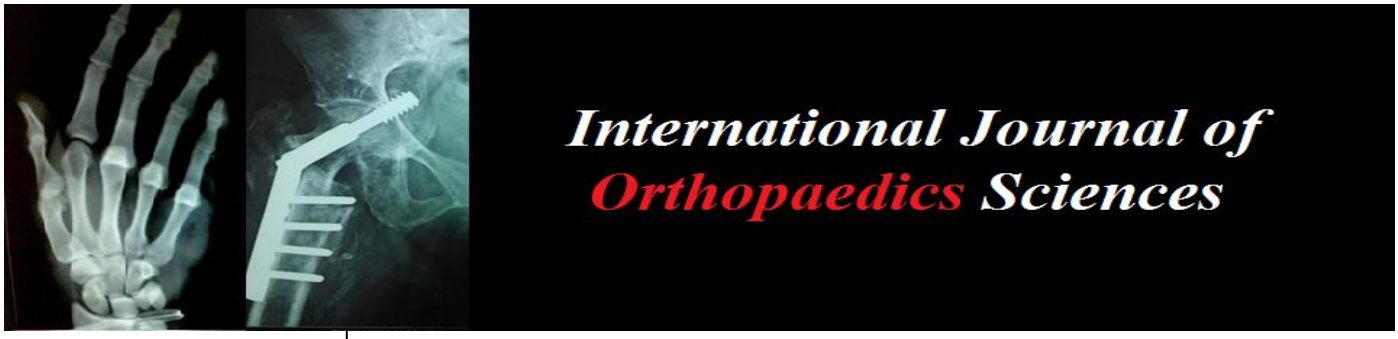


E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2024; 10(3): 01-10

www.orthopaper.com
Received: 06-05-2024
Accepted: 09-06-2024

Dr. Vaibhav Gautam
M.S. Orthopedic Surgery Attending Consultant, Department of Orthopedics, Indraprastha Apollo Hospital, New Delhi, India

Dr. Ramani Narasimhan
M. S. Orthopedic Surgery, Fellow- Pediatric Orthopedic Surgery (USA) Senior Consultant, Department of Pediatric Orthopedic Surgery, Indraprastha Apollo Hospital, New Delhi, India

Corresponding Author:
Dr. Ramani Narasimhan
M. S. Orthopedic Surgery, Fellow- Pediatric Orthopedic Surgery (USA) Senior Consultant, Department of Pediatric Orthopedic Surgery, Indraprastha Apollo Hospital, New Delhi, India

Management of developmental dysplasia of the hip in children from 0 to 5 years of age: Retrospective study of cases at a tertiary health care centre

Dr. Vaibhav Gautam and Dr. Ramani Narasimhan

DOI: https://doi.org/10.22271/ortho.2024.v10.i3a.3568

Abstract
Objective: The aim of this study was to analyse results of our treated patients of Developmental Dislocation of the Hip (DDH) in the age range from birth to 5 years.
Materials and Methods: This was a retrospective observational and analytical study. One hundred & fifty-three dislocated hips in 111 patients (42 male & 69 females) in age range from birth to 5 years were included. The minimum follow-up was 36 months in this study with a mean follow up of 86 months. On the basis of the management modality adopted, we chose to divide all the patients into 3 main groups; group 1-Pavlik harness-assisted reduction or closed reduction under general anaesthesia, with 34 patients, group 2-open reduction alone with 46 patients, and group 3- open reduction with supplementary procedures with 31 patients. The management results were assessed using both clinical (modified Mc Kay) and radiological assessment (Severin) criteria applicable to each group. Salter and Thompson classification was used to assess AVN.
Results: At the final follow-up, the results were evaluated in accordance to individual groups. Descriptive statistical analysis was carried out. Categorical data were presented in number and percentage. Residual acetabular dysplasia, re-dislocation, stress fracture and avascular necrosis were the complications in our study. On the basis of clinical criteria, in 34 patients in group 1, 100 percent patients had excellent to good outcome (34). In second group with 46 patients, 95.6 percent patients had excellent to good outcome (44) and 4.3 percent (2) patients had fair outcome. In third group with 31 patients, 90.3 percent patients had excellent to good outcome (28) and 9.6 percent (3) patients had fair outcome. No patients in either of the groups showed poor result.
In group 1, 97.95 percent (48 hips) had good radiological outcome on basis of Severin criteria (Severin type I and II) and 2.04 percent (1 hip) had fair result (Severin type III). In group 2, 94.91 percent (56 hips) had good result (Severin type I and II) and 5.08 percent (3 hips) had fair result (Severin type III). In group 3, 95.55 percent (43 hips) had good result (Severin type I and II) and 4.44 percent (2 hips) had fair result (Severin type III).
AVN was seen in 4 hips in group 3, out of which only one had class B presentation as per Salter Thompson classification (Severin type III).
Conclusion: Most studies in literature have concentrated on using age as the criteria to assign treatment which denies flexibility in tackling patients with DDH who lie at the intersection of such groups. Operative management of DDH is more likely in patients beyond one year of age. Assessment and analysis of non-operative and operated patients of DDH cannot be combined together as factors leading to adverse outcomes like RAD, AVN etc, are more likely to occur in the latter group. Irrespective of the treatment modality used in these dislocated hips, there should always be emphasis on the concentric reduction without undue pressure on femoral head. Supplementary procedures like appropriate pelvic osteotomy, or pelvic along with femoral osteotomy would be necessary to maintain reduction in older children.
Level of evidence: Level IV-Retrospective observational and analytical study.

Keywords: Hip, developmental dislocation, birth to 5 years of age, management.

Introduction
Developmental dysplasia/dislocation of hip (DDH) is a spectrum of hip disorders that range from a mildly dysplastic but concentrically reduced and stable hip, to a hip that is frankly dislocated and severely dysplastic [1].

The goal in management of DDH is to achieve a stable concentrically reduced hip joint at the earliest avoiding the complications of treatment, for example avascular necrosis (AVN) of the femoral head. The treatment options for DDH vary depending on the age at presentation. There still is a significant variation in management of DDH in children from birth to 5 years of age and hence, we conducted a study on our treated patients with DDH to understand and analyse results of management.

Materials and Methods

This was a retrospective observational and analytical study. We included a total of 111 cases of DDH (153 hips), age ranging from birth to 5 years, who were treated between January 2005 and January 2018 at our centre. We included DDH patients with frank dislocations managed (either conservatively or operatively) from birth to 5 years of age with minimum follow-up of 36 months. Our exclusion criteria were patients who had acetabular dysplasia only without hip dislocation, who had undergone any prior significant intervention (closed reduction or surgery) for DDH, management after 5 years of age, teratological DDH, any associated congenital, neurological, myopathic, or traumatic condition of lower limbs which could affect the outcome of DDH management, any associated visceral anomalies (ex. TOF, Laryngomalacia, etc.) which could increase morbidity and affect the outcome of DDH management, or patients with follow-up less than 36 months.

