THE PLANET

Original Article

Clinical, Functional, and Radiological Outcomes Following the Modified Dunn Procedure for Severe Slipped Capital Femoral Epiphysis: A Prospective Observational Study

Muhammad Monjur-ul-Alam[1*], Selim Reza[2], Tapas Mandal[3], Mohammad Hossain Rasel[4], Faisal Amin Ahmed[5], Shubha Prasad Das[6]

ARTICLE INFO

Received: 28 October 2026
Accepted: 02 November 2026
Published Online: 08 November 2026

DOI: 10.5281/zenodo.24047246

Volume: 10, Number: 3, Page: 1258-1261

e-ISSN: 2789-5912
ISSN: 2617-0817

*Corresponding author

ABSTRACT

Objective: Severe slipped capital femoral epiphysis (SCFE) may cause proximal femoral deformity, femoroacetabular impingement (FAI), pain, and early degenerative change. The modified Dunn procedure aims to restore proximal femoral anatomy through surgical hip dislocation while preserving the femoral-head blood supply. To describe clinical, functional, radiological outcomes, and complications after the modified Dunn procedure for severe SCFE at a tertiary orthopaedic centre in Dhaka, Bangladesh. **Methods & Materials:** This prospective observational study included 20 patients (20 hips) treated at NITOR between July 2020 and July 2024. Mean age was 12.5 years (range 10–16); 13 patients were male and 7 were female. Mean follow-up was 26.2 ± 14 months (range 12–50). Functional measures included the Harris Hip Score (HHS) and WOMAC; radiographic measures included Southwick and alpha angles. **Results:** The recorded HHS was 91.95 (range 75.3–99.2), and WOMAC was 94.4 ± 10.6 (range 38–100). Mean Southwick angle changed from 62.2 ± 8.1° (range 50–83°) preoperatively to 7.3 ± 3.5° (range 2–15°) postoperatively. Mean alpha angle changed from 93.5 ± 21.1° (range 72.4–114.6°) to 41 ± 6.4° (range 24–54°). Recorded complications included avascular necrosis (2/20, 10%), implant failure (1/20, 5%), one superficial infection, and heterotopic ossification (1/20, 5%). **Conclusions:** The recorded cohort data indicate radiographic correction and favourable functional scores after the modified Dunn procedure. Avascular necrosis and other complications remain important outcomes.

Keywords: *avascular necrosis; Harris Hip Score; modified Dunn procedure; slipped capital femoral epiphysis; WOMAC*

1. *Associate Professor, Paediatric Orthopaedic Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh (ORCID: 0009-0009-2061-0133)*
2. *Associate Professor, Department of Orthopaedic Surgery, NITOR, Dhaka, Bangladesh*
3. *Assistant Registrar, Orthopaedic Surgery, Gopalgonj Medical College Hospital, Bangladesh*
4. *Associate Professor, Paediatric Orthopaedic Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh*
5. *Assistant Professor, Orthopedic Surgery, Shahid Jakir Hossain Border Guard Hospital, Dhaka, Bangladesh*
6. *Assistant Professor, Paediatric Orthopaedics, Sir Salimullah Medical College, Dhaka, Bangladesh*

INTRODUCTION

Slipped capital femoral epiphysis (SCFE) is an adolescent hip disorder characterized by displacement of the proximal femoral epiphysis relative to the metaphysis through the physis. It most commonly presents during rapid growth and may cause hip, groin, thigh, or referred knee pain with a limp. Delayed diagnosis or residual deformity can contribute to restricted motion, femoroacetabular impingement (FAI), cartilage injury, and early osteoarthritis [1-6].

Slip severity is commonly assessed using the Southwick angle, while stability is often classified using the Loder criteria [6,7]. In situ fixation is widely used, particularly for stable slips, but it does not correct the deformity in severe cases. The modified Dunn procedure, performed through surgical hip dislocation, permits subcapital realignment and direct assessment of the femoral head–neck junction; however, avascular necrosis (AVN) remains a major concern [3,8-12].

