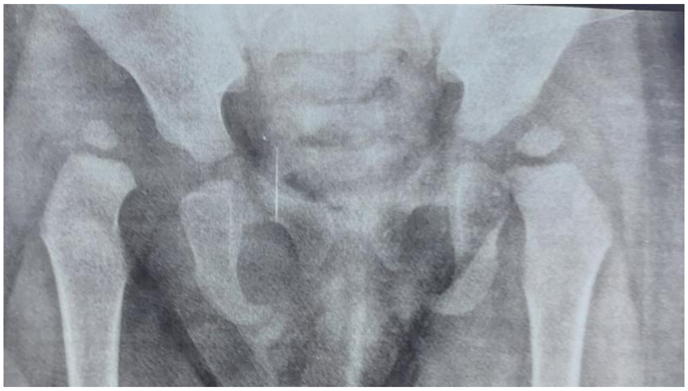
Table 3: Comparison of the acetabular index (AI) between the studied groups

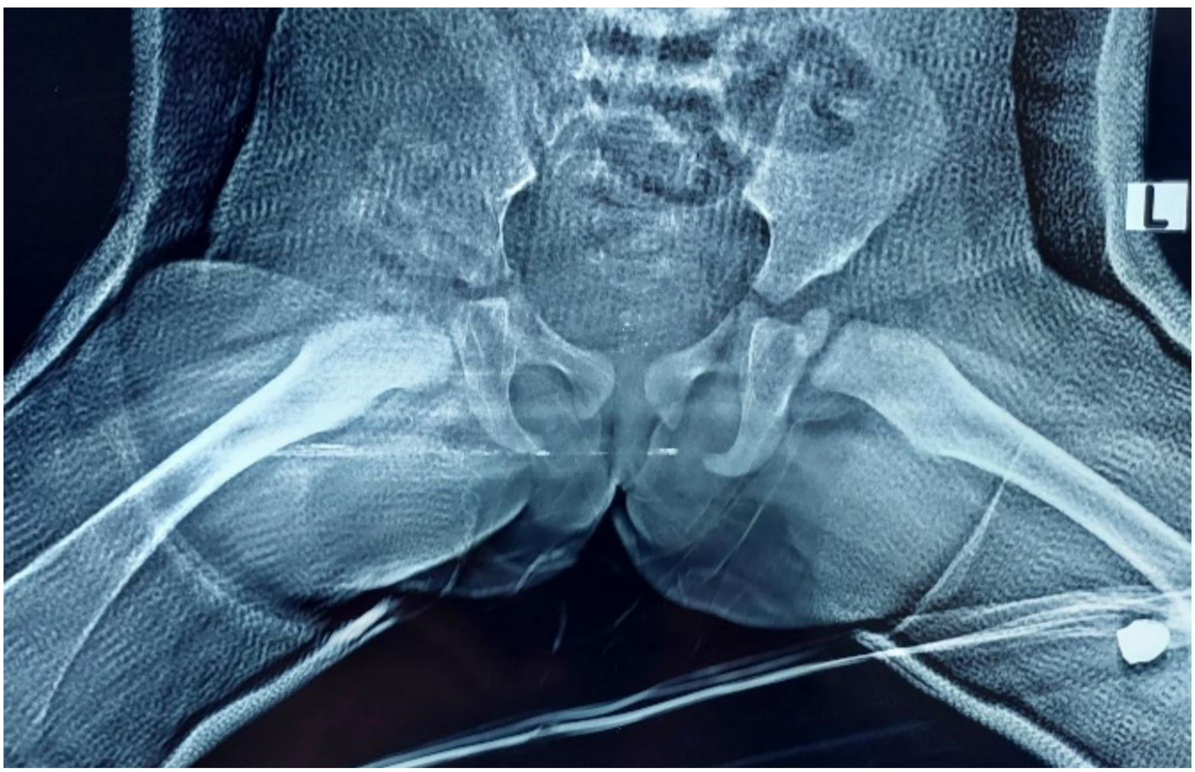
	Group A (patients=20) (hips=26)	Group B (patients =21) (hips=25)	P value
Acetabular index			
Preoperative			
Mean ± SD	40.96±6.98	38.64±3.26	0.13
Median (min-max)	41(26-52)	40(32-45)	
Postoperative			
Mean ± SD	26.37±6.9	20.54±3.42	<0.001
Median (min-max)	26.5(7-44)	20(12-32)	
After 6 M			
Mean ± SD	22.7±6.5	16.5±3.59	0.001
Median (min-max)	23(5.5-38)	17(8-28)	
Last FU			
Mean ± SD	18.96±5.37	12.26±3.6	<0.001
Median (min-max)	19.5(5-30)	12(2-25)	

