Levels of evidence in the treatment of slipped capital femoral epiphysis: a systematic review

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Abstract

The primary aim of this study was to analyze the current level of evidence available on the surgical management of Slipped Capital Femoral Epiphysis (SCFE). Secondary aims were to correlate the level of evidence with the impact factor of the journal to evaluate the level of evidence over time, and to evaluate the geographic distribution of the studies. Therapeutic studies published in English between January 1991 and August 2014 that reported on SCFE were identified via electronic search performed using the databases PubMed, EMBASE, and the Cochrane Library. The search terms used included: Slipped capital femoral epiphyses OR SCFE OR Slipped upper femoral epiphyses OR SUFE AND Management OR Treatment. Correlation between the level of evidence and the impact factor of the journal were analyzed together with linear regression models to reveal any significant trends over time. A total of 1516 studies were found, of which 321 were included in the final analysis. The most frequent study type was the case series (51.1%) followed by case reports (22.4%) and expert opinions (14.0%). Randomized control trial accounted for only 0.6%. The Journal of Pediatric Orthopedics (American) had the most studies (22.6%) and the highest number of level 2 (n = 1) and level 3 (n = 15) type evidence. There was no progression of level of evidence over time. There was no correlation between level of evidence and impact factor of journal. The majority of therapeutic studies on SCFE are of low level of evidence. High-level RCTs are difficult to perform in pediatric orthopedic surgery, however the management of SCFE would benefit from well-designed, multicenter, clinical RCTs to advance evidence-based practice.

Introduction

Slipped capital femoral epiphysis (SCFE) is the most common hip disorder affecting adolescents with an estimated incidence of between 1 to 24.6 per 100,000 children between the ages of 8 and 15.1,2 The relative frequency to Caucasians is highest with Polynesians (5.6:1), Blacks (3.9:1) and Hispanics (2.5:1).1 Delayed diagnosis is believed to be the most important factor associated with poor outcomes.3,4 Less severe and stable slips have been successfully managed with in situ pinning to protect against further displacement. The treatment of high grade unstable slips is more controversial with a recent trend toward surgical hip dislocation and reduction of the slip normally with a corrective femoral osteotomy.5 The residual healed deformity can lead to femoro-acetabular impingement (FAI) and eventual degenerative osteoarthritis.5,7

The concept of evidence-based medicine (EBM) was first described in the 1980’s as the conscientious, explicit, and judicious use of the current best evidence in making decisions about the care of individual patients. EBM grading system can be obtained in the Oxford Centre for Evidence-Based Medicine (CEBM).7 A study gave a level from 1 to 5 on the basis of its design and as 1 of 4 different types on the basis of its content. Level 1 is the highest level of evidence, which includes high quality, randomized controlled trials (RCTs); and level 5, is the lowest level of evidence, and includes expert opinions. This system is accepted and used by most of the medical world including most orthopedic journals. Despite the importance of SCFE, to our knowledge there are few studies that explore the surgical management of SCFE and to categorize them by study type and level of evidence as proposed by the Oxford CEBM.

Materials and Methods

This review adheres to the methodology set down in the Preferred Reporting Items for Systematic reviews and Meta-analyses guidelines and the Cochrane handbook.10 A systematic electronic search was performed using PubMed (Medline), EMBASE, and the Cochrane Library. Studies published from January 1st, 1991 to August 1st, 2014 were included. The following search terms were used: Slipped capital femoral epiphyses OR SCFE OR Slipped upper femoral epiphyses OR SUFE AND Management OR Treatment. Only papers written in English were included.

Study selection

The first two authors sorted the studies based on abstracts from the electronic search. Each author sorted through the databases, which was then validated by the other author. The included studies were then sorted into CEBM study types (Table 1) and into treatment type. If a study involved multiple treatment types it was placed in category that the majority of the study involved. If the abstract did not provide enough information for classification then the full text was obtained (n = 128). Once the decision was made to include the manuscript for further analysis then authorship and journal of publication were assessed. Any disagreements between reviewers were resolved by discussion. The senior author was consulted if a consensus could not be reached at any stage of the analysis and categorization.

Inclusion and exclusion criteria

We included all studies in English that had a primary emphasis on the therapeutic management of SCFE. Prognostic and diagnostic studies were included if they defined the relationship between the treatment and the clinical outcomes. Studies that reported solely on outcomes (e.g. CT evaluation of screw position) without clinical correlation were excluded. Reviews including systematic reviews were excluded if they did not primarily report on the management of SCFE. Studies involving patients with genetic or metabolic disturbances associated with SCFE were excluded. Studies on animals, anesthesia and analgesia, biology and histology, cadavers, diagnostic tools, economics, epidemiology, imaging results without clinical outcome, rehabilitation protocols, revision surgery, and surgery for long term complications such as hip arthroplasty for osteoarthritis were excluded. Furthermore, editorials, letters, notes, proceedings, and conference abstracts were also excluded.