Published reports describe variable complication rates and emphasize the technical demands of the procedure and the importance of surgeon experience [12-16]. Evidence from prospective cohorts in different settings remains useful for describing outcomes and complications. This study aimed to document clinical, functional, and radiological outcomes and complications following the modified Dunn procedure for severe SCFE at NITOR, Dhaka, Bangladesh.

METHODS & MATERIALS

Study design and setting

This prospective observational study was conducted at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh, from July 2020 to July 2024. The study included 20 patients with 20 hips. The recorded ethics approval date was 5 March 2020.

Participants and eligibility

Patients had severe SCFE and were treated with the modified Dunn procedure through surgical hip dislocation. The eligibility threshold was a Southwick angle greater than 50°. The reported age range was 10–16 years, and minimum follow-up was 12 months.

Inclusion criteria were severe SCFE, age at surgery ≤17 years, treatment with the modified Dunn procedure through surgical hip dislocation, and minimum 12-month follow-up. Exclusion criteria were previous in situ fixation or other surgery of the index hip, slips secondary to metabolic or endocrine disease, and pathological slips.

Baseline characteristics

The cohort comprised 13 male patients (65%) and 7 female patients (35%), with a mean age of 12.5 years (range 10–16). Nineteen hips were classified as stable and one as unstable using the Loder criteria. Chronicity was recorded as 1 acute and 19 chronic slips.

Surgical procedure and postoperative care

The modified Dunn procedure was performed through a Ganz surgical hip dislocation approach with trochanteric flip osteotomy and capsulotomy, preserving the retinacular vessels. The epiphysis was mobilized, metaphyseal callus was removed as needed, and anatomical reduction was achieved and stabilized. Femoral-head perfusion was assessed intraoperatively. Associated deformities

BDJOURNALS.ORG Copyright © 2026 The Planet. Published by Sher-E-Bangla Medical College, Barishal, Bangladesh. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

were addressed when indicated, followed by capsular closure and fixation of the trochanteric osteotomy. Postoperative rehabilitation was individualized according to fixation stability and healing.

Postoperative protocol describes non-weight-bearing for 6–8 weeks, followed by protected weight-bearing with crutches for a further 4–8 weeks depending on radiographic healing, progressive physiotherapy, and restriction of vigorous activity for 6 months.

Outcome measures

The primary functional outcome was the Harris Hip Score (HHS). WOMAC was also recorded as a functional outcome measure. Preoperative HHS and pain or range-of-motion measurements were not provided in the available manuscript.

Radiological outcomes were the Southwick slip angle and alpha angle before and after surgery, Tönnis osteoarthritis grade, and documentation of FAI.

Recorded complications included AVN, implant failure, infection, heterotopic ossification, femoral neck or trochanteric nonunion, limb-length discrepancy, growth-plate closure, hip instability or subluxation, neurological or vascular injury, and reoperation.

Statistical analysis

Continuous variables are summarized as mean ± standard deviation and range where available; categorical outcomes are summarized as counts and percentages. No p-values or inferential comparisons are reported in this manuscript.

RESULTS

Baseline characteristics and follow-up

Twenty patients with 20 hips were included. Mean age at surgery was 12.5 years (range 10–16); 13 patients (65%) were male and 7 (35%) were female. Nineteen hips were stable and one was unstable according to the Loder criteria. Mean follow-up was 26.2 ± 14 months (range 12–50). The recorded chronicity distribution was 1 acute and 19 chronic slips.

Table I

Baseline characteristics of the NITOR cohort.

