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CASE SERIES

Is Surgical Hip Dislocation Necessary in Slip Reduction? The Preliminary Results of Extended Dunn Technique in Slipped Capital Femoral Epiphysis

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ABSTRACT

Treatment of severe Slipped Capital Femoral Epiphysis (SCFE) using the Modified Dunn technique has become a preferred method, but it carries a steep learning curve. We introduce an alternative technique whereby surgical realignment is performed without a surgical hip dislocation. This series involved five cases (6 hips) of moderate to severe SCFE (slip angle 45° to 60°). This series reviewed the short-term complications, functional status, avascular necrosis, and chondrolysis. Slip severity was moderate in two hips and severe in four hips. Five out of six hips demonstrated satisfactory functional and radiological outcomes. Only one patient with an absence of pre-reduction femoral head bleeding developed avascular necrosis. None experienced slip progression or chondrolysis. In the treatment of severe SCFE, the Extended Dunn is a less traumatic technique, easier to master when compared to other techniques with short-term functional outcome and complication rate comparable to that of Modified Dunn technique.

Keywords: Extended Dunn, Slipped Capital Femoral Epiphysis, Severe Slip SCFE.

INTRODUCTION

The incidence of Slipped Capital Femoral Epiphysis (SCFE) has been static for decades, with an annual incidence ranging from 5-10/100,000 individuals in Canada and the United States.[1-2] Severe SCFE remains a challenging condition and controversy persists regarding the best treatment. In situ pinning appears to be the safest choice of treatment, but an unsatisfactory outcome is almost guaranteed if there is a slip of more than 50 based on the Southwick slip angle classification. Several obstacles exist in preventing a successful in-situ pinning in severe slips. First, an entry point at the intracapsular anterolateral aspect of the femoral neck renders a difficult entry. Second, the screw will traverse the femoral neck horizontally, passing through anterolateral cortex, metaphysis, posteromedial cortex and ending at the center of femoral epiphysis. This leads to tremendous biomechanical stresses on the screw that can result in fixation failure. Even with successful pinning, the hip risks ending up with femoral-acetabular cam impingement (44.4%), due to labral impingement by either the screw or bump, causing premature osteoarthritis, gait disturbances, and poor long-term outcome.[3] The natural progression of a malunited slip is deterioration over time, which is inevitable. Purposeful closed reduction or inadvertent partial reduction in unstable SCFE is associated with a high risk of avascular necrosis (AVN) ranging from 28% to 50%.[4-6] It is therefore no longer acceptable because of this potentially devastating complication.

Several osteotomy techniques have been introduced to correct the deformity in SCFE. However, osteotomy outcome varies, with most associated with a high rate of femoral head osteonecrosis 10% - 100%.[7] Recently, there has been a propensity to realign severe SCFE via surgical hip dislocation using the Modified Dunn technique as the vascular supply to the epiphysis would be safeguarded at the time of manipulation. The Modified Dunn procedure has gained worldwide attention and has become the gold standard in severe SCFE management because of its good outcome and low AVN rate. The key to ensuring adequate epiphyseal perfusion is meticulous development of a long posterior retinacular flap containing important feeding vessels to the epiphysis. AVN rates following the Modified Dunn procedure in Tannast's series was only 2% in 53 hips.[8] Despite that, many surgeons hesitate to perform a surgical hip dislocation because of the steep learning curve.

In this study, we propose an alternative technique, the Extended Dunn procedure, is proposed whereby

realignment of femoral epiphysis is performed without a surgical hip dislocation. With this technique, the ligamentum teres artery is preserved and the femoral epiphysis remains in the socket throughout the surgery. We hypothesize that this technique would provide safe, effective management of severe slips, reduce AVN, restore normal anatomy, and restore hip function to as near normal as possible.

CASE SERIES

This was a prospective observational study with 5 patients (6 hips) with moderate to severe SCFE at a single institution from January 2018 - June 2022. All 5 patients underwent the Extended Dunn procedure, and were operated on by two paediatric orthopaedic surgeons, both from the same institution. In all unilateral involvements, prophylactic pinning of the contralateral hip was done. The case series was registered with national review board (approval number NIH.800-4/4/1 Jld.113).

