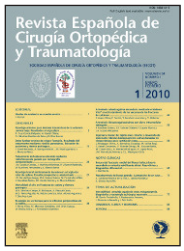
Rev esp cir ortop traumatol. 2011;**55(2)**:110-115

Revista Española de Cirugía Ortopédica y Traumatología

www.elsevier.es/rot



ORIGINAL ARTICLE

Cuneiform osteotomy of femoral neck as treatment for slipped capital femoral epiphysis sequelae

D. Parodi, [a,b,c,*] **J. Besomi,** [a, b, c] **C. Tobar,** [a,b,c] **J. Valderrama,** [a,c] **L.E. Moya,** [a,b,c] **C. Mella,** [a,c] **J. Lara,** [a,c] **J. López** [a,b,c]

[a] *Unidad de Cadera y Pelvis, Clínica Alemana de Santiago, Chile*
[b] *Departamento de Traumatología, Hospital Padre Hurtado, Chile*
[c] *Facultad de Medicina Clínica Alemana, Universidad del Desarrollo, Chile*

Received September 5, 2010; accepted December 22, 2010

KEYWORDS
Epiphysiolysis;
Surgical hip dislocation;
Femoroacetabular impingement;
Hip osteoarthritis

Abstract
Introduction: Abnormal hip anatomy of untreated Slipped Capital Femoral Epiphysis (SCFE), a prototype of cam impingement deformity, is a cause of early hip degeneration.
Objective: To describe an original technique of cuneiform osteotomy of the femoral neck to relocate femoral epiphysis in patients with sequelae of SCFE.
Methods: Seven hips in 6 male patients with sequelae of severe SCFE, with a mean age of 15 years (13-16), and with a mean of 9.2 months of hip pain and severe limp, were treated. All of the cases had closed growth cartilage at the time of consultation.
Surgical technique and results: In all cases we performed a cuneiform osteotomy of the femoral neck with relocation of epiphysis. A dissection and elevation of cervical periosteum to protect the epiphyseal vessels of the femoral head was performed. Then, the cuneiform osteotomy of the femoral neck was performed with relocation of the femoral epiphysis to the anatomical position and osteosynthesis. We achieved an epiphyseal-shaft angle correction from 66º preoperative to 11º postoperative. The mean follow up was 37 months (4-59).
Conclusion: Cuneiform osteotomy of the femoral neck proposed in patients with sequelae of SCFE is an alternative treatment that achieves good anatomical and imaging results in young patients.

*Corresponding author.
E-mail: danteparodi@gmail.com (D. Parodi).

PALABRAS CLAVE
Epifisiólisis;
Luxación controlada de cadera;
Pinzamiento femoro-acetabular;
Osteoartritis de cadera

Osteotomía cervical cuneiforme femoral para el tratamiento de la secuela de epifisiólisis

Resumen
Introducción: La alteración anatómica de la epifisiólisis no tratada, prototipo de la deformidad del pinzamiento femoro-acetabular tipo cam, causa degeneración articular precoz de la cadera.
Objetivo: Describir una técnica original de osteotomía cervical cuneiforme (OCC) para reposicionar anatómicamente la epífisis femoral, en la secuela de epifisiólisis.
Material y método: Se operaron 7 caderas en 6 pacientes masculinos, con secuela de epifisiólisis severa; edad promedio de 15 años (13-16), cuyo motivo de consulta fue coxalgia y claudicación severa de 9,2 meses promedio. Todos con cierre del cartílago fisiario femoral al momento de la consulta.
Técnica quirúrgica y resultados: En todos los casos se realizó una OCC y reposición de la epífisis femoral. Se realizó disección y elevación del periostio cervical para proteger los vasos epifisiarios de la cabeza femoral; a continuación se realizó la OCC, se reposicionó la epífisis femoral en la ubicación anatómica y se realizó una osteosíntesis. Se logró una corrección del ángulo eje epifisiario desde 6° preoperatorio a 11° postoperatorio. El seguimiento promedio fue 37 meses (4-59).
Conclusión: La OCC femoral, propuesta en pacientes con secuela de epifisiólisis, es una alternativa de tratamiento, que logra buenos resultados anatómicos y radiológicos en pacientes jóvenes.