Characteristic	NITOR cohort
Study period	July 2020–July 2024
Patients / hips	20 patients / 20 hips
Age at surgery	12.5 years (range 10–16)
Sex	Male: 13 (65%); female: 7 (35%)
Loder stability	Stable: 19; unstable: 1
Chronicity	Recorded: acute 1; chronic 19
Mean follow-up	26.2 ± 14 months (range 12–50)
Severity threshold	Southwick angle >50° in draft

Functional and radiological outcomes

The recorded HHS was 91.95 (range 75.3–99.2), and WOMAC was 94.4 ± 10.6 (range 38–100). Mean Southwick angle decreased from 62.2 ± 8.1° to 7.3 ± 3.5°. Mean alpha angle decreased from 93.5 ± 21.1° to 41 ± 6.4°. These values are descriptive; paired statistical significance has not been established in the available manuscript data.

Table II

Functional and radiological outcomes.

Outcome	NITOR cohort
Harris Hip Score	91.95 (range 75.3–99.2)
WOMAC	94.4 ± 10.6 (range 38–100)
Preoperative Southwick angle	62.2 ± 8.1° (range 50–83°)
Postoperative Southwick angle	7.3 ± 3.5° (range 2–15°)
Preoperative alpha angle	93.5 ± 21.1° (range 72.4–114.6°)
Postoperative alpha angle	41 ± 6.4° (range 24–54°)
FAI / Tönnis grade / Femoral-head sphericity	0 cases recorded / Grade 0: 19 hips; grade 3: 1 hip / Osteochondroplasty recorded in all 20 hips

Complications and reoperations

AVN was recorded in 2 of 20 patients or hips (10%). One implant failure (1/20, 5%) occurred at 3 months and was followed by revision surgery. One superficial infection and one case of heterotopic ossification were recorded. No cases were recorded for femoral neck or trochanteric nonunion, limb-length discrepancy, growth-plate closure, hip instability or subluxation, or neurological or vascular injury.

Table III

Recorded complications and events.

Complication / event	NITOR cohort
Avascular necrosis	2/20 (10%)
Implant failure	1/20 (5%); occurred at 3 months; revision performed
Infection	1 superficial infection
Heterotopic ossification	1/20 (5%)
Femoral neck / trochanteric nonunion	0 cases recorded
Limb-length discrepancy	0 cases recorded
Growth-plate closure	0 cases recorded
Hip instability / subluxation	0 cases recorded
Neurological / vascular injury	0 cases recorded
Reoperation / Tönnis grade 3 / early OA	1 revision after implant failure / 1 hip