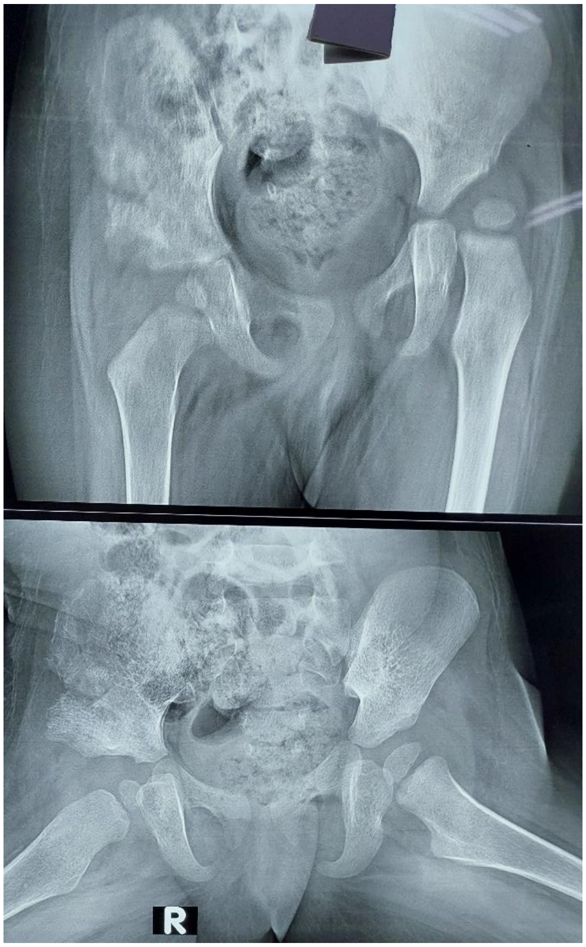
In group A, the complication rate was 26.9 % (7 hips); one hip had an intraoperative anterior inferior iliac spine (AIIS) fracture. Two hips had AVN; one was grade II Kalamaci, and the other was grade IV Kalamaci. One hip had overcorrection; the AI was 5^o; this case suffered from varus proximal femur, causing abduction and flexion limitation with limping. There was also one hip with post-operative subluxation and limping; additionally, this case suffered from a fracture of the distal femur that healed during the cast period. Two cases (2 hips) suffered from osteotomy site complications: one hip with intra-operative crushing of the distal osteotomy fragment and the other hip early postoperative graft slippage, and these two cases were under 18 months old.

In group B, the complication rate was 16 % (4 hips); one hip had a postoperative infection associated with AVN (grade III Kalamaci), which was presented by 1 cm LLD and limping. One hip had AVN (grade I Kalamaci) with adduction contracture and limping. One hip had overcorrection; the AI was 6^o. One case suffered from a distal femoral fracture immediately after hip spica cast removal that healed within 4 weeks using a posterior slab. Group B had no reports of distal osteotomy fragment crushing or graft slippage among children younger than 18 months.