Surgical Technique: Patients underwent general anaesthesia and were placed in lateral decubitus position. The involved limb was cleaned and draped in a sterile fashion. A straight incision was centred over the greater trochanter. The fasciae latae was incised and split along its fibres followed by excision of trochanteric bursa to expose the underlying structures. The Gibson interval was identified between the gluteus medius and maximus. After retracting the gluteus medius anteriorly, the piriformis and gluteus minimus muscle were visualized. Trochanteric osteotomy was performed leaving the posterior fibers of the gluteus medius tendon attached to the greater trochanter. This step is important to prevent injury to the deep branch of the medial femoral circumflex artery (MFCA). The osteotomised trochanter together with the gluteus medius and vastus lateralis was mobilised anteriorly, exposing the capsule. A Z-capsulotomy was preferred to expose the slipped femoral epiphysis. It is mandatory to avoid tractional injuries to the retinacular vessels at this stage. Two temporary Kirschner wires were inserted at the femoral neck and advanced to the femoral epiphysis under an image intensifier. Once the wires were holding the femoral epiphysis, the limb was externally rotated to expose the anterior part of the femoral head before a 2mm drill bit was used to make a small hole at the visualised epiphysis. Bleeding from the drilling hole indicated viability of the femoral head. With the femoral head in the socket, the periosteum was incised along the femoral neck. Careful periosteal elevation is crucial to develop the retinacular soft tissue flap containing the deep branch of the MFCA, posterior capsule and the short external rotators. At the level of the trochanter osteotomy, part of the superior and posterior cortex were chiselled off to release tension as well as avoid direct injury to the posterior retinacular flap while elevating the periosteum (Figure 1). After complete isolation of flaps until reaching the lesser trochanter, the femoral epiphysis was gently separated from the metaphysis by external rotation (Figure 2). At this point, the posteroinferior retinacular flap was still attached to the femoral epiphysis. Removal of callus at metaphyseal-epiphyseal junction with femoral neck shortening was performed to further prevent tension on the retinacular vessels after reduction. The growth plate at the epiphysis was then removed using a high-speed burr in a controlled manner (Figure 3). Removing the remaining growth plate accelerates consolidation and revascularization of the epiphysis. In order to ensure perfect placement of screws, partially threaded guide wires were drilled from the centre of the metaphyseal stump, exiting just below the trochanter osteotomy site. These guide wires were withdrawn until the wire tip were flush at the metaphyseal stump. Without applying tension onto the posterior retinacular flap, the metaphyseal stump was manually reduced onto the epiphysis in the acetabulum. The previous threaded guide wire was then advanced into femoral epiphysis under an image intensifier without disturbing the articular cartilage. A 7.3mm fully threaded cannulated screw was inserted. Femoral epiphysis perfusion was confirmed again by bleeding femoral epiphysis after reduction (Figure 4). The capsular repair was performed without being watertight as leaving the capsule partially open allows draining of the haematoma, negating the increased intracapsular pressure and tamponade effect.[9] The posterior retinacular flap was then reattached loosely. The greater trochanter was fixed with two 3.5mm cortical screws. All unaffected sides were prophylacti-cally pinned in-situ. Postoperatively, non-weight-bearing ambulation was instructed. Partial weight-bearing was allowed after six weeks when there were signs of healing of the trochanteric osteotomy. Full weight-bearing was permitted after three months when radiological evidence of greater trochanter union and fusion across the physeal plate manifested.

RESULTS

Among these 5 patients, 4 (80%) were males. The Average age at time of surgery was 14.4 ± 5.9 years (range, 11-25 years). The left hip was involved in two

patients, right hip in two patients, and bilateral in one patient. The average duration of symptoms before surgery was 19.6 ± 16.6 days. The mean follow-up was 28.8 ± 14.6 months. No patient was lost to follow-up.

Based on Loder classification, five out of six hips in this series were classified as unstable slips and one hip was stable. To assess the chronicity using Fahey and O'Brien's classification, three hips were designated as acute on chronic slips and another three as acute slips. Based on the Southwick slip angle classification, two slips were considered moderate, and four were classified as severe.

Intra-operatively, femoral head drilling was performed using 2.0mm drill to assess femoral epiphyseal perfusion pre-reduction and post-reduction. Rapid bleeding was observed from five femoral epiphysis before and after epiphyseal reduction. Only one femoral head had no bleeding after drilling for both pre- and post-epiphyseal reduction. The slip angle was improved from a mean of 51 (range 45°-60°) preoperatively, to 8 (range 2-15) postoperatively.