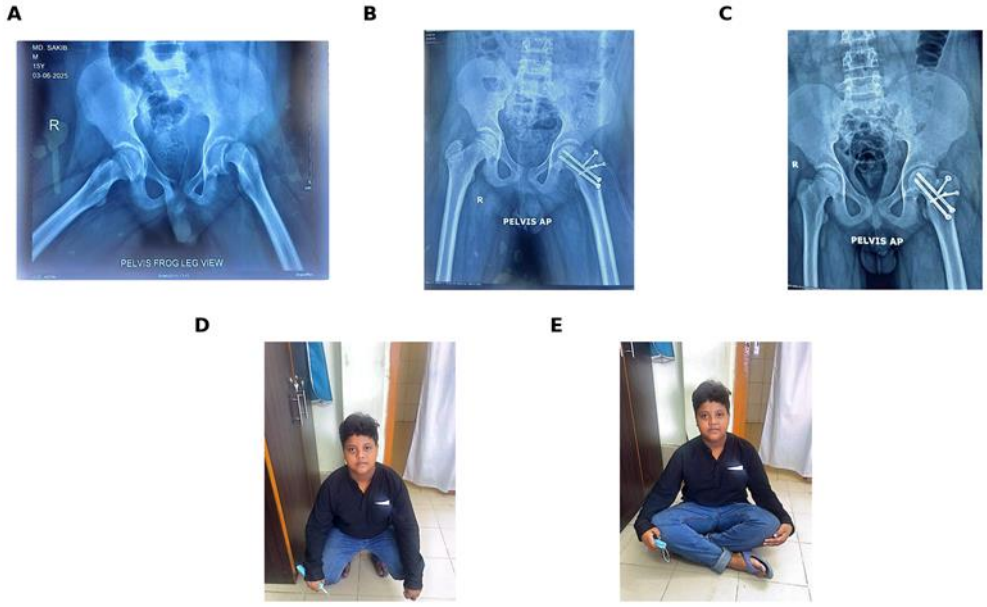


Figure 1. Clinical, radiological, and functional outcomes following the Modified Dunn procedure for severe slipped capital femoral epiphysis. (A) Preoperative frog-leg radiograph demonstrating severe left-sided slipped capital femoral epiphysis. (B) Early postoperative anteroposterior pelvis radiograph demonstrating fixation of the affected hip. (C) Follow-up anteroposterior pelvis radiograph demonstrating maintained fixation and satisfactory radiographic alignment. (D) Postoperative functional assessment demonstrating the patient's ability to perform deep squatting. (E) Postoperative functional assessment demonstrating the ability to sit comfortably in a cross-legged position.

DISCUSSION

This prospective observational cohort describes clinical, functional, and radiological outcomes after the modified Dunn procedure for severe slipped capital femoral epiphysis (SCFE) at a tertiary orthopaedic centre in Bangladesh. The principal recorded findings were a reduction in the mean Southwick angle from 62.2° to 7.3° and in the mean alpha angle from 93.5° to 41°. The recorded Harris Hip Score (HHS) was 91.95, while the WOMAC score was 94.4 ± 10.6. Together, these findings suggest that substantial radiographic correction and favourable postoperative functional scores were observed in this cohort. However, because preoperative HHS and paired individual-level functional measurements were not available in the manuscript dataset, the functional results should be interpreted as descriptive postoperative findings rather than proof of improvement from baseline.

The modified Dunn procedure uses surgical hip dislocation to provide direct access to the femoral head–neck junction and permit subcapital realignment of the epiphysis [3,8,9]. In severe SCFE, residual proximal femoral deformity may contribute to femoroacetabular impingement (FAI), restricted motion, cartilage injury, and later degenerative change [10]. Anatomical correction is therefore an important surgical objective. Nevertheless, the procedure is technically demanding and requires careful handling of the retinacular vessels because disruption of femoral-head blood supply may lead to avascular necrosis (AVN) [11,12]. Systematic reviews and comparative studies describe variable outcomes, with differences in slip severity and stability, patient selection, surgical technique, surgeon experience, and duration of follow-up affecting interpretation [13,14]. The present cohort provides a small institutional description of outcomes, but it cannot establish superiority over in-situ fixation or other treatment strategies because there was no comparison group [13].

AVN was recorded in 2 of the 20 hips (10%) in this cohort. AVN remains a key concern after the modified Dunn procedure, and systematic reviews have reported variable rates across published series [11,12]. A meta-analysis focused on AVN reported that the rate differs by slip stability, emphasizing the importance of interpreting a small cohort in its clinical context [15]. The observed proportion should be interpreted cautiously: two events in a cohort of 20 patients produce an imprecise estimate, and the available data do not allow reliable analysis of predictors such as slip stability, chronicity, severity, or operative factors. The findings therefore support continued surveillance for AVN rather than a conclusion that the procedure has a low or high risk relative to other techniques.

Other recorded complications were one implant failure (5%) requiring revision surgery at three months, one superficial infection, and one case of heterotopic ossification (5%). Implant failure and reoperation are recognized outcomes reported in studies of the modified Dunn procedure, although rates vary with fixation methods and cohort characteristics [11,12,15]. No nonunion, limb-length discrepancy, growth-plate closure, hip instability or subluxation, or neurological or vascular injury was recorded in this series. These observations describe the events documented in this cohort, but the small sample size limits the ability to estimate uncommon complications. The manuscript does not provide detailed event-specific follow-up or standardized grading for all complications; these details should be added if they are available in the clinical records.