All patients were divided into 3 groups, according to the modality of treatment adopted (Table 1).

In group I, all patients were treated using either Pavlik harness assisted reduction (PHAR), or closed reduction (CR) with or without adductor tenotomy (AT) under general anaesthesia (GA). PHAR was tried in infants with hips not reducing on couch in this group. This was done for a minimum of 6 weeks of duration and then if successful was replaced by an abduction orthosis if the child's age exceeded 6 months. PHAR was tried in patients till 4 months of age failing which CR under GA was resorted to. Patients who underwent CR with or without AT (AT when passive abduction $\leq 30°$) under GA, also had intra-operatively hip arthrogram to assess the stability of reduction, and the reduction was considered good if there was a narrow rim of medial dye pool (< 5 mm) on the arthrogram. They were given hip spica for 10 to 12 weeks. We did not apply pre-reduction skin traction in any patient.

In group II, patients were treated by open reduction (OR) using anterior Smith-Peterson's approach with adductor tenotomy (percutaneous), followed by hip spica.

In group III, patients were treated by OR using anterior approach, AT (percutaneous), and a pelvic osteotomy alone or along with femoral osteotomy. The per-operative test of stability was done to help in our decision of selection of any supplementary procedure [2]. The pelvic procedure performed was trans-iliac incomplete pelvic acetabuloplasty (DEGA). The femoral procedure done was Derogation Osteotomy Proximal Femur with minimal varus (VDRO) with or without femoral shortening.

All patients were followed-up at the immediate postoperative period, at 6 weeks, at 12 weeks, at 4 months, and then at 4 monthly intervals. At 36 months follow up, patients were evaluated clinically by using the Modified McKay criteria [3] (classified the outcomes as excellent to good, fair or poor), and radiologically by using Severin criteria [4] (good outcome for Severin I & II, fair outcome for Severin III and poor outcome for Severin IV, V & VI) (Table 2).

Hip stability was assessed by Ortolani sign (for dislocated hip) and Barlow's provocative test (for dislocatable hip) in younger infants, and Telescopic test was done in older children. Dislocatable, or dislocated reducible hips were considered as unstable hips. We used Salter and Thompson classification system for grading of AVN [5].

Results were based on the number of patients who were either excellent to good, fair, or poor in that particular group. In bilateral cases, priority was given to low scores, for example if one hip was graded as good and another hip was graded as fair, then the overall result to this patient was graded as a fair result. Descriptive analysis was carried out. Categorical data were presented in number and percentage. SPSS statistical software (version 25, SPSS Inc., Chicago, IL, USA) were used for statistical analysis where ever applicable.

Results

The patient distribution in our study has been summarised in Table 1. At the final follow-up, the results were evaluated in accordance to individual groups in Table 3. On the basis of clinical criteria, in 34 patients in group 1, 100 percent patients had excellent to good outcome (34). In second group with 46 patients, 95.6 percent patients had excellent to good outcome (44) and 4.3 percent (2) patients had fair outcome. In third group with 31 patients, 90.3 percent patients had excellent to good outcome (28) and 9.6 percent (3) patients had fair outcome. No patients in either of the group showed poor result.

In group 1, 97.95 percent (48 hips) had good radiological outcome on basis of Severin criteria (Severin type I and II) and 2.04 percent (1 hip) had fair result (Severin type III). In group 2, 94.91 percent (56 hips) had good result (Severin type I and II) and 5.08 percent (3 hips) had fair result (Severin type III). In group 3, 95.55 percent (43 hips) had good result (Severin type I and II) and 4.44 percent (2 hips) had fair result (Severin type III). One case of 5 months old child with bilateral DDH successfully treated with bilateral CR & AT and their follow-up is shown in Figure 1. Another case of 4+10 years old bilateral DDH child treated successfully with bilateral AT and OR with VDRO with femoral shortening and DEGA pelvic osteotomy is shown in Figure 2.

Residual acetabular dysplasia (RAD), re-dislocation, stress fracture and avascular necrosis were the complications in our study (Table 4). AVN was seen in total of 4 patients in group III (Type A in 3 patients and Type B (Figure 3) in one patient). One patient in group 3 had re-dislocation and later during the course of treatment, developed stress fracture of shaft femur which was treated by open reduction and internal fixation with plate & screws (Figure 4). One patient in group 1 developed RAD which required operative intervention at later stage. Three patients in group 2 developed residual acetabular dysplasia and required supplementary procedures. One patient in group 3 who underwent open reduction with DEGA pelvic osteotomy for acetabular dysplasia redeveloped dysplasia.

Discussion

The endeavour in this retrospective study was to divide the patients ranging from 0 to 5 years of age, into 3 groups based on the basic treatment modalities assigned as per a consistent protocol followed towards treatment selection and assess our outcomes at the end of 36 months of treatment. Most studies in literature [6] have concentrated on using age as the criteria to assign treatment which denies flexibility in tackling

patients with DDH who lie at the intersection of such groups, the 'grey area' (Figure 5). Such papers state about assigning CR to patients till 1 year of age but there were 2 patients in our study between 10 & 12 months of age who failed to fulfil the criteria of concentric reduction after CR and hence were treated by OR and were included in our 2nd group. Both cases had satisfactory outcome at final assessment. There was also 1 case aged 13 months which was successfully managed by CR. Similarly, there were 3 patients in our study between 21 to 24 months of age who failed the test of stability [2] after OR alone and hence needed pelvic procedure (included in our 3rd group). All 3 cases had a satisfactory outcome at final evaluation. Hence even though we had smaller number of patients in these 'grey areas', we feel it is important to consider this dilemma that one could face while assigning treatment around these ages. We evaluated each group separately and did not attempt to club the outcome of all groups. We felt that each group of patients pose a challenge in themselves and warranted individual attention.

There was a preponderance of females in our study. We felt that the outcomes measured by clinical assessment gave a better picture about the patient's function. The outcome of any bilateral case was influenced by the worse hip. Radiological results did not really correlate with clinical outcomes at the end of final assessment. Long term follow-up would be needed to perhaps see for resonance between clinical and radiological outcomes.