Statistically, there was no significant difference between groups A and B regarding post-operative complications. Figures 5 and 6 show two illustrative DDH cases managed by HTIBO and DPO, respectively.

a  b 

c 



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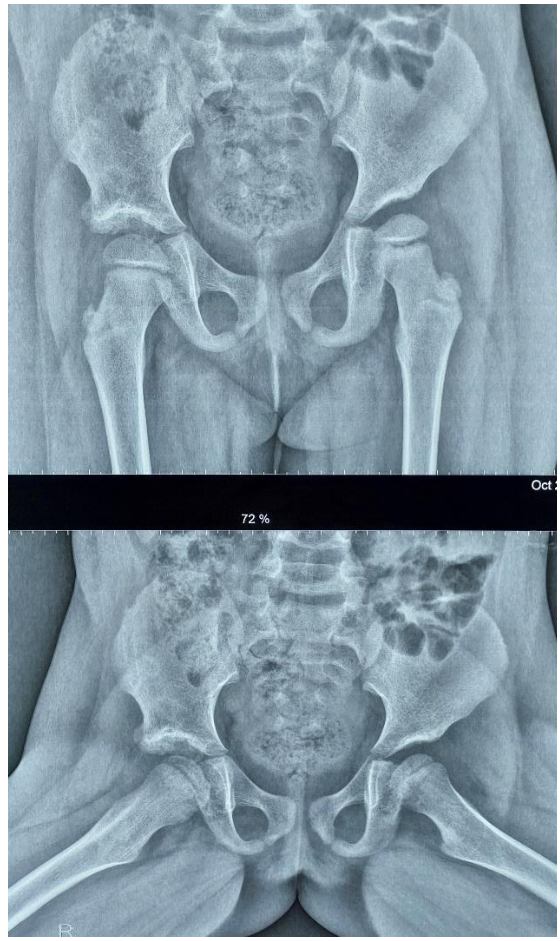

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Figure 5: an 18-month-old female child with right DDH treated by HTIBO, a and b) pre-operative x-ray. c) early post-operative follow-up x-ray of hip spica shows the HTIBO osteotomy. d) 3 months post-operative follow-up x-ray showing the healed site of HTIBO. e) a 24-month follow-up anteroposterior and lateral x-rays of the pelvis and both hip joints show reduced hip joints and improved AI with intact Shenton lines bilaterally.