The radiological findings also require cautious interpretation. The mean Southwick angle decreased from 62.2° preoperatively to 7.3° postoperatively, while the mean alpha angle decreased from 93.5° to 41°. A comparative systematic review found better radiological correction of Southwick and alpha angles with the modified Dunn procedure than with in-situ fixation, although it did not find improved clinical outcomes or a significant difference in AVN/chondrolysis odds [13]. The changes in this cohort are directionally consistent with the radiological correction described in the literature, but the manuscript reports summary values without paired statistical testing, individual-level changes, or confidence intervals. Accordingly, the results do not establish statistical significance or show how consistently correction was achieved

across patients. The recorded Tönnis grades and absence of recorded FAI should likewise be interpreted in light of the assessment method and follow-up duration. Longer-term cohort studies have examined survivorship, osteoarthritis, and outcomes after modified Dunn surgery, but their findings should not be directly equated with this 20-patient series unless patient characteristics, slip severity and stability, outcome definitions, and follow-up periods are comparable [19,21–25]. Some reports describe favourable longer-term outcomes, while systematic reviews emphasize variation in reported complications and the need for additional long-term evidence [11,15]. The current study is best viewed as a descriptive contribution from a Bangladeshi tertiary orthopaedic centre. Its prospective design and documentation of functional, radiological, and complication outcomes are useful strengths; its sample of 20 patients, lack of a control group, absence of preoperative functional scores, and follow-up range of 12–50 months limit causal inference and assessment of long-term osteoarthritis or late AVN.

STRENGTHS AND LIMITATIONS

The study's strengths include its prospective observational design, defined institutional setting, and documentation of functional, radiological, and complication outcomes. Limitations include the small sample size, absence of a control group, and follow-up limited to 12–50 months.

CONCLUSION

In this 20-patient cohort, the recorded data suggest substantial radiographic correction and favourable functional scores following the modified Dunn procedure for severe SCFE. AVN was recorded in 2/20 cases (10%), alongside one implant failure, one superficial infection, and one case of heterotopic ossification. These findings remain preliminary until the identified data and reporting gaps are resolved. Longer follow-up and larger comparative studies are needed to clarify the procedure's long-term outcomes and complication profile.

CONFLICT INTERESTS

The authors declare no competing financial, professional, or personal interests related to this manuscript.Funding:

FUNDING

This research received no specific grant from any public, commercial, or not-for-profit funding agency.

ACKNOWLEDGMENTS

The authors thank the teachers and faculty of NITOR, Dhaka, participating patients, hospital staff, colleagues, and all others who contributed to this study.