PHAR was an important treatment mode in group I. Ultrasound was the imaging used to monitor treatment. There has been a recommendation of waiting till 30 days of age at least before initiating treatment with PHAR as early intervention may be unnecessary [7]. We initiated PHAR at the earliest whenever there was dislocation as we felt that chances of success with it is much more when initiated in early infancy. Although bilaterality has been thought to increase the chances of PHAR failure [8, 9], 4 bilateral cases tackled before 2 months fared well with PHAR. Clinically irreducible hips with less than 20% head coverage had high chances of PHAR failure [9]. Older infants & with complete dislocations are likely to fail PHAR treatment [10]. One infant in our study who was close to 3 months of age and had Graf IV dislocated hip, did not respond to PHAR. After a trial of 4 weeks, we resorted to CR and got a good result. Recommendation for CR under general anaesthesia (GA) in all Ortolani positive dislocated hips after 1 month of age are available in the literature [11]. We feel that all Graf IV dislocated hips that are not reducible in the outdoor clinics before the age of 3 months may be given a trial of PHAR for a month failing which CR under GA needs to be done. Although a recent study has downplayed the fear of any Pavlik harness disease, one needs to be vigilant [12, 13]. We are sceptical about the studies in literature advocating closed reduction in older children to avoid open surgery [14, 15]. Having a low threshold for converting a CR to OR during primary intervention especially in older infants can possibly prevent complications such as AVN. There also seems to be a wide variation in the incidence of AVN from 4% to 60% after CR [16]. Any case with a passive abduction of the involved hip after reduction, of less than or equal to 30° was subjected to an adductor tenotomy in this group. This is supposed to increase the safe zone, decrease the pressure on the femoral head, hence reduce the incidence of AVN [17, 18, 19]. We immobilized all the infants undergoing CR for 10-12 weeks using hip spica. Studies show preliminary traction decreasing the incidence of AVN undergoing CR for DDH [20, 21, 22], but any traction will have an insignificant effect on the main obstacles for reduction for eg. pulvinar, tight hour-glass capsule, transverse acetabular ligament, hypertrophied ligamentum teres (all intracapsular).

All hips in group 2 were managed by OR with adductor tenotomy. Early reduction has been advocated in toddlers both closed or open to avoid concomitant supplementary bony procedures and osteonecrosis [23, 24]. CR primarily beyond infancy would possibly increase the risk of an excessive undue pressure put on the femoral ossification nucleus when subconsciously 'forcing' it in the socket to avoid open surgery [25]. There are studies which emphasize the chances of AVN with OR alone [26]. We believe that the risk of any AVN with OR could be reduced by meticulous dissection and soft-tissue handling. All patients had the FON easily reaching the acetabulum on manual traction on the limb on the table. We focused on systematically removing all the obstacles of the reduction under direct vision, performed capsulorrhaphy in all cases, and paid special attention to a proper postero-lateral moulding of the spica cast over the affected side after surgery inside the theatre. We found that overlapping of the femoral ossification nucleus (FON) over the ischial tuberosity is a good per-operative radiological sign to ensure hip reduction after applying the spica. We did not get a CT/MRI routinely post-op in order to ensure hip reduction. We concentrated on achieving a concentric OR in this group of young toddlers after discussing prognosis thoroughly with family. Predicting Residual Acetabular Dysplasia (RAD) in hips which had concentric reduction is difficult but the majority agree on a good remodelling acetabular capacity in this age group [27,28].

In group 3, the 1st supplementary procedure that we considered after OR was an acetabular procedure as the remodelling potential of acetabulum diminishes beyond 5 years [29, 30]. We had 3 toddlers between 21 to 24 months who needed a supplementary procedure along with OR to maintain reduction. We feel that all cases between 18 to 24 months with preoperative acetabular index > 40° and a per-op safe zone of < 20° need the supplementary pelvic osteotomy as the acetabuli (as compared to proximal femur), do not have sufficient remodelling capacity [31]. DEGA was the pelvic procedure done when needed in the age group between 18 to 24 months [32]. Most studies stress the need for a proper reduction as a pre-requisite to any supplementary procedure [33]. Combining DEGA with femoral derotation osteotomy was never a problem as the acetabuloplasty did not interfere with the acetabular version. Excessive femoral anteversion with increasing age can lead to loss of reduction and hence needed to be addressed [34]. Femoral shortening was entertained only in older children. One needed to be careful in shortening the femora indiscriminately as excessive loss of tissue tension can have a negative effect on maintaining the reduction. DEGA was adopted not only because of our comfort with it but also for a reasonable anterior and lateral coverage with this acetabuloplasty.

The 3 main complications were acetabular dysplasia, re-dislocation/subluxation & AVN [35]. RAD was seen in some older infants and toddlers where CR/OR was done. Chances for osteonecrosis increases with more extensive surgeries [35]. Having stated that, regular adductor tenotomies, femoral shortening, and delicate soft-tissue handling helped us to avoid AVN and get good results in majority. One case of bilateral DDH in an older child had 3 out of 4 complications mentioned (Figure 4). Timely interventions in tackling the complications led to a good result even in this case at final follow up. It is important to have constant communication with family and build that necessary trust and confidence in

them, especially while dealing with complications during management.

Appropriate screening measures to detect and treat DDH earlier, results in a better outcome [36, 37]. The main limitations in our study were it being retrospective and with a selection bias. However, we do believe that having a single Pediatric Orthopaedic Surgeon managing all cases, and a mean follow-up of 86 months were our strengths. We hence could analyse our results better to understand and correlate the assigned treatment in accordance with the patient's age. Preventing osteonecrosis by avoiding any undue pressure over femoral head, prevents a bad result. Persistent PH-assisted attempts of reduction in Graf IV hips in younger infants, persisting with CR to avoid OR in older infants and toddlers, tendency to indiscriminately use a K-wire to keep the head in 'best' position in the socket, and hesitation to perform appropriate femoral shortening in older children, are all examples of situations increasing the chances of AVN and possibly leading to poor results. Assessment and analysis of non-operative and operated patients of DDH cannot be combined together as factors leading to adverse outcomes like RAD, AVN etc, are more likely to occur in the latter group. Open reduction focusing on proper tissue handling and systematically removing all obstacles of the reduction under direct vision, will reduce the chances of both re-dislocation and osteonecrosis. Irrespective of the treatment modality used in these dislocated hips, there should always be emphasis on the concentric reduction without undue pressure on femoral head. This remains an important prerequisite for any supplementary procedure to be additionally performed to maintain a reduction in an older child. Supplementary procedures like appropriate pelvic osteotomy, or pelvic along with femoral osteotomy would be necessary to maintain reduction in older children.

