

ORIGINAL ARTICLE

DEVELOPMENTAL DYSPLASIA OF THE HIP IN OLDER CHILDREN; PROSPECTS OF FUNCTIONAL AND RADIOLOGICAL OUTCOME FOLLOWING A SINGLE STAGE TRIPLE PROCEDURE

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Background: Developmental dysplasia of the hip (DDH) is a diverse entity, which range from mild acetabular dysplasia to frank irreducible hip dislocation. Data regarding the safety and efficacy of one stage triple procedure is limited. Our aim was to analyse the mid-term functional and radiological outcome of single stage triple procedure for children with DDH after walking age. **Methods** This is a prospective case series of 23 patients (26 hips) who were diagnosed as cases of DDH between July 2014 and June 2017. We included patients with age 20 months and above from both genders who underwent the single stage triple procedure of open reduction, femoral and pelvic osteotomy during the three years. Functional and radiological outcome were assessed according to McKay's and Severin's grading systems respectively. **Results:** Sixteen (69.6%) girls and 7 (30.4%) boys with a mean age of 4.4 ± 1.9 years. The mean follow-up duration was 8.9 ± 3.2 months. The mean preoperative acetabular index (AI) was $40.3^\circ \pm 2.7^\circ$ which reduced to an average of $23.4^\circ \pm 3.8^\circ$ at the end of follow-up. Eight (34.8%) of patients achieved grade I (excellent) of McKay's classification and 9 (39.1%) grade II (good). Postoperatively, 22 (95.7%) patients were below grade III and only one (4.3%) patient was in grade IVa. One case of avascular necrosis of femoral head was observed. **Conclusion:** The single stage triple procedure involving femoral and pelvic osteotomies have excellent functional and radiological outcomes, however, avascular necrosis of the femoral head, redislocation and osteoarthritis in long-term are the adverse events associated with the condition.

Keywords: Developmental dysplasia of hip; Children; Outcome; Triple procedure; Single stage

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INTRODUCTION

Developmental dysplasia of the hip (DDH) is a diverse entity, which range from mild acetabular dysplasia to frank irreducible hip dislocation. Early diagnosis of this disorder and referral to specialist centre is paramount. However, in our setup, patients are usually delayed due to lack of awareness about the problem as well as the negligence on the part of the family of the child.^{1,2} This is important clinically, because management of hip dislocation in older children is different as compared to small children.³ Older children are difficult to manage and achievement of complete reduction of the hip joint is a very challenging task due to associated complications and less than optimal functional improvement.⁴ This is because with time the per articular soft tissues are shortened as well as dysplasia of the acetabulum, constriction of the acetabular capsule, fixation of the inversion of the limbus, thickened round ligament, infiltration of the acetabulum by fibrous tissue and femoral anteversion. In such situations, if the condition is left

untreated, it will lead to early onset osteoarthritis and significant morbidity.^{5,6}

Common modalities employed in older children with DDH are bracing, closed reduction with traction, open surgical reduction and pelvic or femoral osteotomies.^{7,8} Osteonecrosis of the femoral head is a common complication which can now be reduced by avoiding rigid immobilisation in an abducted position.⁹ This is possible by employing femur-shortening osteotomies when needed. This has been supplemented by the introduction of pelvic bone osteotomy which is indicated in children above the age of 18 months.^{4,10,11}

The use of traction prior to reduction of the hip has been recommended reduced femoral head necrosis due to ischaemia. However, some studies have suggested that it is of no benefit due to inconsistencies in results. Similarly, reduction of hip with realignment has been reported to result in incomplete relief of the dysplasia.¹² Reduction is improved with femoral shortening and also does not affect osteonecrosis of femoral head. Recently, multiple studies have shown that a combination of open reduction, release of the capsular constriction,

femoral shortening and pelvic osteotomies all can be done in a single stage and is associated with improved outcome.^{13,14}

Though this single stage triple procedure is a challenging procedure as compared to stage wise reduction. However, better outcomes for a single stage procedure may save the patient from repeat surgery as well as higher functional capacity. We, undertook this study to analyse functional and radiological improvement of this procedure in children above 3 years of age.