Five out of six hips demonstrated satisfactory functional and radiological outcomes. Four patients with five hips had pain-free ambulation with no AVN. Two examples with results are illustrated in Figure 5.

Only one patient with absent pre-reduction femoral head bleeding developed AVN 6 months post-operatively. None of the patients experienced post-operative hip pain, slip progression or chondrolysis.

A summary of demographic data, peri-operative findings, and treatment outcomes is shown in Table 1.

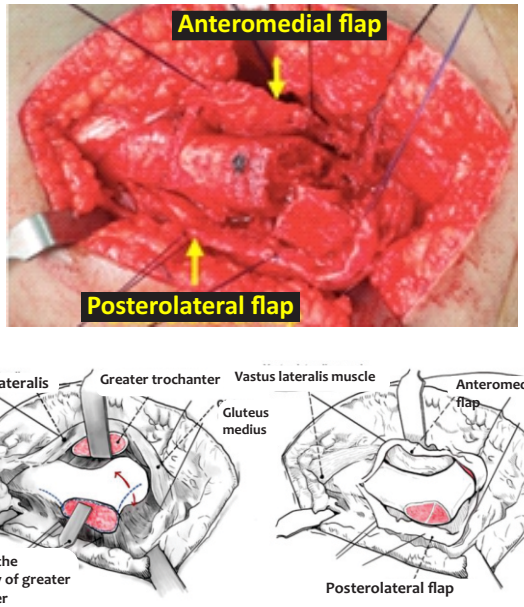


Figure 1: Development of posterior and anterior retinacular flap: Chisel at the periphery of greater trochanter following the blue dotted line to develop retinacular flap

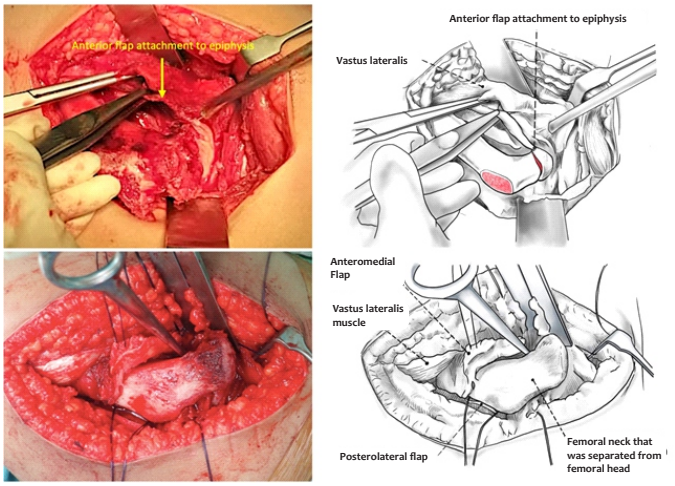


Figure 2: Separation of metaphysis from epiphysis

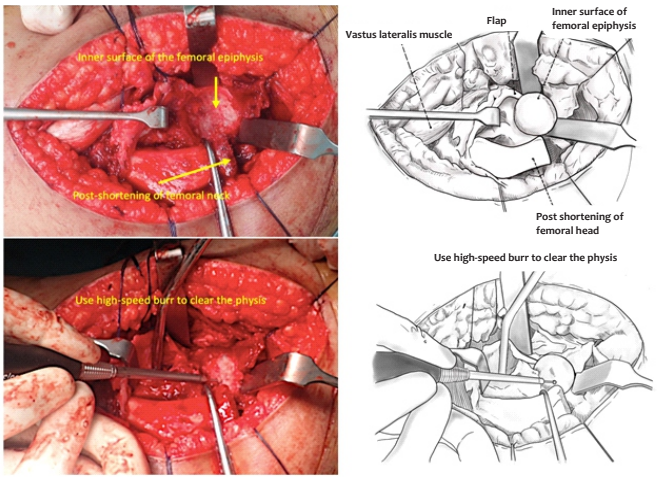
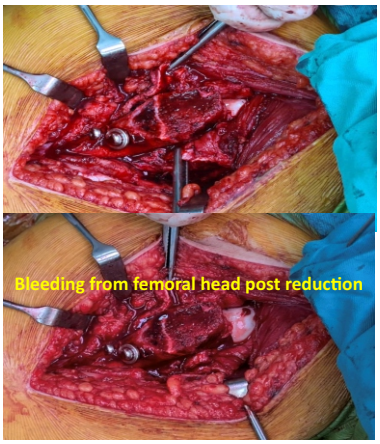


Figure 3: Physeal clearance and neck shortening.