Introduction

Epiphysiolysis or slipped capital femoral epiphysis (SCFE) corresponds to an anterior-superior displacement of the metaphysis through the physis over the femoral epiphysis, which remains in the acetabulum. This failure at the growth cartilage level creates a three-dimensional deformity characterized by varus of the distal fragment in the coronal plane, extension in the sagittal plane and external rotation in the axial plane.[1] This pathology is of unknown etiology, occurs in adolescence and has an incidence of 0.2-10 per 100,000.[1,2] Its main risk factors are biomechanical (obesity, femoral retroversion and increased physeal obliquity) and biochemical (hormonal changes of puberty), which together lead to further weakness of the physis.[1,3] It is more common in men (60%).[1,2] It is bilateral in 20%-50% of cases and the mean age at diagnosis is 13.5 years for males and 12 in females.[1]

It is currently classified as stable or unstable depending on the walking ability of the patient; stable when the patient is able to walk with or without a cane and typically appears with coccydynia, limping and limitation of motion range, particularly internal rotation; and unstable when the patient is unable to walk with or without a cane and usually suffers intolerable pain. This classification has prognostic value in terms of risk of developing complications such as avascular necrosis (AVN).[1,4]

The diagnosis is confirmed by anterior-posterior (AP) radiograph and Lauenstein projection, which shows the posteroinferior displacement of the epiphysis in relation to the metaphysis. In addition, the AP pelvis radiograph should show the Steel sign (double radiographic density given by the superposition of the epiphysis and medial metaphysis) and the epiphysis just below the Klein line drawn on the anterior-superior edge of the femoral neck (fig. 1). The severity of SCFE can be classified according to the degree of displacement of the epiphysis on the metaphysis into mild (<33%), moderate (33%-50%) or severe (>50%)[1,5]; or according to the difference between the angles of the epiphyseal axle into mild (<30º), moderate (30-50º) or severe (>50º).[1,6]

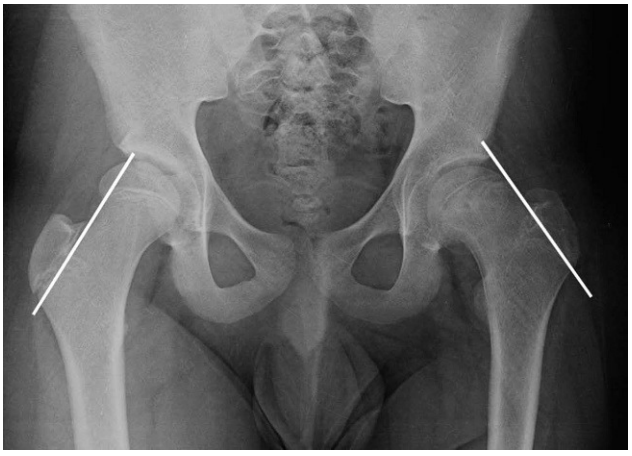


Figure 1 Radiograph of AP pelvis, showing the epiphysis below the Klein line on the left hip, a radiological sign of SCFE.

Early treatment is indicated to prevent progression and complications: AVN and chondrolysis. The treatment recommended most often is *in situ* fixation with a screw for stable SCFE; for unstable SCFE, it is immediate or urgent

Figure 2 Lauenstein radiograph, showing the sequelae of severe SCFE on the left hip (67-12º = 55º).

joint aspiration (to remove the haematoma, reduce intra-articular pressure and improve perfusion to the femoral head[7]), followed by reduction and fixation with a screw.[1,8,9] Therapeutic approaches have recently been proposed that aim to restore anatomy in acute SCFE by Dunn surgery modified through SHD (Surgical Hip Dislocation).[10,11] The aim is to restore hip function and free mobility of femoro-acetabular impingement, so as to prevent early joint degeneration in future. There is still controversy regarding the degree of displacement of the femoral epiphysis tolerable without compromising its function and avoiding early osteoarthritis.[11,12]