MATERIAL AND METHODS

This is retrospective analysis of prospectively collected data, between July 2014 to June 2017 at the department of Orthopaedics, Khyber Teaching Hospital (KTH), Peshawar. The study was approved by the institutional review board. All patients/guardians provided informed consent for any invasive procedure. We included patients from both genders with an age range of 3–10 years with congenital dislocation of the hip joint, who underwent a triple procedure involving open reduction, femoral shortening derotation and Salter's osteotomy in a single stage. We excluded patients with neuromuscular disorders, syndromic major anomalies, recurrent DDH cases and those cases who were managed conservatively.

Data was collected about patient demographics, laterality, preoperative gait and range of motion. Radiological data was collected about the degree of derotation required, presence or absence of osteoarthritis, redislocation and osteonecrosis as well as any postoperative complications such as wound infection, seroma formation, and transfusion requirement. Functional recovery was determined using the McKay's grading¹⁵ at 3-monthly interval during the first year and 6 monthly thereafter, while radiological recovery was graded by utilising the Severin's classification¹⁶ at similar intervals.

We used the anterior approach of Smith-Petersen using the bikini incision. Hip joint exposure was performed by dissection of muscles from the iliac crest. The iliopsoas muscle was released with excision of the pulvinar leading to surgical release of the ligamentum teres. The transverse acetabular ligament was incised and traction was applied to the lower limb in order to quantify the amount of muscle contractures around the joint. In case if there were strong contractures, it was usually difficult to reduce the joint.

We followed the Salter¹⁷ osteotomy technique for the pelvic region and femoral osteotomy and shortening was performed using the Predrag Klisix¹⁸ technique. This was achieved using a lateral approach where femoral proximal end was

approached by careful subperiosteal dissection. Once this region was exposed, a transverse osteotomy at the lesser trochanteric region was performed. The degree of femoral overlap was assessed in order to guide the degree of femoral osteotomy that was required. This osteotomy was fixed with a small plate. In most cases, a shortening of about 1–2 cm was required for the final femoral head reduction keeping a minimal strain on soft tissues.

The derotational osteotomy was guided by the amount of femoral anteversion. If anteversion was more than 60°, derotation was performed. It was achieved during the femoral osteotomy by keeping the proximal segment in full internal rotation and external rotation of the distal femoral segment, so that the patella was directed anteriorly. At this point the fixation plate was applied.

The acetabular assessment involved the extent of coverage of the femoral head, in order to decide whether a pelvic osteotomy was required. We performed a Salter osteotomy using a gigli saw. This involves removal of a bone wedge at the anterior aspect of the iliac crest. This pelvic osteotomy enables movement of the two segments of the innominate bone to move over each other and is moved in anterolateral direction. The bone wedge was inserted at the site of osteotomy and fixed using K-wires.

Complete reduction of the hip joint was confirmed in abduction and extension and capsule was closed tightly. Immobilisation of the hip was achieved using hip spica in mild flexion (30°) and abduction (45°) for 6–8 weeks. Similarly, the K-wires used in osteotomy fixation were removed at 6–8 weeks. Weight bearing was gradually allowed at 8–10 weeks duration, initially with crutches and later without it.

The initial follow-up was at 2 weeks for two times and at 3 monthly intervals thereafter for one year. In our practice the loss to follow-up is very high due to various factors such as poverty, improper access to hospitals, incomplete electronic communication availability in peripheral areas and overall lack of education. Patients usually consider their first surgery as curative and they think that there is a need for follow-up in case a problem arrives. However, we tried our best to follow-up the patients as long as possible. Initially our aim was to complete a follow-up of at least three years, but majority of patients were lost to follow-up during the initial year. This limits our ability to follow-up the patients for longer term outcomes, especially the rates of osteoarthritis development and the onset and progression of avascular necrosis (AVN). This is the reason we have not included these parameters in our follow-up data.

All of the data was entered and analysed using SPSS version 25.0. Outcome was staged according to the McKay's grading and is presented according to these classes. The statistical significance was kept at ≤ 0.05 .