Table 1: Patient distribution

Groups	Modality of treatment	Total patients	Male	Female	Right	Left	Bilateral	Mean follow up (months)
Group 1	Closed reduction	34	7	27	3	16	15	96.3
Group 2	Open reduction alone	46	16	30	10	23	13	88.7
Group 3	Open reduction with supplementary procedures	31	10	21	6	11	14	73.5
		111	42	69	19	50	42	86.16

Table 2: Clinical and Radiological assessment criteria (A) Clinical assessment criteria (Modified McKay criteria)

Grade	Rating	Description
I	Excellent	Painless, stable hip; no limp, more than 15 degrees of internal rotation; negative Trendelenburg sign
II	Good	Painless, stable hip; slight limp, slight decrease in hip motion; negative Trendelenburg sign
III	Fair	Minimum pain; moderate stiffness; positive Trendelenburg sign
IV	Poor	Significant pain

Table 2: (B) Radiological assessment criteria (Severin's criteria)

Class	Description	Centre-edge angle (Degrees)
I	Normal appearance	>=15 (5-13 yrs.) >= 20 (>14 yrs.)
II	Mild deformity of the femoral head and neck or the acetabulum	>=15 (5-13 yrs.) >= 20 (>14 yrs.)
III	Dysplasia or moderate deformity of the femoral head and neck or the acetabulum, or both	<15 (5-13 yrs.) <20 (>14 yrs.)
IV	Subluxation of the femoral head	
V	Articulation of the femoral head with a false acetabulum	
VI	Radiolocation	

Table 3: Clinical and Radiological results in different groups at final follow-up

Groups	Total patients	Clinical Results				Total Hips	Radiological Results		
		Excellent	Good	Fair	Poor		Good	Fair	Poor
Group I	34	13	21	0	0	49	48	1	0
Group II	46	16	28	2	0	59	56	3	0
Group III	31	12	16	3	0	45	43	2	0
Total	111					153			

Table 4: Complications in different groups

Complication	Group I	Group II	Group III	Total
AVN	--	--	4	4
Redis location	--	--	1	1
RAD	1	3	1	5
Stress fracture	--	--	1	1

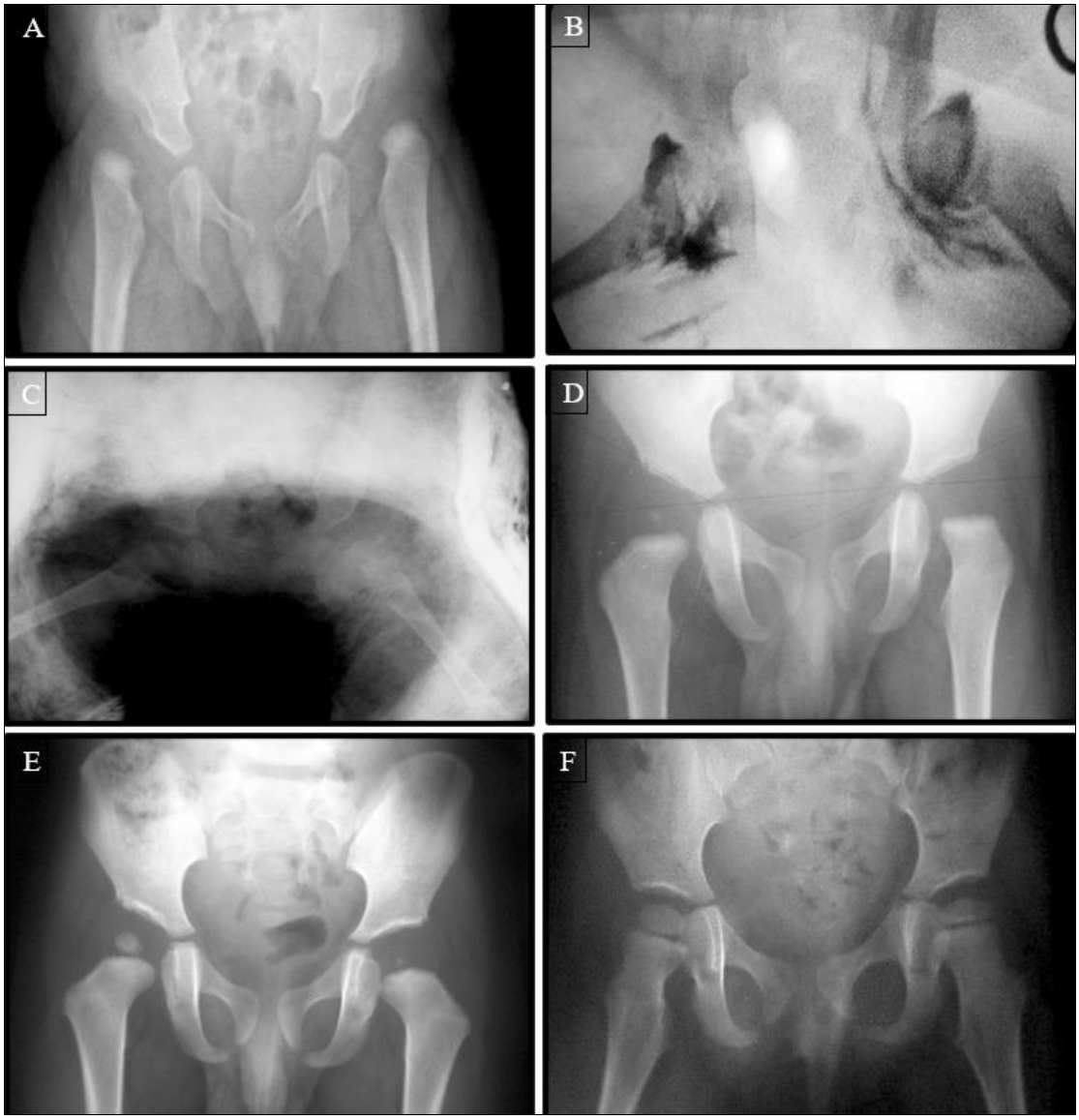
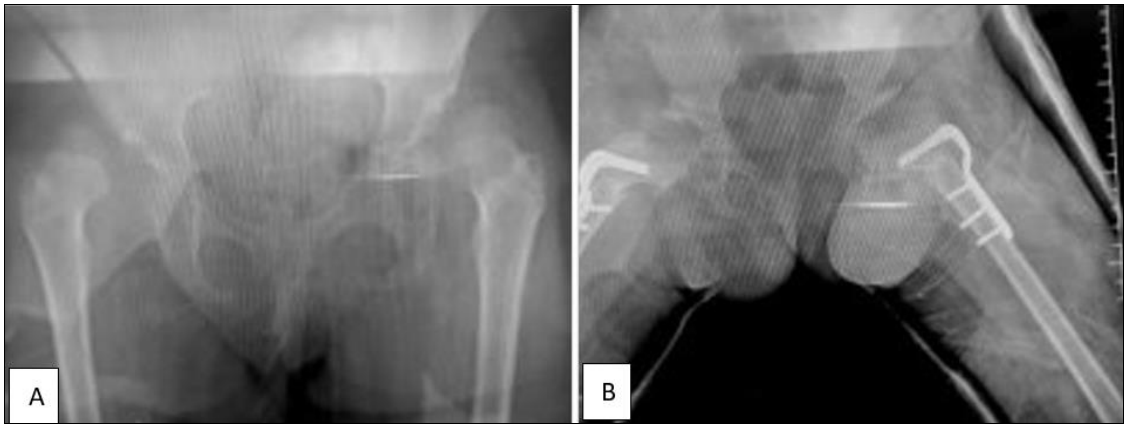


Fig 5: Months old baby with B/L dislocation (History of manipulations earlier); (A) pre-op radiological images showed B/L DDH, treated by B/L arthrogram + AT + CR + HS; (B) intra-operative arthrogram picture showed well reduced hips; (C) post-op 12 weeks; (D) post-op 6 months, femoral ossific nucleus visible on the right side; (E) post-op 10 months, tear drops and source better, femoral ossific nucleus visible on the left side; (F) post-op 2 years.