However, the treatment for the sequelae of SCFE -once bone healing has occurred- is still controversial.[13,14] Biring GS et al[14] published a series of 25 hips operated on by subcapital cuneiform osteotomy, as described by Fish,[15] using a Watson Jones approach in patients with severe SCFE and skeletal maturity; they obtained satisfactory clinical and radiological results in the medium term, with a complication rate of 28%(12%AVN and 16%chondrolysis).[14]

The anatomical alteration that occurs at the level of the femoral neck-head junction as a result of untreated SCFE is the prototype of the deformity resulting from femoro-acetabular impingement of cam type,[16,17] with a high risk of developing early degenerative joint disease of the hip.[12,18,19] The displacement of the epiphysis that occurs in SCFE alters the biomechanics of the coxofemoral joint, causing hip osteoarthritis.[20,21]

To restore the anatomy, improve function and prevent joint degeneration towards osteoarthritis,[12,20,21] we describe cervical cuneiform osteotomy by SHD as an original technique for the handling of severe SCFE sequelae with bone consolidation in young patients.

Material and method

We performed a prospective study of a case series for the treatment of 7 hips (6 patients, 2 bilateral), with sequelae of severe SCFE,[1,6] (fig. 2), all with bone consolidation and closure of the physis. All the patients were male, with an average age of 15 years (13-16), and had attended consultation due to severe coccydynia and claudication with a mean evolution of 9.2 months (range, 6-12 months) and limiting the range of joint mobility. The radiological study consisted of AP pelvis radiograph and Lauenstein projection, which measured the epiphyseal axle angle, and severity was classified according to the Southwick method.[6] Computed tomography (CT) was used to confirm bone consolidation of the growth cartilage, carry out surgical planning, compare the postoperative results and confirm the consolidation of cervical osteotomy and of the major trochanter by evidence of bone trabeculae passage.

All hips were operated by cervical cuneiform osteotomy (CCO) using SHD[11,22] as an approach, at the Padre Hurtado Hospital in Santiago de Chile, during the years 2005 to 2010. Patients were followed up periodically with radiological analyses including radiograph and CT for the evaluation of the results, consolidation and presence of AVN at 3, 6 and 12 postoperative months and then annually. All patients followed the same rehabilitation program, consisting of partial load with 2 canes for the first 6 weeks and then progressive load increase for the next 6 weeks. Full range of hip mobility was allowed during this period, supervised by a physical therapist. The return to activities of daily living (ADL) took place after 3 months, and sports activities were resumed 18 months after surgery, with confirmed bone healing.

To carry out this study, we obtained informed consent from all patients and their tutors, as well as approval from the institution (IRB).

Surgical technique

The patient was placed in a lateral position for the approach to the hip with SHD.[22] Once the femoral head was dislocated, the junction of femoral head and neck was identified at the metaphyseal level and the exuberant bone callus located in the anterior-superior region of the femoral neck was resected. Next, a periosteal flap was raised towards the posterolateral area of the neck and major trochanter, which contained the epiphyseal vessels of the femoral head. The periosteal flap was protected by a thin periosteal elevator. Subsequently, the CCO resection of the anterior and superior base was performed, perpendicular to the axis of the neck and posterior and inferior vertices, using an oscillating saw or osteotome, taking care not to damage the periosteum and epiphyseal vessels protected by the periosteum elevator (fig. 3). This periosteal flap should be extended as much as possible in the proximal direction, to protect the vessels. Once the wedge was obtained and excised, the femoral head was repositioned in an anterior direction, with internal rotation of the lower extremity, centring in relation to the femoral neck (fig. 4). Next, distal to the proximal fixation was carried out using a temporary Kirschner needle and 2 6.5mm AO GF cancellous screws, the edges of the cartilage were stabilised and the acetabulum was also inspected. Reduction of the femoral head in the acetabulum was performed, ensuring it was left free of femoro-acetabular impingement in 90° flexion and 20° internal rotation. Lastly,