RESULTS

We operated 16 (69.6%) girls and 7 (30.4%) boys with a mean age of 53.9 ± 23.7 months. The minimum age was 20 months and maximum was 8.1 years. 7 (30.4%) patients presented with right side involvement and 13 (56.5%) with left side while three patients presented with bilateral dysplasia (6 hips), which makes a total of 26 hips. The mean follow-up duration was 8.9 ± 3.2 months with 95% of patients lost to follow-up during the initial year after surgery. Earlier the average shortening of the affected limb was 1.5 cm which improved to less than 1 cm (mean 0.8 cm) at the last follow-up. The mean preoperative acetabular index (AI) was $40.3^\circ \pm 2.7^\circ$ which reduced to an average of $23.4^\circ \pm 3.8^\circ$ at the end of follow-up. Preoperative, more than half (n=13, 56.5%) patients were in grade I and II of the Tonnis grading for hip dislocation while the rest were in grade III and IV. We observed 8 (34.8%) of patients who achieved grade I (excellent) of McKay's classification, 9 (39.1%) in grade II (good), 4 (17.4%) in grade III (fair) and 2 (8.7%) in grade IV (poor). Table-1 The preoperative Severin's grading included 13 (50.0%) hips in grade V, 8 (30.7%) in

grade IV and 5 (19.2%) in grade III. Postoperatively, 22 (95.7%) patients were below grade III and only one (4.3%) patient was in grade IVa. This one case of poor prognosis developed during the initial 7 months. Table-2

In this study, 15 (65.2%) patients had normal gait, 4 (17.4%) had a short-legged gait and 4 (17.4%) had mild Trendelenburg gait. There was no case of significant limb length discrepancy. Only one patient had a redislocation of the hip after removal of the spica cast. This patient was initially managed conservatively; however, eventually a re-exploration and open reduction was done. Eventually this patient was diagnosed as having progressive AVN of the femoral head and 6.5 months of follow-up.

Table-1: McKay's functional grade distribution across the study sample

| McKay's grade | | |
|---------------|-----------|---------|
| | Frequency | Percent |
| I (Excellent) | 8 | 34.8 |
| II (Good) | 9 | 39.1 |
| III (Fair) | 4 | 17.4 |
| IV (Poor) | 2 | 8.7 |

Table-2: Severin's Radiological grading across the study population

| | Frequency | Percent |
|-----|-----------|---------|
| Ia | 9 | 39.1 |
| Ib | 6 | 26.1 |
| IIa | 4 | 17.4 |
| IIb | 1 | 4.3 |
| III | 2 | 8.7 |
| IVa | 1 | 4.3 |

Table-3: Comprehensive literature review of some recent publications

| Parameter | | Ning <i>et al</i> (2014) | Bhuyan <i>et al</i> (2012) | Umer <i>et al</i> (2007) | Dogan <i>et al</i> (2005) | Forlin <i>et al</i> (2006) | Ganger <i>et al</i> (2005) | Abdullah <i>et al</i> (2012) | Present study |
|-----------|----------------------|--------------------------|----------------------------|--------------------------|---------------------------|----------------------------|----------------------------|------------------------------|---------------|
| Tonnis | Grade I & II | 45.7% | 59.9% | 62% | - | - | 33.3% | - | 56.5% |
| | Grade III & IV | 54.2% | 40% | 38% | - | - | 66.7% | - | 43.5% |
| McKay's | Grade I & II | 79.4% | 89.9% | 86.2% | - | 79.5% | 79.6% | 88% | 73.9% |
| | Grade III & IV | 15.3% | 11.1% | 13.8% | - | 20.5% | 20.4% | 12% | 26.7% |
| Severin's | Grade I, II | 84.7% | 83.3% | 65.5% | 89.5% | 70% | 80% | 88% | 87% |
| | Grade III, IV, V, VI | 15.3% | 16.7% | 34.5% | 10.5% | 30% | 20% | 12% | 13% |
| AVN | | 27.4% | 3.3% | 3.4% | 13.7% | 22.7% | - | 2.3% | 3.8% |