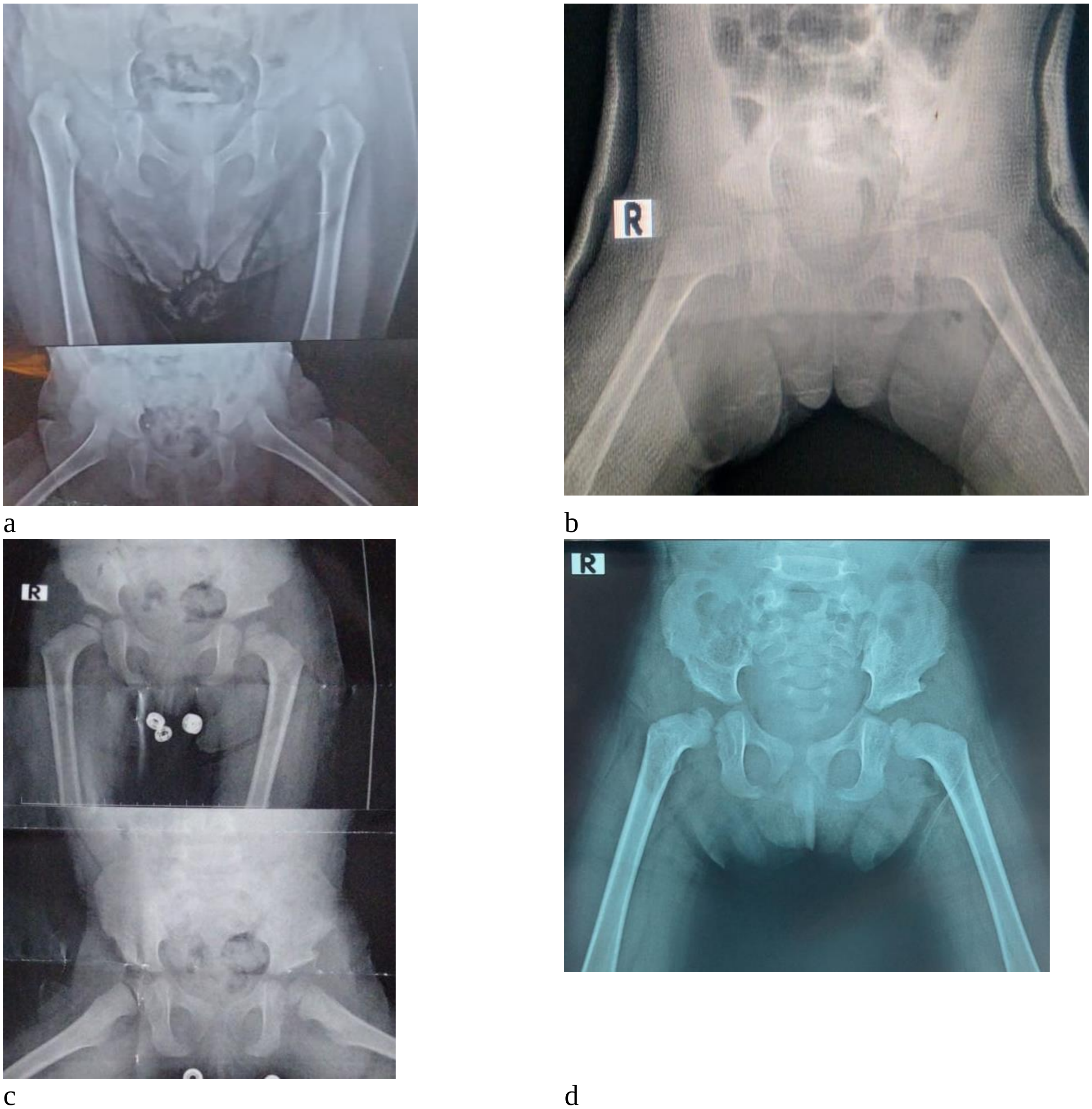

Figure 6: a 16-month-old child with bilateral DDH treated by DPO, a) preoperative x-ray. b) early postoperative x-ray shows the DPO osteotomy. c) A 6-month post-operative x-ray showed reduced hips and improvement of the AI with intact Shenton lines bilaterally. d) final follow-up anteroposterior x-ray of the pelvis and both hip joints showing almost normal hip joints at 12 Months post-operative.

DISCUSSION

The most effective strategy of treatment for DDH across various age groups is still debatable. Techniques for reduction are used with or without femoral osteotomy. Hip stiffness, flexion deformity, subluxation, re-dislocation, persistent hip dysplasia, and AVN were among the high prevalence of sequelae. These side effects happen irrespective of the method of treatment (23).

In the management of DDH, it was recommended to postpone pelvic osteotomy until the age of 18 months to avoid crushing soft, thin bones in younger children (16, 19). In contrast, open reduction and capsulorrhaphy without pelvic osteotomy carry a higher risk of re-operation (6,8,11,16). Recently, HTIBO was published as a new pelvic osteotomy for surgical management of the DDH. It achieves optimal correction of the AI with less image intensifier exposure and less operative time without the need for internal fixation (9).

This prospective comparative cohort study involved 41 DDH patients between the ages of 11 and 35 months. It was divided into two groups: Group A, composed of 20 (26 hips) patients treated by DPO, and Group B, composed of 21(25 hips) patients treated by HTIBO. We found no significant relation between modified Severin classification and the patient's age, although we found a statistically significant relation between modified Severin classification and radiological Severin. According to preoperative AI, the two groups had no statistically significant difference, while the postoperative AI after 6 months and the last follow-up AI had a statistically significant difference. We noticed an improvement in mean AI at the immediate postoperative stage, 6 months, and the last follow-up in group B compared to group A, which was statistically significant, especially in children under 18 months, where these younger patients were 9 (45%) in group A and 6 (28.6%) in group B.