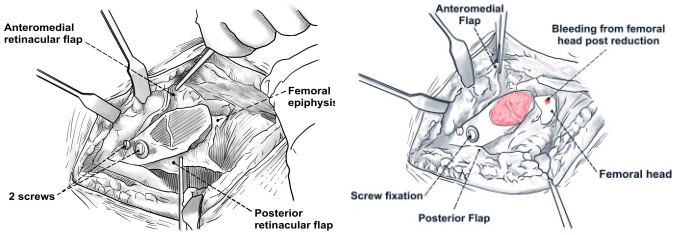


Figure 4: Reduction, fixation, and drilling of femoral head to assess perfusion

Table 1: Clinical summary of all patients and their operative outcomes after Extended Dunn procedure.

Case	Age	Sex	Preexisting Factors	Loder Classification and Chronicity	Preoperative Slip Angle (Based on Lateral Radiograph)	Intra Operative Bleeding from Femoral Head Pre and Post Reduction of Epiphysis	Avascular Necrosis	Chondrolysis	Length of Follow Up
1	25	M	Hypopituitarism secondary to pituitary adenoma	Stable, acute on chronic	60⁰	Present	Partial femoral neck infarction	None	4y5m
2	11	F	No associated medical disease	Unstable, acute	50⁰	No bleeding noted pre reduction	AVN noted at 6 months, lateral head collapse with lateral subluxation	None	2y6m
3	12	M	Obesity, BMI 26	Unstable, acute	55⁰	Present	None	None	2y2m
4*	11	M	Kleefstra syndrome, seizure	Unstable, acute on chronic	Right: 50⁰ Left: 46⁰	Present in bilateral femoral head	None	None	1y7m
5	13	M	No associated medical disease	Unstable, acute	45⁰	Present	None	None	1y4m

AVN: Avascular Necrosis; F: Female; M: Male, Y: Years, M: Months
* Bilateral involvement

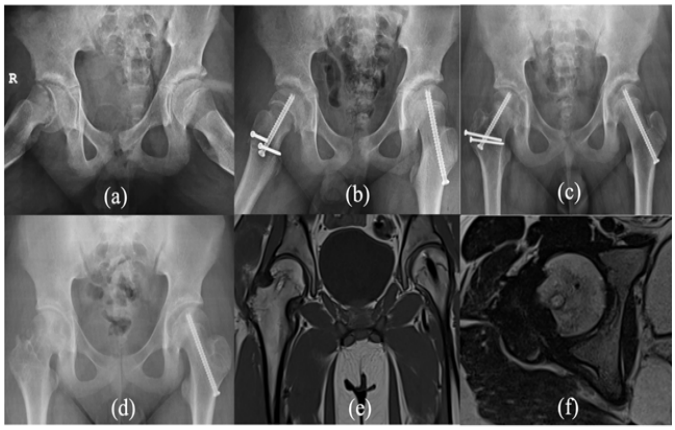


Figure 5: A 13-year-old male presented with acute unstable slip. (a) Pre-operative slip angle was 44. There was bleeding from the femoral head after drilling pre- and post-epiphyseal reduction. (b) Post-operative radiograph following right Extended Dunn Procedure and left in situ pinning. (c) 6 months after surgery, radiograph revealed rounded head with no necrosis of the femoral head. (d) Removal of implants was performed one year after Extended Dunn procedure. (e, f) 16 months post-operative MRI revealed a round femoral head with no avascular necrosis.

DISCUSSION

Management of SCFE has evolved over time. Five decades ago, in situ pinning was considered the gold standard regardless of severity because it provided the best long-term function with the lowest risk of complications.[10] This was partially true as various reduction and osteotomy techniques were associated with an increased risk of osteonecrosis before the emergence of Ganz's surgical hip dislocation and the Modified Dunn technique.[11-13] The natural history of all moderate-severe SCFEs was poor.[14] After the introduction of the Modified Dunn technique, reports of low AVN rates following open reduction and surgical hip dislocation have encouraged re-evaluation of primary reduction. Current trends support primary surgical realignment of severe slips to reduce future morbidity.