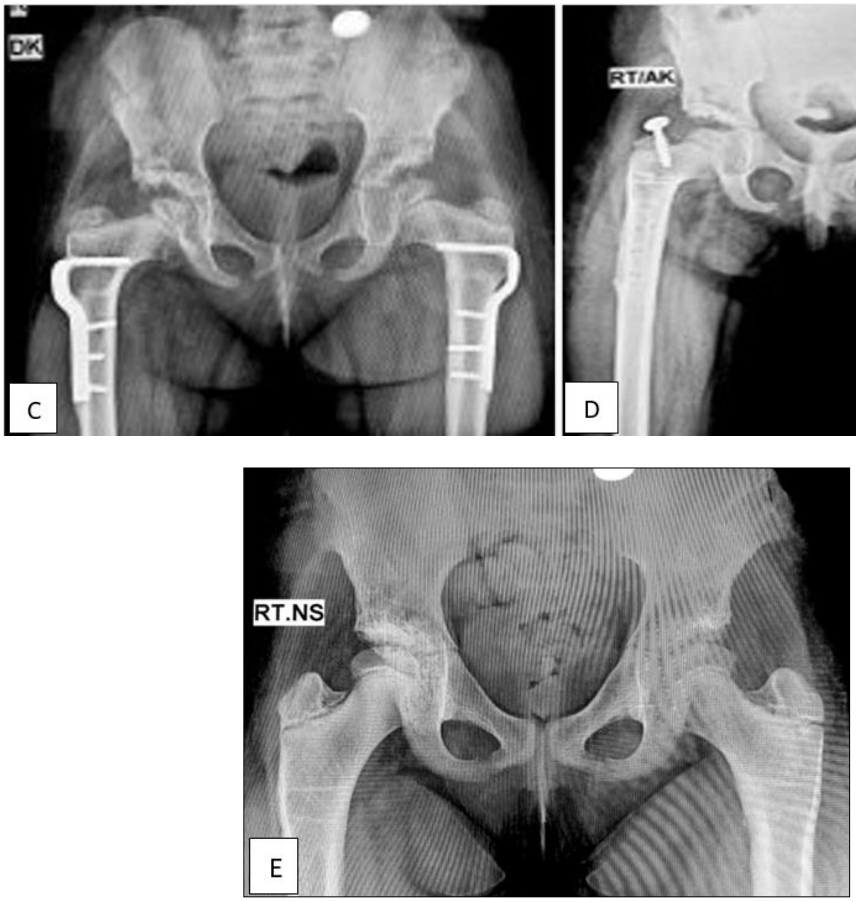
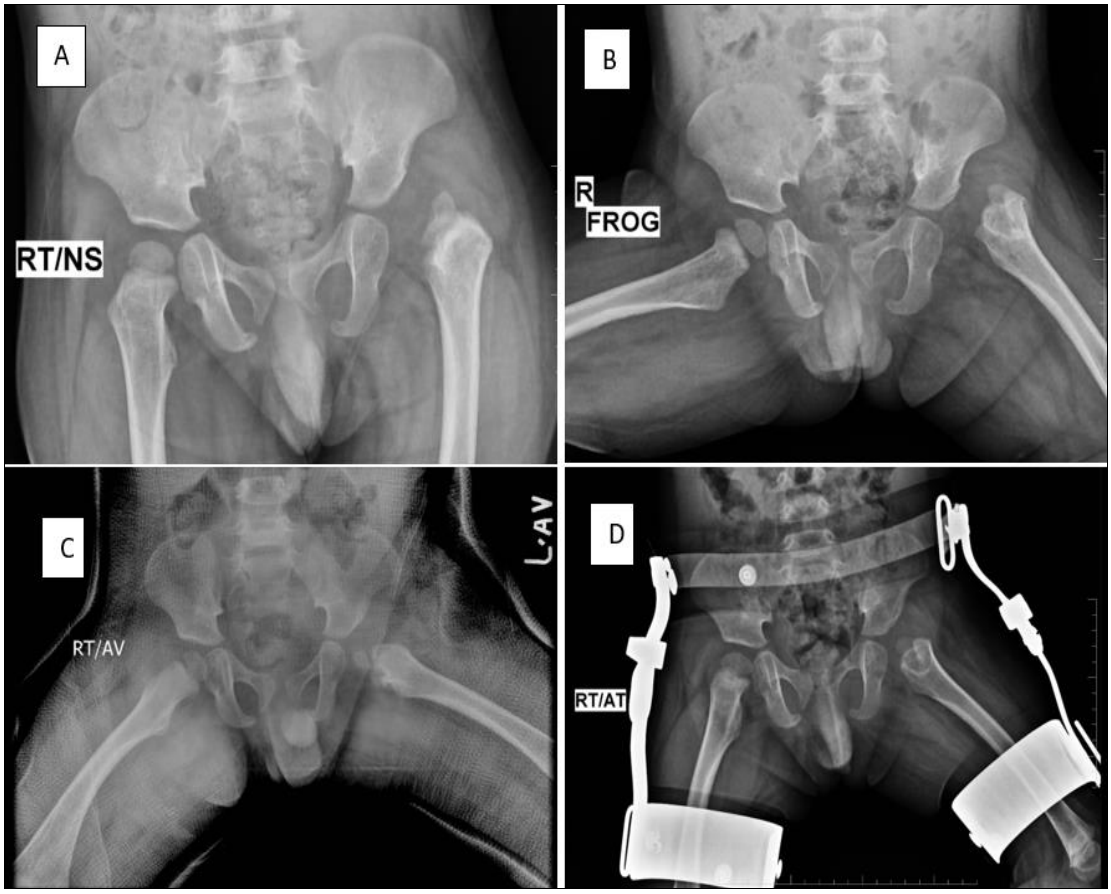


Fig 2(a): X-ray Pelvis with both hips AP view showing bilateral Developmental Dislocation of Hips; Initial presentation at the age of 5 years. (b) Immediate post op x ray, after open reduction bilateral hips with Adductor tenotomy and Femoral VDRO and Dega transilliac pelvic osteotomies with Hip spica (c) One-year post op x ray with both hips contained and healed osteotomies and decreased neck shaft angle both sides (d) X-ray post blade plate removal and bilateral trochanteric epiphysiodesis with screw. Bilateral screws were removed after 1 year and two months (e) X ray at final follow up post epiphysiodesis screw removal at 9 years 9 months' age.