Ruszkowski et al. reported the results of surgical management of DDH in 26 patients (33 hips) whose mean age was 15 months at the surgery (range 6 months to 24 months). All patients were operated on by open reduction, Dega osteotomy, and capsulorrhaphy. The mean follow-up time was 9.4 (5- 14.5) years. They reported his clinical results as 23 patients (89%) were satisfactory, and three patients (11%) were unsatisfactory regarding modified Severin's grading. The radiological results were satisfactory in 26 hips (79%) (14 hips excellent, 12 good) and unsatisfactory in 7 hips (21%) (4 hips fair, three poor) according to Severin's radiographic classification. He reported that one hip developed dislocation after 5 months and one hip (3%) developed AVN after surgery (16).

Al-Ghamdi et al. reported the results of surgical management of DDH in 20 patients (21 hips) whose mean age was 55.6 months at the time of the surgery (range 20 months to 100 months). All patients were operated on by open reduction and Dega osteotomy. The mean follow-up period was 7.3 years. Later, AVN was reported in three cases; two were healed with no residual deformity, whereas the third hip had obvious head deformity with persistent hip subluxation. They did not record perioperative complications. (24).

Refae et al., in their study on 25 hips, had a mean age of 1.77 years and a mean follow-up of 33.3 months. All 25 hips underwent Ming-Hua et al.'s high-cut Dega osteotomy technique

(25). The femoral shortening was performed in 2 hips. The recorded results were that 22 hips (88%) were excellent, two (8%) were good, and one (4%) was fair. They reported a 20 % complication rate (5/20 hips): two hip subluxations, one recurrent dislocation, one developed hip stiffness, and one skin ulcer (26).

HTIBO differs from the high-cut modification of Dega osteotomy described by Ming-Hua et al. in starting point and direction (26). The starting point of HTIBO is posterior to ASIS with a straight direction towards tri-radiate cartilage (9). In contrast, the Ming-Hua osteotomy is between ASIS and AIIS towards the greater sciatic notch (26). H. Amin et al. presented a retrospective multicenter comparison analysis between March 2019 and 2021, 72 patients (81 hips) with DDH between 18 and 30 months. HTIBO treated 34 patients (38 hips), while DPO was used for 38 patients (43 hips) and 52.91 ± 7.59. However, 53.74 ± 7.57 were the mean follow-up times, respectively. They displayed the following findings: Clinical outcomes were better (P=0.01), post-operative cast time was shorter (P<0.01), and intraoperative x-ray exposure was lower (P<0.01) in the HTIBO group. In the HTIBO and DPO groups, the final acetabular indexes were 15.11 ± 3.84, 37.68 ± 7.5, and 14.56 ± 2.65, 34.47 ± 6.26, respectively. They found that neither group had any instances of hip stiffness, LLD, limping, graft dislodgement, re-dislocation, infection, nonunion, or cosmetic deformity and that the McKay criteria had significantly improved (P = 0.01) (27). They documented three AVN type II Kalamachi cases. They concluded that their HTIBO is safe and reliable, can be performed on young DDH children without needing x-ray guidance, and achieved good clinical and radiological results (9).

This current study recorded seven complications (26.9%) in the DPO group (group A), including an AIIS fracture, AVN, overcorrection, subluxation, osteotomy crushing, and graft slippage. Four complications (16%) were recorded in the HTIBO group (group B): one hip experienced a postoperative infection that complicated later with AVN, one hip experienced AVN with adduction contracture, one case overcorrection, and one case distal femoral fracture after cast removal. There were no reported cases of bone-crushing at the osteotomy site or graft slippage in the HTIBO group; in contrast, this was recorded in two cases under 18 months old within DPO where the number of these younger patients (under 18 months old) was 9 (45%) in the HTIBO group and 6 (28.6%) in the DPO group.

The postoperative complications were statistically insignificant between HTIBO and DPO groups.

The advantages of HTIBO are that it relies on direct visualization when performing osteotomy and significantly decreases the need for fluoroscopic guidance (P < 0.01) by improving the learning curve. HTIBO provides a thicker, distal osteotomy piece with a long lever arm, requiring less power to res the acetabulum and reducing the danger of crushing soft bones. This will support the surgeons in starting early therapy of DDH. (9). Our study reported that HTIBO was as effective as DPO for treating DDH in young children, and both osteotomies rapidly improved the AI in children under 18 months due to excellent bone remodeling, so starting reshaping pelvic osteotomy early in younger children is beneficial in avoiding later acetabular dysplasia, subluxation, and reoperation. At the same time, HTIB was safer for the thin, soft bones of younger children (under 18 months) than DPO. However, we recommend that further studies and longer-term follow-ups be needed to corroborate these findings, especially in the pediatric population under 18 months.