We evaluate the safety and efficacy of a new surgical technique for severe SCFE. Surgical steps are similar to the Modified Dunn but no dislocation of femoral epiphysis. Our results showed good short-term clinical and radiological outcomes following the Extended Dunn procedure. Only one patient who had an absence of femoral perfusion before reduction developed radiological evidence of AVN. Our intention to maintain the epiphysis in the socket is to preserve ligamentum teres artery. The importance of ligamentum teres in blood supply to paediatric femoral head has long been proven. Clinical experience strongly supports the preservation of ligamentum teres in any operative procedure.[15,16] It is therefore crucial to make an effort to preserve the ligamentum teres whenever possible.

Dunn first described a treatment protocol for SCFE in 1964.[17] His cervical osteotomy triggered subsequent development of other open-reduction techniques. The pictorial description about the shortened retinacular vessels in chronic slip and the importance of shortening the femoral neck explained the poor results in previous experiences in open reduction. He reported a 4% rate of AVN in 23 hips which underwent open reduction without dislocation using cervical osteotomy. Fish introduced a similar technique for open reduction in 1984.[18] As an additional step, Fish removed the entire physis with the aim to permit passage of metaphyseal blood supply to the epiphysis. With Fish's cuneiform osteotomy in 42 hips, there was only one AVN and one osteoarthritis. Subsequently, no other literature has been able to reproduce the low AVN rate of less than 5% following Dunn's procedure.[11] The surgical hip dislocation by Ganz, is effective in gaining full access to the femoral head without jeopardizing the vascularity.[12] Ziebarth introduced the Modified Dunn procedure in the treatment of SCFE based on the principle of Ganz's surgical hip dislocation.[13] The long posterior retinacular flap is three times longer than the original Dunn technique and the distribution of tension over a larger distance decreases the risk of reduction in epiphyseal perfusion. Early results following Modified Dunn have been promising.[19] In Ziebarth's series, no AVN or chondrolysis was reported. The major differences between Dunn and Modified Dunn are the involvement of surgical hip dislocation, more extensive subperiosteal exposure of the femoral neck with a longer retinacular flap, and physeal clearance in the femoral head in the Modified Dunn procedure. A long-term study evaluating the 10-year result of the Modified Dunn technique showed good results with 2% of AVN.[8] Nonetheless, various small series studying the outcome of the Modified Dunn reported a wide range of AVN ranging from 0%-43%.[8] This inconsistent outcome reflects the technically challenging nature of the Modified Dunn procedure.

The manoeuvre to dislocate the femoral epiphysis may cause chondral injury or epiphyseal fracture. In the Modified Dunn technique, dislocation of epiphysis was performed for inspection post capsulotomy, temporary Kirschner wire fixation and resection of ligamentum teres. Relocation of epiphysis is essential for development of posterior retinacular flap. The temporarily fixed femoral epiphysis was then dislocated again for anteromedial periosteal release.[20] In our opinion,

dislocation of the femoral epiphysis is unnecessary even in severe SCFE. Constant intra-operative control of the femoral head vasculature can be safeguarded with careful subperiosteal exposure of the femoral neck and minute manipulation during dissection. It is vital to ensure zero tractional force during trimming of the metaphyseal callus and manual reduction of the metaphysis on the epiphysis. In the current series, the action of dislocation-relocation-dislocation of the femoral epiphysis is avoided. Fixation of the femoral epiphysis from the articular surface (retrograde technique) is unnecessary as it could be performed using an antegrade method. Reduction of metaphysis onto epiphysis in this technique does not require extra effort.

We believe that this surgical procedure could be the gold standard for the treatment of severe SCFEs. Done correctly, proximal femoral anatomy can be restored primarily with complete correction of the slip angle. Other advantages include reduced risk of chondral injury, preservation of ligamentum teres as well as less surgical steps compared to the Modified Dunn. We acknowledge have several limitations, notably the small number of patients and lack of long-term follow up to evaluate the secondary deterioration. Larger sample size with long-term follow up is required to compare the results with other techniques.

CONCLUSION

In the treatment of severe SCFE, the Extended Dunn procedure is a less traumatic technique that eliminates the necessity to dislocate the femoral epiphysis. This surgical technique showed good short-term functional outcome in our case series with low risk complications.

DISCLOSURE: Figure 1-4 are original figures that are created for this article. It is not based on any previously published image.

CONFLICT OF INTEREST: The authors declare no conflict of interest.