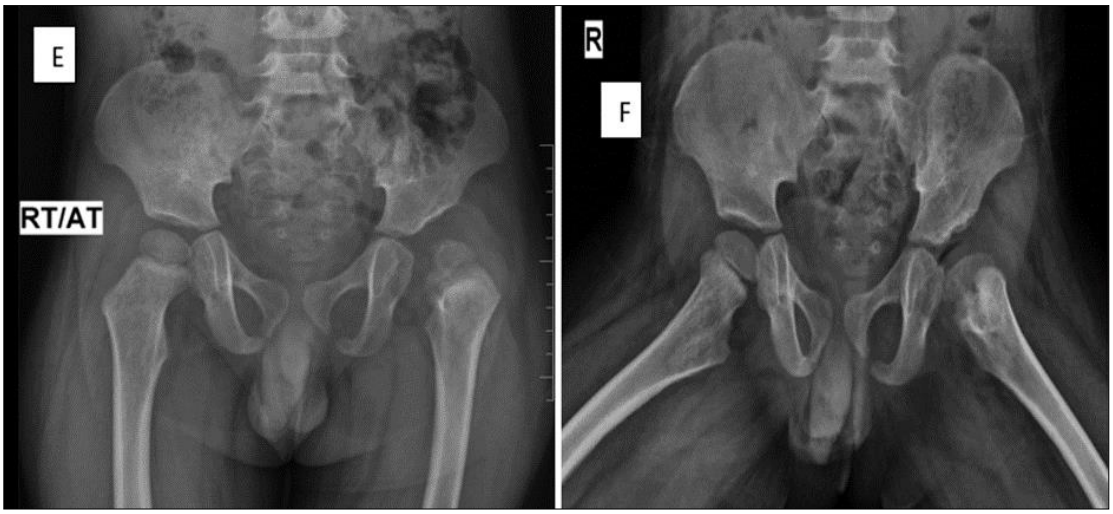
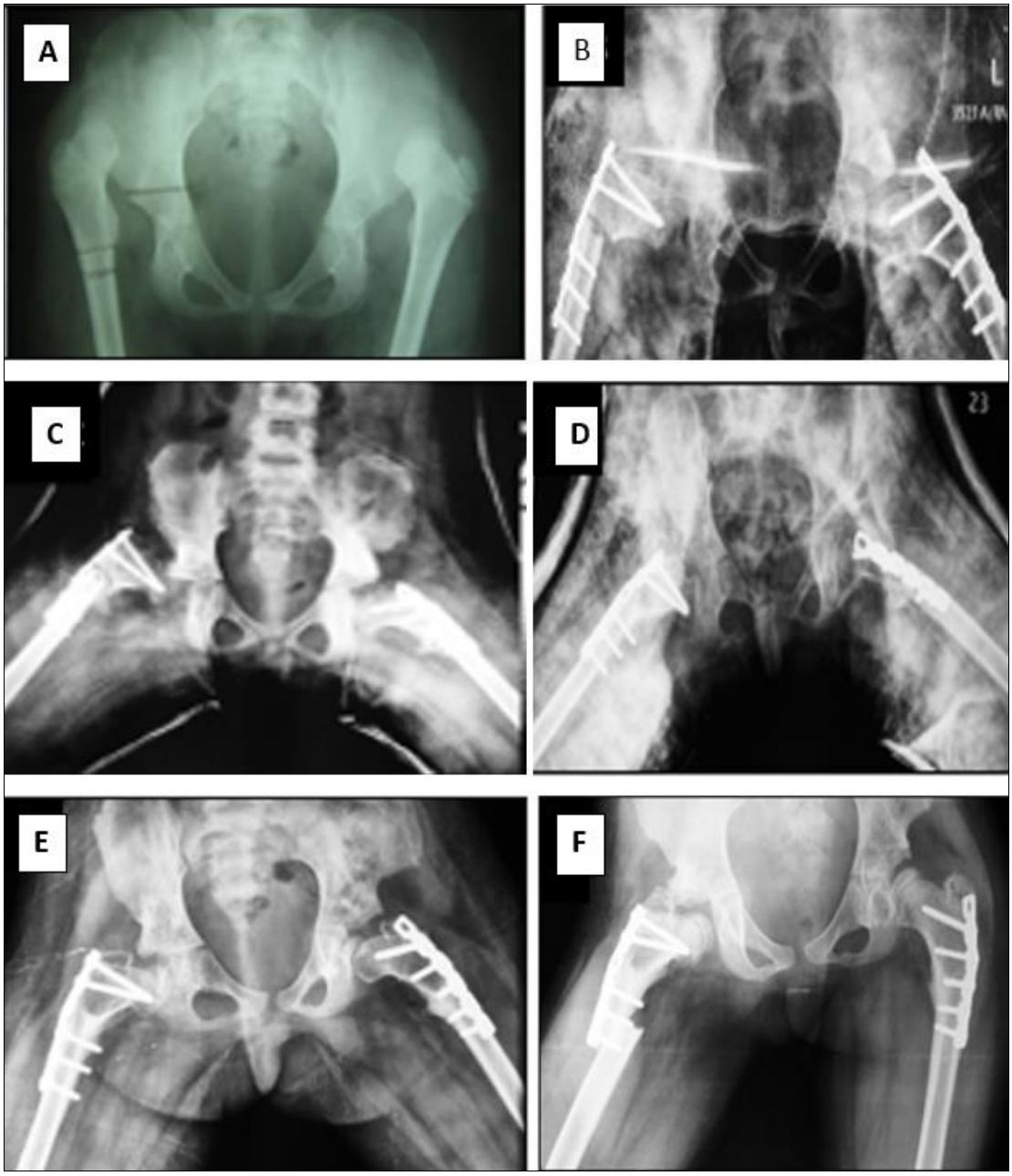


Fig 3: (A & B) 18 months male child with pelvis with both hips x ray showing left Hip Developmental dislocation. (C) Immediate post op x ray after Adductor tenotomy and open reduction left hip with spica application. (D) Post 3 months post op x ray with residual acetabular dysplasia and femoral nucleus present but smaller as compared to contralateral side. (E & F) 1-year post op x ray showing residual acetabular dysplasia along with global involvement of head due to grade 4 Avascular necrosis left hip