Our study has certain limitations. (a) the selected patients were not randomly selected. (b) the sample size is relatively small. (c) The study only reports short-term results (mean follow-up times of 17.4 and 19.5 months for the two groups); this is an essential limitation since DDH outcomes require being investigated over a longer time to determine the hip's long-term stability and the development of any late complications. (e) We did not apply the McKay criteria to all patients, as these criteria should apply to children above five years old (27), whereas this was unsuitable for most of the younger patients in this investigation due to short follow-up.

CONCLUSION

HTIBO may be a suitable alternative to DPO for the treatment of DDH in younger children with Tönnis grade III and IV dysplasia. It is safer and more effective for patients younger than 18 months old and has a superior postoperative acetabular index to DPO, with a lesser complication rate.

Author contributions

Hesham Refae studied the design and reviewed the manuscript and final drafts.

Mohamed Abdelmoniem Elnkhely studied design, performed the procedures, collected data, and wrote the first and final drafts of the manuscript.

Hisham Abdel-Ghani studied the design and reviewed the manuscript and final drafts.

Ebeed Yasin studied the design, performed the procedures, wrote the first manuscript, and reviewed the final drafts.

Declarations

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REFERENCES

1. Shipman SA, Helfand M, Moyer VA, Yawn BP. Screening for developmental dysplasia of the hip: a systematic literature review for the US Preventive Services Task Force. Pediatrics. 2006 Mar;117(3).
2. Vitale MG, Skaggs DL. Developmental dysplasia of the hip from six months to four years of age. J Am Acad Orthop Surg. 2001;9(6):401–11.
3. El-Sayed MMH, Hegazy M, Abdelatif NM, ElGebeily MA, ElSobky T, Nader S. Dega osteotomy for the management of developmental dysplasia of the hip in children aged 2-8 years: results of 58 consecutive osteotomies after 13-25 years of follow-up. J Child Orthop. 2015 Jun 23;9(3):191–8.
4. Zhang S, Doudoulakis KJ, Khurwal A, Sarraf KM. Developmental dysplasia of the hip. Br J Hosp Med (Lond). 2020 Jul 2;81(7).
5. Cooper AP, Doddabasappa SN, Mulpuri K. Evidence-based management of developmental dysplasia of the hip. Orthop Clin North Am. 2014;45(3):341–54.
6. Gillingham BL, Sanchez AA, Wenger DR. Pelvic osteotomies for the treatment of hip dysplasia in children and young adults. J Am Acad Orthop Surg. 1999;7(5):325–37.
7. Karlen JW, Skaggs DL, Ramachandran M, Kay RM. The Dega osteotomy: a versatile osteotomy in the treatment of developmental and neuromuscular hip pathology. J Pediatr Orthop. 2009 Oct;29(7):676–82.
8. Wenger DR, Bomar JD. Human hip dysplasia: evolution of current treatment concepts. J Orthop Sci. 2003;8(2):264–71.
9. Hosam El-Din Amin, Hisham Abdel-Ghani, Naguib Basha, Mahmoud Badawy, Alaa Abououf, Ahmed Darweash EYasin. High trans-iliac incomplete bi-cortical pelvic osteotomy vs dega osteotomy in treatment of developmental dysplasia of the hip in young children: A new technique. Orthopaedics & Traumatology: Surgery & Research [Internet]. 2025;(ISSN 1877-0568). Available from: https://doi.org/10.1016/j.otsr.2025.104191.%0A
10. Ahmed E, Mohamed Abo-Heg AH, Wael H. Surgical treatment of the late - presenting developmental dislocation of the hip after walking age. Acta Ortop Bras. 2013;21(5):276–80.
11. Murphy RF, Kim YJ. Surgical Management of Pediatric Developmental Dysplasia of the Hip. J Am Acad Orthop Surg. 2016 Sep 1;24(9):615–24.
12. Faciszewski T, Kiefer GN, Coleman SS. Pemberton osteotomy for residual acetabular dysplasia in children who have congenital dislocation of the hip. J Bone Joint Surg Am. 1993;75(5):643–9.
13. Utterback TD, MacEwen GD. Comparison of pelvic osteotomies for the surgical correction of the congenital hip. Clin Orthop Relat Res. 1974;No. 98(98):104–10.
14. Pemberton PA. Pericapsular osteotomy of the ilium for the treatment of congenitally dislocated hips. Clin Orthop Relat Res. 1974;No. 98(98):41–54.