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REFERENCES

1. Ravinsky R, Rofaiel J, Escott BG, Lim Z, Ravi B, Howard A. Epidemiology of Slipped Capital Femoral Epiphysis in Ontario, Canada. J Pediatr Orthop 2019; 39:e165-e7. doi:10.1097/BPO.0000000000001254
2. Lehmann CL, Arons RR, Loder RT, Vitale MG. The epidemiology of slipped capital femoral epiphysis: an update. J Pediatr Orthop 2006; 26:286-90. doi:10.1097/01.bpo.0000217718.10728.70
3. Lang P, Panchal H, Delfosse EM, Silva M. The outcome of in-situ fixation of unstable slipped capital femoral epiphysis. J Pediatr Orthop B 2019; 28:452-7. doi:10.1097/BPB.0000000000000596
4. Napora JK, Morris WZ, Gilmore A, Hardesty CK, Son-Hing J, Thompson GH, et al. Purposeful Closed Reduction and Pinning in Unstable Slipped Capital Femoral Epiphysis Results in a Rate of Avascular Necrosis Comparable to the Literature Mean. Orthopedics 2021; 44:92-7. doi:10.3928/01477447-20210201-02
5. Kitano T, Nakagawa K, Wada M, Moriyama M. Closed reduction of slipped capital femoral epiphysis: high-risk factor for avascular necrosis. J Pediatr Orthop B 2015; 24:281-5.
6. Abu Amara S, Cunin V, Ilharreborde B; French Society of Pediatric Orthopaedics (SOFOP). Severe slipped capital femoral epiphysis: A French multicenter study of 186 cases performed by the SoFOP. Orthop Traumatol Surg Res 2015; 101:S275-S9. doi:10.1016/j.otsr.2015.04.005
7. 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. doi:10.2106/JBJS.I.01385
8. Tannast M, Jost LM, Lerch TD, Schmaranzer F, Ziebarth K, Siebenrock KA. The modified Dunn procedure for slipped capital femoral epiphysis: the Bernese experience. J Child Orthop 2017; 11:138-46. doi:10.1302/1863-2548-11-170046
9. Gordon JE, Abrahams MS, Dobbs MB, Luhmann SJ, Schoenecker PL. Early reduction, arthrotomy, and cannulated screw fixation in unstable slipped capital femoral epiphysis treatment. J Pediatr Orthop 2002; 22:352-58.
10. Loder RT, Aronsson DD, Weinstein SL, Breur GJ, Ganz R, Leunig M. Slipped capital femoral epiphysis. Instr Course Lect 2008; 57:473-98.
11. Lawane M, Belouadah M, Lefort G. Severe slipped capital femoral epiphysis: the Dunn's operation. Orthop Traumatol Surg Res 2009; 95:588-91. doi:10.1016/j.otsr.2009.07.014
12. Ganz R, Gill TJ, Gautier E, Ganz K, Krugel 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; 83:1119-24. doi:10.1302/0301-620x.83b8.11964
13. Ziebarth K, Zilkens C, Spencer S, Leunig M, Ganz R, Kim YJ. Capital realignment for moderate and severe SCFE using a modified Dunn procedure. Clin Orthop Relat Res, 2009; 467:704-16. doi:10.1007/s11999-008-0687-4
14. Weinstein SL. Natural history and treatment outcomes of childhood hip disorders. Clin Orthop Relat Res 1997; 227-42.

15. Bardakos N V, Villar RN. The ligamentum teres of the adult hip. J Bone Joint Surg Br 2009; 91:8-15. doi:10.1302/0301-620X.91B1.21421
16. Perumal V, Woodley SJ, Nicholson HD. Neurovascular structures of the ligament of the head of femur. J Anat 2019; 234:778-86. doi:10.1111/joa.12979
17. Dunn DM. The treatment of adolescents slipping of the upper femoral epiphysis. J Bone Joint Surg Br 1964; 46:621-9.
18. Fish JB. Cuneiform osteotomy of the femoral neck in the treatment of slipped capital femoral epiphysis. J Bone Joint Surg Am 1984; 66:1153-68.
19. Masse A, Aprato A, Grappiolo G, Turchetto L, Campacci A, Ganz R. Surgical hip dislocation for anatomic reorientation of slipped capital femoral epiphysis: preliminary results. Hip Int 2012; 22:137-44. doi:10.5301/HIP.2012.9208
20. Ganz R, Huff TW, Leunig M. Extended retinacular soft-tissue flap for intra-articular hip surgery: surgical technique, indications, and results of application. Instr Course Lect 2009; 58:241-55.