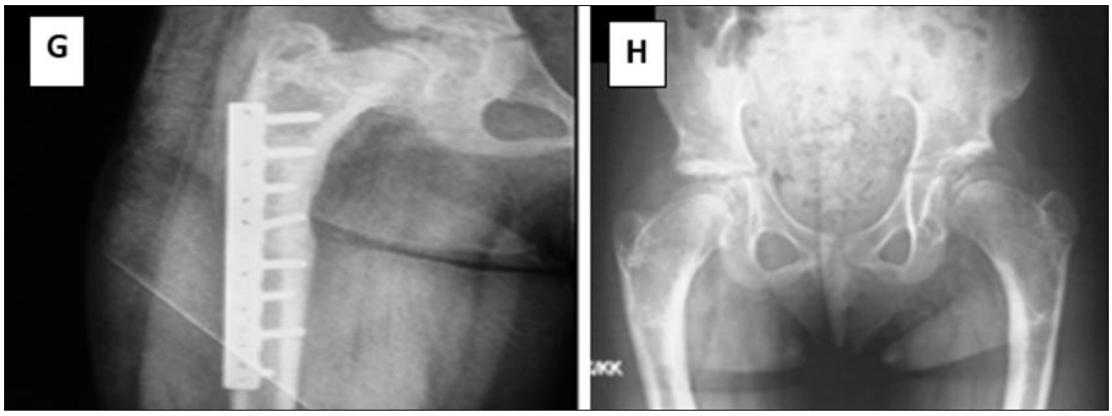


Fig 4: (A) 3 years old girl pre-op x-ray pelvis with both hips, treated by bilateral Adductor Tenotomy with Open Reduction with Varus De-rotation Osteotomy with Femoral Shortening and DEGA pelvic osteotomy followed by Hip Spica ; (B) immediate post-op; (C & D) At 6 weeks right hip dislocated, which was treated by Open Reduction and Readjustment of distal alignment (E) post-op 10 months; (F & G) post-op 16 months (fracture shaft femur due to stress riser), treated by Open reduction and internal fixation with plate & screws; (H) post-op 4 years final radiological images (after implant removal).

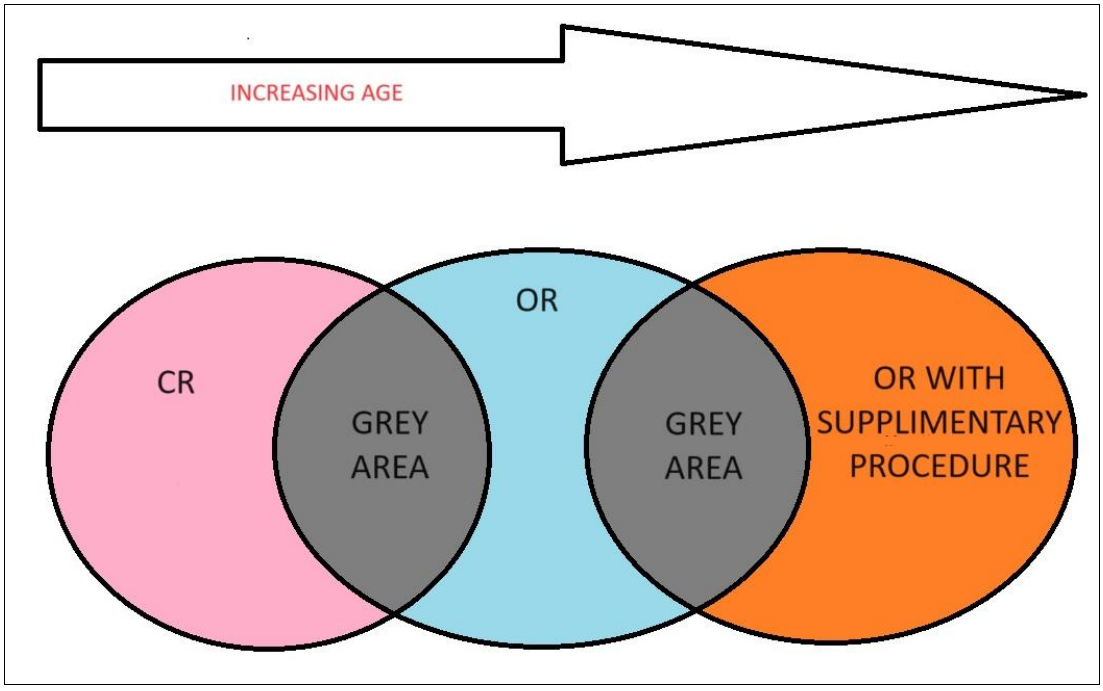


Fig 5: "Grey area" - overlapping modalities of treatment in children with advancing age

Acknowledgements: None

Conflict of Interest: None

Funding/Sponsorship: This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors

Informed Consent: Not applicable

Authors contribution

1. Dr Vaibhav Gautam - Conceptualization, Methodology, Data curation, Writing- Original draft preparation
2. Dr Ramani Narasimhan - Conceptualization, Supervision, Writing, Reviewing, Editing and Finalising

References

1. Cooper AP, Doddabasappa SN, Mulpuri K. Evidence-based management of developmental dysplasia of the hip. Orthopedic Clinics. 2014 Jul 1;45(3):341-54.
2. Zadeh HG, *et al*. Test of stability as an aid to decide the need for osteotomy in association with open reduction in developmental dysplasia of the hip. The Journal of Bone and Joint Surgery. British Volume. 2000;82(1):17-27. doi:10.1302/0301-620x.82b1.9618.
3. Berkeley ME, *et al*. Surgical therapy for congenital dislocation of the hip in patients who are twelve to thirty-six months old. The Journal of Bone and Joint Surgery. American Volume. 1984;66(3):412-20.
4. Severin E. Contribution to the knowledge of congenital dislocation of the hip joint. Late results of closed reduction and arthrographic studies of recent cases. Acta Chir Scand. 1941;63:1-142.
5. Salter RB, Thompson GH. Legg-Calvé-Perthes disease. The prognostic significance of the subchondral fracture and a two-group classification of the femoral head involvement. The Journal of Bone & Joint Surgery. 1984 Apr;66(4):479-89.
6. Murphy RF, Kim YJ. Surgical management of pediatric developmental dysplasia of the hip. The Journal of the American Academy of Orthopaedic Surgeons. 2016;24(9):615-24. DOI: 10.5435/JAAOS-D-15-00154.