15. Millis MB, Zaltz I. Current perspectives on the pediatric hip: selected topics in hip dysplasia, Perthes disease, and chondrolysis: synopsis of the hip subspecialty session at the POSNA Annual Meeting, May 1, 2013, Toronto. J Pediatr Orthop. 2014;34 Suppl 1:S36–43.

16. Ruszkowski K, Pucker A. Simultaneous open reduction and Dega transiliac osteotomy for developmental dislocation of the hip in children under 24 months of age. J Pediatr Orthop. 2005 Sep;25(5):695–701.

17. M E Berkeley JHD, T E Cain MMD. Surgical therapy for congenital dislocation of the hip in patients who are twelve to thirty-six months old - PubMed. J Bone Joint Surg Am . 1984;66(3):412–20.

18. K S Shih, J H Wang, T M Wang, S C Huang. One-stage correction of neglected developmental dysplasia of the hip by open reduction and pemberton osteotomy - PubMed. J Formos Med Assoc. 2001;100(6):397–402.

19. Czubak J, Kowalik K, Kawalec A, Kwiatkowska M. Dega pelvic osteotomy: indications, results and complications. J Child Orthop. 2018;12(4):342–8.

20. D Tönnis. Normal values of the hip joint for the evaluation of X-rays in children and adults - PubMed. Clin Orthop Relat Res . 1976;119:39–47.

21. Gibson PH, Benson MKD. Congenital dislocation of the hip. Review at maturity of 147 hips treated by excision of the limbus and derotation osteotomy. Journal of Bone and Joint Surgery - Series B. 1982;64(2):169–75.

22. Ward WT, Vogt M, Grudziak JS, Tümer Y, Cook PC FRD. Severin classification system for evaluation of the results of operative treatment of congenital dislocation of the hip. A study of intraobserver and interobserver reliability. May;79(5):656-63. doi: 10.2106/00004623-199705000-00004. PMID: 9160937. J Bone Joint Surg Am. 1997;

23. Siddiqui MK, Shafi MK, Qaisrani B. Evaluation of the Results of Operative Treatment of Hip Dysplasia in Children after the walking age. Vol. 11.

24. Al-Ghamdi A, Rendon JS, Al-Faya F, Saran N, Benaroch T, Hamdy RC. Dega osteotomy for the correction of acetabular dysplasia of the hip: a radiographic review of 21 cases. J Pediatr Orthop. 2012 Mar;32(2):113–20.

25. Ming-Hua D, Rui-Jiang X, Wen-Chao L. Dega-Osteotomie mit hoher Inzision zur Therapie der Hüftdysplasie bei Kindern unter 6 Jahren. Orthopade. 2016;45(12):1050–7.

26. Refae HH, Ahmed AH, Tageldeen Elemary M, Hamdy E, Ahmed M. Evaluation of high cut Dega osteotomy for management of developmental hip dysplasia in children. SVU-International Journal of Medical Sciences. 2021 Aug 1;4(2):246–56.

27- Vallamshetla VRP, Mughal E, O'Hara JN. Congenital dislocation of the hip: a reappraisal of the upper age limit for treatment. J Bone Jt Surg - Ser B 2006;88:

1076–81. https://doi.org/10.1302/0301-620X.88B8.17592.