DISCUSSION

Concentric reduction of the hip joint is the primary goal of the surgery for DDH. As described earlier, lack of health facilities in far-flung areas and an overall lack of expertise in the primary care setting about the diagnosis of DDH are the frequent reasons for late presentation in our country.^{19,20} This lead to increasing deformity, gait problems, hip joint degenerative changes, muscle contractures development and significant pain in walking for the young child. Moreover, DDH is amenable to traction and closed reduction in younger infants.²¹ Once a

child starts walking, the hip joint and the soft tissues around it starts moulding to the stresses imposed leading to contractures, AVN of the femoral head and osteoarthritis. Older children frequently need surgical reduction and reformation of the distorted acetabulum in order to restore normal gait and joint stability.^{22,23}

The triple procedure as discussed above is an extensive procedure and undertaking it in one stage has the advantage of saving the patient from repeated staged procedures.⁴ It is the treatment of choice in late diagnosed DDH. This procedure involves femoral shortening which is the basic step in reducing pressure on the femoral head. During the

last decade, several studies have reported the success of this single stage triple procedure. We undertook the study to analyse the outcome of our patients. We undertook the pelvic osteotomy as described by Salter. This pelvic osteotomy decision was undertaken with the patient age, dislocation grade (Tonnis) and the preoperative acetabular index.^{11,24,25}

The studies reporting about these procedures have shown a satisfactory functional outcome and good radiological grades especially in children above three years. Dogan and colleagues²⁶ have reported a good functional and radiological grade in 89.5% of patients in a sample of 22 patients. Similarly, Forlin and co-workers²⁷ have reported on 20 children above the age of 4 years with 70% good to excellent McKay and Severin's grade. However, they reported that a patient above the age of 7 years is more likely to

Table-3

Longer follow-up studies have shown AVN of the femoral head as the major complication of the disorder itself with an increased rate after surgical reduction. Ning *et al*³⁰ has reported an overall 27% poor outcome. They have suggested, however, that optimal femoral shortening and good postoperative position of the hip joint in spica case may avoid AVN. In a multiple logistic regression analysis, Ning *et al*³⁰ have shown that age and preoperative Tonnis grade is a predictor of postoperative AVN and poor functional outcome. They have shown that younger patients, especially those between 3–6 years of age have good overall functional and radiological outcome and that as the age of the patient increases, outcome worsens. This shows the importance of earlier diagnosis and treatment of DDH. However, controversy still exist as to which age group is best for this single stage triple procedure.^{4,9}

Another common complication is redislocation and residual dysplasia. Their incidence is reported in the range of 0–8%.¹⁹ The risk factors for redislocation include incomplete release of the joint from the outward and upward pull by the iliopsoas and other abductors, bilateral joints involvement, abnormal head position, anteversion and incomplete pelvic bones osteotomy. We observed redislocation is two (8.7%) patients which is near the reported range of incidence of this complication. However, as reported by Ning and co-workers, we did not find an association between preoperative Tonnis grade and postoperative redislocation.

The major limitation of our study was a higher rate of loss to follow-up. The other limitations included smaller sample size and single centre experience. A randomised, multicentre trial with

experience poor outcome. Another study from Pakistan by Umer and colleagues²⁸ showed the results of 23 patients with 86% of cases in good or excellent grade. Ganger and co-workers¹² have reported a good and excellent rate of 80% in a 3.5 years mean follow-up. Abdullah and colleagues²⁹ have reported a good and excellent outcome in 88% patients. As stated above, 74% of our patients had good and excellent functional outcome while 87% had good or excellent radiological outcome. In a larger study of 864 hips by Ning *et al*³⁰, there was 80% good or excellent outcome during an average of 6.2 years follow-up. This shows that our results with respect to functional and radiological outcome are in agreement with the above cited studies and that this single stage triple procedure with pelvic osteotomy do confer benefit to DDH patients.

longer follow-up may be the answer to most of the limitations of our study.

CONCLUSIONS

Developmental dysplasia of the hip is a common idiopathic disorder affecting young children and it significantly affect the quality of life of patients in their adult lives. The single stage triple procedure involving femoral and pelvic osteotomies have excellent functional and radiological outcomes, however, avascular necrosis of the femoral head, redislocation and osteoarthritis in long-term are the adverse events associated with the condition. It is pertinent to recommend this procedure in children older than 3 years of age with late diagnosed developmental dysplasia of the hip.

AUTHORS' CONTRIBUTION

MS: Data collection. SH: Literature search. MS: SPSS and data analysis. MAK: Proof reading. SU: Write up.

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