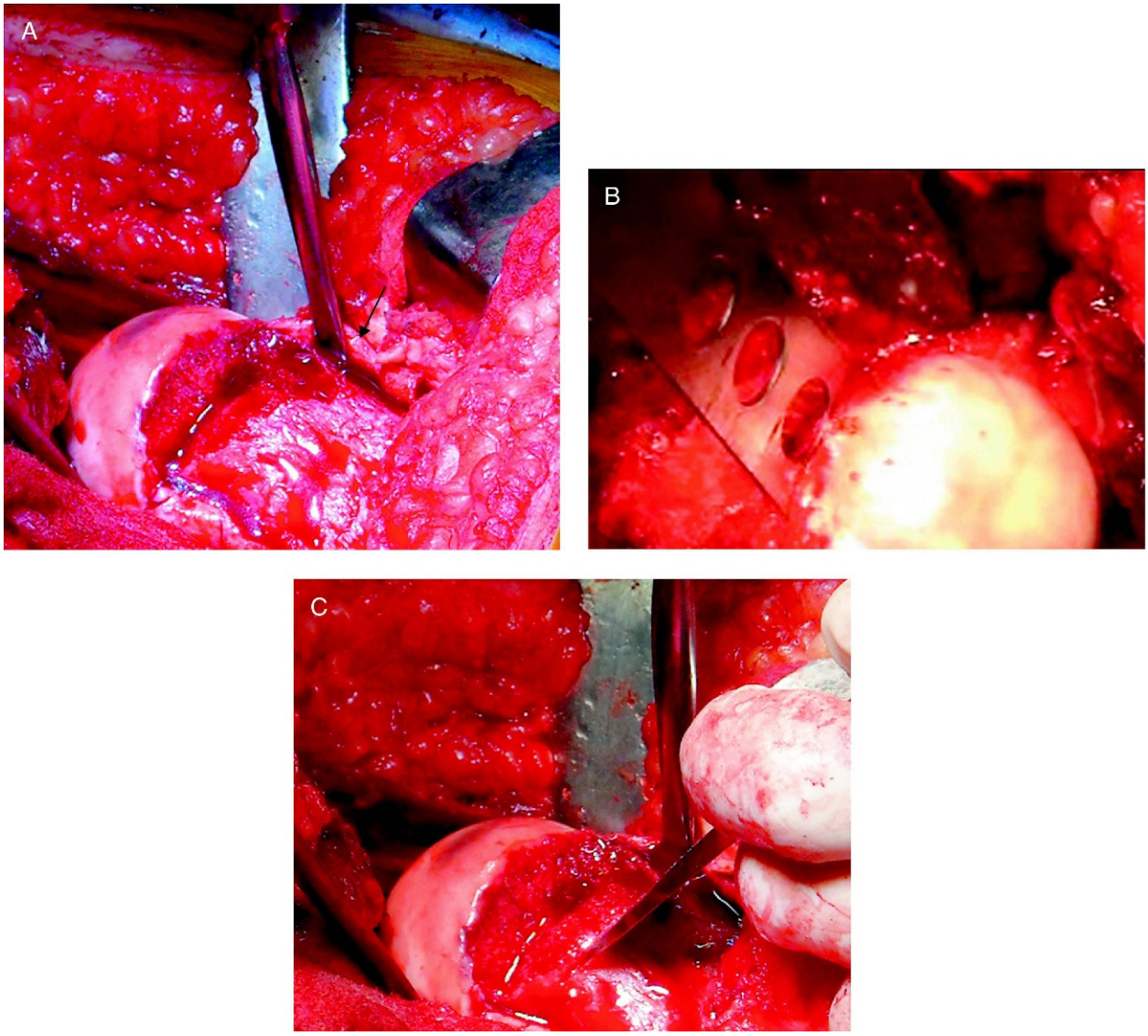


Figure 3 A) Protection of femoral epiphyseal vessels using a periosteal elevator. The arrow shows the periosteum containing epiphyseal vessels. B) Cervical osteotomy using an oscillating saw. C) Cervical osteotomy using an osteotome.