7. Larson JE, Patel AR, Weatherford B, Janicki JA. Timing of Pavlik harness initiation: Can we wait? Journal of Pediatric Orthopaedics. 2019 Aug 1;39(7):335-8.
8. Atalar H, Sayli U, Yavuz OY, Uraş I, Dogruel H. Indicators of successful use of the Pavlik harness in infants with developmental dysplasia of the hip. International Orthopaedics. 2007;31(2):145-50. DOI: 10.1007/s00264-006-0097-8.
9. Lerman JA, Emans JB, Millis MB, Share J, Zurakowski D, Kasser JR. Early failure of Pavlik harness treatment for developmental hip dysplasia: clinical and ultrasound predictors. Journal of Pediatric Orthopaedics. 2001 May 1;21(3):348-53.
10. Ömeroğlu H, Köse N, Akceylan A. Success of Pavlik harness treatment decreases in patients≥ 4 months and in ultrasonographically dislocated hips in developmental dysplasia of the hip. Clinical Orthopaedics and Related Research®. 2016 May 1;474(5):1146-52.
11. Sriram K. Developmental dysplasia of the hip: Management under six months of age. Indian Journal of Orthopaedics. 2003 Oct;37(4):223-6.
12. Gornitzky AL, Schaeffer EK, Price CT, Institute IH, Sankar WN. Pavlik harness disease revisited: Does prolonged treatment of a dislocated hip in a harness adversely affect the α angle? Journal of Pediatric Orthopaedics. 2018 Jul;38(6):297.
13. Suzuki SH. Ultrasound and the Pavlik harness in CDH. The Journal of Bone and Joint Surgery. British Volume. 1993 May;75(3):483-7.
14. Wicart P, Seringe R, Glorion C, Brassac A, Rampal V. Closed reduction in late-detected developmental dysplasia of the hip: indications, results and complications. Journal of Children's Orthopaedics. 2018 Aug 1;12(4):317-22.
15. Li Y, Lin X, Liu Y, Li J, Liu Y, Pereira B, *et al*. Effect of age on radiographic outcomes of patients aged 6-24 months with developmental dysplasia of the hip treated by closed reduction. Journal of Pediatric Orthopaedics B. 2020 Sep 1;29(5):431-7.
16. Bradley CS, Perry DC, Wedge JH, Murnaghan ML, Kelley SP. Avascular necrosis following closed reduction for treatment of developmental dysplasia of the hip: a systematic review. Journal of Children's Orthopaedics. 2016 Dec 1;10(6):627-32.
17. Salter RB, Kostuik J, Dallas S. Avascular necrosis of the femoral head as a complication of treatment for congenital dislocation of the hip in young children: a clinical and experimental investigation.
18. Cai Z, Li L, Zhang L, Ji S, Zhao Q. Dynamic long leg casting fixation for treating 12-to 18-month-old infants with developmental dysplasia of the hip. Journal of International Medical Research. 2017 Feb;45(1):272-81.
19. Zhang Z, Li H, Li H, Zhang Z. Timing for closed reduction procedure for developmental dysplasia of the hip and its failure analysis. BMC Musculoskeletal Disorders. 2020 Dec;21(1):1-7.
20. Sankar WN, Gornitzky AL, Clarke NM, Herrera-Soto JA, Kelley SP, Matheney T, *et al*. Closed reduction for developmental dysplasia of the hip: early-term results from a prospective, multicenter cohort. Journal of Pediatric Orthopaedics. 2019 Mar;39(3):111.
21. Sibiński M, Murnaghan C, Synder M. The value of preliminary overhead traction in the closed management of DDH. International Orthopaedics. 2006 Aug 1;30(4):268-71.
22. Cha SM, Shin HD, Shin BK. Long-term results of closed reduction for developmental dislocation of the hip in children of walking age under eighteen months old. International Orthopaedics. 2018 Jan 1;42(1):175-82.
23. Holman J, Carroll KL, Murray KA, MacLeod LM, Roach JW. Long-term follow-up of open reduction surgery for developmental dislocation of the hip. Journal of Pediatric Orthopaedics. 2012 Mar 1;32(2):121-4.
24. Pospischill R, Weninger J, Ganger R, Altenhuber J, Grill F. Does open reduction of the developmental dislocated hip increase the risk of osteonecrosis? Clinical Orthopaedics and Related Research®. 2012 Jan 1;470(1):250-60.
25. Biçimoglu A, Ag H, Ömeroglu H, Tümer Y. Six years of experience with a new surgical algorithm in developmental dysplasia of the hip in children under 18 months of age. Journal of Pediatric Orthopaedics. 2003 Nov 1;23(6):693-8.
26. Firth GB, Robertson AJ, Schepers A, Fatti L. Developmental dysplasia of the hip: open reduction as a risk factor for substantial osteonecrosis. Clinical Orthopaedics and Related Research. 2010 Sep 1;468(9):2485-94.
27. Lindstrom JR, Ponseti IV, Wenger DR. Acetabular development after reduction in congenital dislocation of the hip. JBJS. 1979 Jan 1;61(1):112-8.
28. Zamzam MM, Kremli MK, Khoshhal KI, Abak AA, Bakarman KA, Alsiddiky AM, *et al*. Acetabular cartilaginous angle: a new method for predicting acetabular development in developmental dysplasia of the hip in children between 2 and 18 months of age. Journal of Pediatric Orthopaedics. 2008 Jul 1;28(5):518-23.
29. Malvitz TA, Weinstein SL. Closed reduction for congenital dysplasia of the hip. Functional and radiographic results after an average of thirty years. The Journal of Bone and Joint Surgery. American Volume. 1994 Dec 1;76(12):1777-92.
30. Brougham DI, *et al*. The predictability of acetabular development after closed reduction for congenital dislocation of the hip. The Journal of Bone and Joint Surgery. British Volume. 1988;70(5):733-6. DOI: 10.1302/0301-620X.70B5.3192570.
31. Ramani N, Patil MS, Mahna M. Outcome of surgical management of developmental dysplasia of hip in children between 18 and 24 months. Indian Journal of Orthopaedics. 2014 Oct;48:458-62.
32. Grudziak JS, Ward WT. Dega osteotomy for the treatment of congenital dysplasia of the hip. JBJS. 2001 Jun 1;83(6):845-54.
33. Salter RB, Dubos JP. The first fifteen years' personal experience with innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip. Clinical Orthopaedics and Related Research®. 1974 Jan 1;98:72-103.
34. Vitale MG, Skaggs DL. Developmental dysplasia of the hip from six months to four years of age. JAAOS - Journal of the American Academy of Orthopaedic Surgeons. 2001 Nov 1;9(6):401-11.
35. Narasimhan R. Complications of management of developmental dysplasia of the hip. Indian Journal of Orthopaedics. 2003 Oct 1;37(4):237.
36. Hooper N, *et al*. Developmental dysplasia of the hip: An examination of care practices of orthopaedic surgeons in India. Indian Journal of Orthopaedics. 2020;55(1):158-68. DOI: 10.1007/s43465-020-00233-0.

37. Aroojis A, *et al*. Surveillance for developmental dysplasia of the hip in India: Consensus guidelines from the Pediatric Orthopaedic Society of India, Indian Academy of Pediatrics, National Neonatology Forum of India, Indian Radiological and Imaging Association, Indian Federation of Ultrasound in Medicine and Biology, Federation of Obstetric and Gynaecological Societies of India, and Indian Orthopaedic Association. Indian Pediatrics. 2022;59(8):626-35.

How to Cite This Article
Gautam V, Narasimhan R. Prospective study on the functional and radiological outcome of open reduction and plating for intraarticular fractures of the calcaneum. International Journal of Orthopaedics Sciences. 2024;10(3):01-10.