Key words: Levels of evidence; systematic review; slipped capital femoral epiphysis; management. Contributions: the authors contributed equally. Conflict of interest: the authors declare no potential conflict of interest.

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Data selection
A database was created using Microsoft Access (v. 2010, Microsoft). The data extracted from the reviewed papers included: title, author, year, journal, volume, issue, pages, ISSN, abstract, database provider, category, study type, level of evidence, and country. All higher-level studies [RCT and systematic review (SR)] had a deeper analysis performed. The RCT was ranked level 2 if it had lesser quality with regards to follow up, randomization and blinding. Level of evidence of the studies determined the SR level. General reviews were classified as expert opinions (level 5) as they do not meet the Cochrane criteria of a systematic review. The level of evidence attributed to the study by the publishing journal was reviewed and in any cases of discrepancy the researchers’ assessment was used.

Synthesis of results
Statistical analysis was performed using Stata (StataCorp. 2009. Stata Statistical Software: Release 11. College Station, TX: StataCorp LP). Pearson correlation coefficients were calculated between the mean level of evidence and impact factor of journals that had 10 or more articles included.

Results
The electronic search yielded a total of 1516 results from the Medline (n=810), EMBASE (n=698) and Cochrane databases (n=8). A total of 610 duplicate articles were removed: 8 were from PubMed; 602 were from EMBASE. Of the remaining 906 records, 452 were removed following screening of the abstracts leaving a total of 454 records. Of records, 133 were screened, based on the full text for a remaining 321 records, of which 307 were from PubMed, 12 were EMBASE and 2 from the Cochrane library (Figure 1).

Characteristics of studies
The most frequent study type was the case series (n=164; 51.1%) followed by case reports (n=72; 22.4%). The results from categorization are shown in Table 1. The most frequent level of evidence was type 4 (n=166; 51.7%) and results of the level of evidence classification are shown in Table 2. The level 2 evidence studies were both RCTs (n=2; 100%).

The top 8 journals by number of publications represented 63.9% of all studies (Table 3). The Journal of Pediatric Orthopaedics (JPO), The Journal of Pediatric orthopaedics B (JPOB) and Clinical Orthopaedics and Related Research (CORR) had the most number of
studies at 46.7% of all studies. JPO had the most studies (n=74; 22.6%) and the highest number of level 2 (n=1) and level 3 (n=15) type evidence. There was no significant correlation between the level of published evidence and journal impact factor (Table 3).

Over the 23.5-year time period examined, there has been no change in the mean level of evidence published. The majority of studies from 1991 to 2003 were level 4 and 5 case series/reports (91%) and this remained relatively unchanged by 2014 (87.6%). The geographical location of the studies is given in Table 4. North American journals were noted to have published 58.9% of the available literature within the reference period, 23.1% of publications originated from Europe and 11.5% from Asia with the remaining publications equally distributed across Africa, Australia and the Middle East.

The largest amounts of studies examining the surgical treatment options in SCFE were those involving the use of single percutaneous in situ screws. Most of the studies were level 4 (n=55) followed by level 3 (n=12) and level 2 (n=1) evidence as displayed in Table 5.

### Discussion and Conclusions

The aim of this study was to evaluate the quality of evidence in the surgical management of SCFE. Our review identified 321 papers reporting the clinical outcomes of SCFE. Disappointingly, but perhaps not unsurprisingly, there were no published studies containing level 1 evidence and there were only 2 studies which provided level 2 evidence. Furthermore, most of the studies examining specific surgical treatment options involved single percutaneous screw fixation and were of level 4 evidence. We do not feel that this lack of high quality evidence reflects a lack of respect in this condition, but instead highlights the practical and ethical challenges inherent in the surgical management of children. When examining our findings in the context of other similar studies our results do not stand in isolation. Ostlie and colleagues reported that RCTs represented only 0.05% of all pediatric general surgery studies in the past decade.11 Within the broader orthopedic literature therapeutic studies with level 4 and 5 evidence are the most common orthopedic studies reported in the literature.13,14 Cashin and colleagues examined all available studies published in JPO, JPO-B and The Journal of Children’s Orthopaedics over a four year period and determined that evidence graded level 1 and 2 made up 8% of the literature while level 4 studies were again the majority at 58%.15

We agree that the high proportion of level 4 and 5 studies in part are due to the ethical barriers limiting the use of placebo procedures in surgical research.16,17 Given the relative rarity of the condition we agree that cohort studies and case reports are easier to perform, cheaper, and less time consuming than RCTs.18 Furthermore, RCTs are difficult to facilitate due to dispersion of cases through a large number of centers with incumbent the variation of patient presentation, and treatment by individual surgeons.17

Improving the level of evidence in a number of the level 4 studies we reviewed, could have been achieved by performing the study prospectively and utilizing a control group. Zaidi and colleagues and Obremskey and colleagues both proposed that a level-4 study such as a retrospective case series could become a level 3 study with an historical control group.13,19 Level 4 studies can provide valuable information for patient management if they are well designed, this includes a prospective, homogenous patient population, strict inclusion and exclusion criteria, standardized treatment protocol, close patient follow up and predetermined outcome measures.13