REFERENCES

1. Lehmann CL, Arons RR, Loder RT, Vitale MG. The epidemiology of slipped capital femoral epiphysis: an update. J Pediatr Orthop. 2006; 26:286–90.
2. Herngren B, Stenmarker M, Vavruch L, Hagglund G. Slipped capital femoral epiphysis: a population-based study. BMC Musculoskelet Disord. 2017; 18:304.
3. Ganz R, Gill TJ, Gautier E, Ganz K, Krügel N, Berlemann U. Surgical dislocation of the adult hip. A technique with full access to the femoral head and acetabulum without the risk of avascular necrosis. J Bone Joint Surg Br. 2001;83(8):1119–1124.
4. Ippolito E, Bellocci M, Farsetti P, Tudisco C, Perugia D. An ultrastructural study of slipped capital femoral epiphysis: pathogenetic considerations. J Orthop Res. 1989; 7:252–9.
5. Peck DM, Voss LM, Voss TT. Slipped capital femoral epiphysis: diagnosis and management. Am Fam Physician. 2017;95(12):779–784.
6. Loder RT. Slipped capital femoral epiphysis. Am Fam Physician. 1998;57(9):2135–2142.
7. Gholve PA, Cameron DB, Millis MB. Slipped capital femoral epiphysis update. Curr Opin Pediatr. 2009;21(1):39–45.
8. Dunn DM. The treatment of adolescent slipping of the upper femoral epiphysis. J Bone Joint Surg Br. 1964; 46:621–9.
9. Dunn DM, Angel JC. Replacement of the femoral head by open operation in severe adolescent slipping of the upper femoral epiphysis. J Bone Joint Surg Br. 1978;60B:394–403.
10. Leunig M, Casillas MM, Hamlet M, et al. Slipped capital femoral epiphysis: early mechanical damage to the acetabular cartilage by a prominent femoral metaphysis. Acta Orthop Scand. 2000; 71:370–5.
11. Gorgolini G, Caterini A, Efremov K, Petrungaro L, De Maio F, Ippolito E, et al. Surgical treatment of slipped capital femoral epiphysis (SCFE) by Dunn procedure modified by Ganz: a systematic review. BMC Musculoskelet Disord. 2022;22(Suppl 2):1064. doi:10.1186/s12891-022-05071-9.
12. Zuo B, Zhu JF, Wang XY, Wang CL, Ma F, Chen XD. Outcome of the modified Dunn procedure in severe slipped capital femoral epiphysis. J Orthop Surg Res. 2020; 15:506.
13. Cheok T, Smith T, Berman M, et al. Is the modified Dunn's procedure superior to in situ fixation? A systematic review and meta-analysis of comparative studies for management of moderate and severe slipped capital femoral epiphysis. J Child Orthop. 2022;16(1):27–34.
14. Ebert N, Rupprecht M, Stuecker R, et al. Outcome of the modified Dunn procedure in severe chronic or acute on chronic slipped capital femoral epiphysis. J Orthop Surg Res. 2019;14(1):349.
15. Sankar WN, Vanderhave KL, Matheney T, et al. The modified Dunn procedure for unstable slipped capital femoral epiphysis: a multicenter perspective. J Bone Joint Surg Am. 2013; 95:585–91.
16. Novais EN, Hill MK, Carry PM, et al. Modified Dunn procedure is superior to in situ pinning for short-term clinical and radiographic improvement in severe stable SCFE. Clin Orthop Relat Res. 2015; 473:2108–17.
17. Abdelazeem AH, Beder FK, Abdel Karim MM, et al. The anatomical reduction of a moderate or severe stable slipped capital femoral epiphysis by modified Dunn subcapital osteotomy using the Ganz approach. Bone Joint J. 2016;98-B (9):1283–8.
18. Madan SS, Cooper AP, Davies AG, Fernandes JA. The treatment of severe slipped capital femoral epiphysis via the Ganz surgical dislocation and anatomical reduction: a prospective study. Bone Joint J. 2013;95-B:424–9.
19. Huber H, Dora C, Ramseier LE, et al. Adolescent slipped capital femoral epiphysis treated by a modified Dunn osteotomy with surgical hip dislocation. J Bone Joint Surg Br. 2011; 93:833–8.
20. Slongo T, Kakaty D, Krause F, Ziebarth K. Treatment of slipped capital femoral epiphysis with a modified Dunn procedure. J Bone Joint Surg Am. 2010; 92:2898–908.
21. Ziebarth K, Zilkens C, Spencer S, et al. Capital realignment for moderate and severe SCFE using a modified Dunn procedure. Clin Orthop Relat Res. 2009; 467:704–16.
22. Lerch TD, Vuilleumier S, Schmaranzer F, et al. Patients with severe slipped capital femoral epiphysis treated by the modified Dunn procedure have low rates of avascular necrosis, good outcomes, and little osteoarthritis at long-term follow-up. Bone Joint J. 2019;101-B (4):403–14.
23. Ziebarth K, Milosevic M, Lerch TD, et al. High survivorship and little osteoarthritis at 10-year follow-up in SCFE patients treated with a modified Dunn procedure. Clin Orthop Relat Res. 2017; 475:1212–28.
24. Persinger F, Davis RL, Samora WP, Klingele KE. Treatment of unstable slipped capital epiphysis via the modified Dunn procedure. J Pediatr Orthop. 2018; 38:3–8.
25. Passaplan C, Gautier L, Gautier E. Long-term follow-up of patients undergoing the modified Dunn procedure for slipped capital femoral epiphysis. Bone Jt Open. 2020;1(4):80–7.