Table 1 Southwick Severity Classification[6]

	Preoperative angle	Classification	Postoperative angle	Classification*
1	(66–12) = 54°	Severe	12º	Normal
2	(67–12) = 55°	Severe	12º	Normal
3	(66–12) = 54°	Severe	10º	Normal
4	(68–12) = 56°	Severe	12º	Normal
5	(67–12) = 55°	Severe	12º	Normal
6	(65–12) = 53°	Severe	12º	Normal
7	(66–12) = 54°	Severe	11º	Normal
x	(66–12) = 54°	Severe	11.1º	Normal

*Based on to the normal epiphyseal angle studied by Aronson et al[23] and Santili et al.[24]

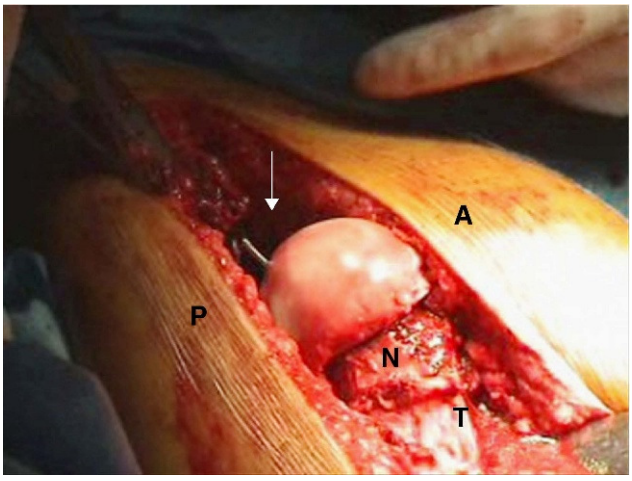


Figure 4 Repositioned femoral head. A: anterior, P: posterior, N: femoral neck, T: major trochanter. The arrow shows the acetabulum.

the joint capsule was closed and the major trochanter was fixed with 2×3.5mm AO GF cortical screws. Closure was performed by layers and no drainage was set.

Results

The radiological analysis, conducted by an independent observer from the surgical team, showed an improvement in the epiphyseal shaft angle from 66º on average (65-68º) preoperatively to 11.1° (10-12°) postoperatively (Δ 55) (table 1) (fig. 5).

The mean follow up was 37 months (4-59 months). Bone consolidation was obtained in all cases at 10.2 weeks (8-12) after the intervention, on average. One patient reported discomfort in relation to the osteosynthesis material of the major trochanter, which was surgically removed 18 months after surgery with a favourable response. There were no cases of delayed consolidation of the cervical osteotomy or the major trochanter osteotomy. There were no further complications.

All cases complied with the rehabilitation program established, with return to sports activities at 18 months after the intervention.

Figure 5 Postoperative Lauenstein radiograph showing replacement and normalisation of the epiphyseal axle angle.

Discussion

Current evidence shows that the femoral-acetabular impingement poses a risk of joint degeneration for the hip joint.[18,19] A sequel of SCFE is an established cause of cam-type impingement[12,13] with a high risk of early coxarthrosis.[12,18,19] Deformity of the proximal femur causes a loss of the anterior-superior offset in the union of the femoral head and neck. The challenge is thus to achieve anatomical correction in this group of young patients.

Multiple surgical treatments have been proposed for the treatment of these sequelae, based on corrective osteotomies at different levels depending on the physeal closure and the degree of deformity of the femoral head-neck union. In the 70s and 80s, authors like Fish,[15] Dunn[25] and Abraham[26] designed corrective osteotomies with variable results regarding the degree of correction and high AVN rates. In 1994, Fish described a technique in which a cuneiform osteotomy of the femoral neck was performed to correct the anatomical defect that occurred in patients with moderate to severe and chronic SCFE using the Watson Jones[15] anterior approach. Subsequently, Biring published data in 2006 using the same technique in patients who had reached skeletal maturity, with results that were not exempt from complications: 12% of avascular necrosis and 16% of chondrolysis.[14] In 2007, Leunig et al[10] described a safe technique with good medium-term results in patients with acute, acute on chronic or chronic SCFE, carrying out surgical hip dislocation, resection of the soft metaphyseal bone callus and a soft tissue flap to protect the femoral epiphyseal vessels. The authors suggest their technique as indicated for patients with ossification of the growth cartilage, but warn of the technical difficulties existing for the mobilisation of the epiphysis as they describe it.[10,11] The main difference with our proposed technique is that we performed a cuneiform resection osteotomy at the level of the femoral neck. Our proposal describes a technique for treating patients with sequelae of SCFE, once bone consolidation and/or physeal closure has taken place, making a cuneiform cervical osteotomy with a periosteal flap, through a controlled surgical hip dislocation as described by Ganz et al and Leunig et al,[10] obtaining vascular protection of the irrigation of the femoral head and minimising the risk of avascular necrosis.

The approaches used by Biring, Dunn, and Fish, unlike our approach with SHD, did not make adequate bone exposure possible or were insufficient for significant corrections, so their indications were limited. The surgical techniques attempting to reduce physeal displacement in an open manner carried unacceptable rates of AVN and chondrolysis over 35% In 2007, Coapa et al[27] reported 20% of AVN in cervical osteotomies with an anterior hip approach.

Subsequently, in the 90s, thanks to a better anatomical understanding of the vascularisation of the femoral head, Ganz[22] described the technique for controlled surgical hip dislocation used for the treatment of femoral-acetabular impingement, achieving complete joint exposure without the risk of AVN. Using this technique as a surgical approach, we can expose the hip fully, especially at the site of the neck-head union. Furthermore, we can identify the entry site of the epiphyseal vessels, so we can perform osteotomies with the assurance of avoiding damaging femoral head irrigation by conducting a thorough mobilisation of the periosteal flap containing the vessels. Our treatment by cuneiform resection osteotomy achieves correction of hip bone deformity at the site of occurrence, so no secondary deformities are added, as is the case with intertrochanteric or subtrochanteric osteotomies; our treatment leaves a consistent joint, with restored normal anatomy and full mobility, free from femoro-acetabular impingement. Although our case series has limitations due to its small size and lack of long-term monitoring, the results are promising.

Cuneiform femoral neck osteotomy described in patients with severe SCFE sequelae (with ossification of the growth cartilage) is, in this small group, a good alternative treatment that achieves good anatomical and radiographic results in young patients.

Level of evidence

Level of evidence IV.

Conflict of interest

The authors declare no conflict of interest.

References

1. Aronsson DD, Loder RT, Breur GJ, Weinstein SL. Slipped capital femoral epiphysis: current concepts. J Am Acad Orthop Surg. 2006;14:666–79.
2. Loder RT. The demographics of slipped capital femoral epiphysis: an international multicenter study. Clin Orthop Relat Res. 1996;322:8–27.
3. Loder RT, Aronson DD, Dobbs MB, Weinstein SL. Slipped capital femoral epiphysis. Instr Course Lect. 2001;50:555–70.
4. Loder RT, Richards BS, Shapiro PS, Reznick LR, Aronson DD. Acute slipped capital femoral epiphysis: The importance of physeal stability. J Bone Joint Surg Am. 1993;75:1134–40.
5. Jacobs B. Diagnosis and natural history of slipped capital femoral epiphysis. Instr Course Lect. 1972;21:167–73.
6. Southwick WO. Compression fixation after biplane intertrochanteric osteotomy for slipped capital femoral epiphysis: a technical improvement. J Bone Joint Surg Am. 1973;55:1218–24.
7. Beck M, Siebenrock KA, Affolter B, Notzli H, Parvizi J, Ganz R. Increased intraarticular preassure reduces blood flow to the femoral head. Clin Orthop Relat Res. 2004;424:149–52.
8. Aronsson DD, Loder RT. Treatment of the unstable (acute) slipped capital femoral epiphysis. Clin Orthop Relat Res. 1996;322:99–110.
9. Stevens DB, Short BA, Burch JM. In situ fixation of the slipped capital femoral epiphysis with a single screw. J Pediatr Orthop. 1996;5:85–9.
10. Leunig M, Slongo T, Kleinschmidt M, Ganz R. Subcapital correction osteotomy in slipped capital femoral epiphysis by means of surgical hip dislocation. Oper Orthop Traumatol. 2007;19:389–410.
11. 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.
12. Goodman DA, Feighan JE, Smith AD, Latimer B, Buly RL, Cooperman DR. Subclinical slipped capital femoral epiphysis. Relationship to osteoarthrosis of the hip. J Bone Joint Surg Am. 1997;79:1489–97.
13. Mooney 3rd JF, Sanders JO, Browne RH, Anderson DJ, Jofe M, Feldman D, et al. Management of unestable/acute slipped capital femoral epiphysis: results of a survey of the POSNA membership. J Pediatr Orthop. 2005;25:162–6.
14. Biring GS, Hashemi-Nejad A, Catterall A. Outcomes of subcapital cuneiform osteotomy for the treatment of severe slipped capital femoral epiphysis after skeletal maturity. J Bone Joint Surg (Br). 2006;88-B:1379–84.
15. Fish JB. Cuneiform osteotomy of the femoral neck in the treatment of slipped capital femoral epiphysis: a follow-up note. J Bone Joint Surg Am. 1994;76-A:46–59.
16. Rab GT. The geometry of slipped capital femoral epiphysis: implications for movement, impingement, and corrective osteotomy. J Pediatr Orthop. 1999;19:419–24.
17. Zebala LP, Schoenecker PL, Clohisy JC. Anterior femoroacetabular impingement: A diverse disease with evolving treatment options. The Iowa Orthop J. 2007;27:71–81.
18. Ganz R, Parvizi J, Beck M, Leunig M, Nötzli H, Siebenrock KA. Femoroacetabular impingement: a cause for osteoarthritis of the hip. Clin Orthop Relat Res. 2003;417:1–9.
19. Leunig M, Beaulé PE, Ganz R. The concept of femoroacetabular impingement: current status and future perspectives. Clin Orthop Relat Res. 2009;467:616–22.
20. Murray RO. The aetiology of primary osteoarthritis of the hip. Radiol. 1965;38:B10–24.
21. Stulberg SD, Cordell LD, Harris WH, Ramsey PL, MacEwen G. Unrecognized childhood hip disease a major cause of idiopathic osteoarthritis of the hip In: Procs third open scientific meeting of the Hip Society. C V Mosby;. 1975:212–28.
22. 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-B:1119–24.
23. Aronson DD, Peterson DA, Miller DV. Slipped capital femoral epiphysis: The case for internal fixation in situ. Clin Orthop Relat Res. 1992;281:115–22.
24. Santili C, Camargo de Assis M, Ige Kusabara F, Lopes Romero I, Sartini CM, Longui CA. Southwick's head-shaft angles: normal standards and abnormal values observed in obesity and patientswith epiphysiolysis. J Pediatr Orthop B. 2004;13:244–7.
25. Dunn DM. The treatment of adolescent slipping of the upper femoral epiphysis. J Bone Joint Surg Br. 1964;46:621–9.
26. Abraham E, Garst J, Barmada R. Treatment of moderate to severe slipped capital femoral epiphysis with extracapsular base-of-neck osteotomy. J Pediatr Orthop. 1993;13:294–302.
27. Coapes CM, Alcelik I, Savvides P, Adedapo A, Montgomery R. Osteotomy of the femoral neck for severe slipped capital femoral epiphysis. Injury Extra. 2007;38:29.