Our finding of no progression of evidence within the field of SCFE treatment over the reference period is not consistent with the broader orthopedic literature. Fu and colleagues reviewed all publications pertaining to anterior cruciate ligament reconstruction (ACL) over a twenty-year period and found a steady progression in the quality of evidence over that time (REF).20 Zaidi and colleagues reviewed the levels of evidence of all foot and ankle articles from the journals Foot & Ankle International, Foot and Ankle Surgery and the Journal of Bone and Joint Surgery (American and British Volumes) and found a trend towards higher levels of evidence from 2000 to 2010 but that the proportion of low levels of evidence (Level 3-4) articles remained close to 90%.19 Cashin and colleagues noted a slight increase in level 3 pediatric orthopedic related articles from 2003 to 2008 in JPO and JPO-B.15

We accept that establishing statistically signifi-
icant correlation between time and evidence grade for SCFE treatment may hampered lower number of publications in the field, but we feel that a strong correlation, if present, would be demonstrated in the 326 papers identified.

Impact factor is a measure of the average number of citations to recent articles published in a particular journal indexed in the Journal Citation Reports. Impact factor is the most commonly used tool for the reader to determine if scientific studies published within a journal are widely accepted. We could find no correlation between the impact factor of a journal and the level of evidence of individual studies on SCFE. This is likely due to the paucity of high-level studies to establish a significant correlation. Articles pertaining SCFE are not widely cited within the broader orthopedic literature and would not be a great influence on impact factor.

While we found that the majority of studies

Table 5. Level of evidence and number of studies supporting each surgical treatment option in the management of slipped capital femoral epiphysis.

| Treatment                                                                 | Level | Studies |
|--------------------------------------------------------------------------|-------|---------|
| Percutaneous in situ screw fixation (single)                             | 2     | 1       |
| Percutaneous in situ screw fixation (single - prophylactic contralateral hip) | 2     | 1       |
| Percutaneous in situ screw fixation (single)                             | 3     | 12      |
| Percutaneous in situ screw fixation (single vs multiple)                 | 3     | 4       |
| Percutaneous in situ screw fixation (single vs staged flexion intertrochanteric femoral osteotomy) | 3     | 4       |
| Percutaneous in situ screw fixation (single vs multiple not specified)   | 3     | 4       |
| Intertrochanteric versus subcapital osteotomy                             | 3     | 2       |
| Intertrochanteric femoral osteotomy                                      | 3     | 2       |
| Percutaneous in situ screw fixation (single +/- manipulation)            | 3     | 1       |
| Percutaneous in situ screw fixation vs K-wires                          | 3     | 1       |
| Percutaneous in situ screw fixation (single +/- anchor device)           | 3     | 1       |
| Modified osteotomy of Dunn-Fish vs osteotomy of Imhauser                 | 3     | 1       |
| Non-operative (casting)                                                  | 3     | 1       |
| Intertrochanteric uniplanar flexion osteotomy vs multiplanar osteotomy    | 3     | 1       |
| Extracapsular base of neck osteotomy vs Southwick osteotomy              | 3     | 1       |
| Femoral neck osteotomy                                                   | 3     | 1       |
| Percutaneous in situ screw fixation (single)                             | 3     | 1       |
| Percutaneous in situ screw fixation (single or multiple)                 | 4     | 23      |
| Percutaneous in situ screw fixation (prophylactic contralateral hip)     | 4     | 17      |
| Femoral neck osteotomy                                                   | 4     | 12      |
| Percutaneous in situ screw fixation (single or multiple +/- manipulation) | 4     | 6       |
| Dunn’s Osteotomy                                                         | 4     | 6       |
| Percutaneous in situ screw fixation (arthroscopic)                       | 4     | 5       |
| Intertrochanteric femoral osteotomy                                      | 4     | 5       |
| K-wires                                                                  | 4     | 4       |
| Casting and manipulation/reduction                                       | 4     | 4       |
| Percutaneous in situ screw fixation vs K-wires                          | 4     | 3       |
| Percutaneous in situ screw fixation (single vs femoral osteotomy)        | 4     | 3       |
| K-wires with open reduction                                              | 4     | 3       |
| Sugioka’s modified Hungria-Kramer intertrochanteric osteotomy            | 4     | 2       |
| Closed bone graft epiphysiodesis                                        | 4     | 2       |
| Subcapital osteotomy                                                    | 4     | 2       |
| Imhauser femoral osteotomy                                               | 4     | 2       |
| TRO (trans-troch rotational osteotomy)                                   | 4     | 2       |
| Percutaneous in situ screw fixation +/- casting                         | 4     | 1       |
| Steinmann pins                                                          | 4     | 1       |
| Intra-articular hip arthrodesis without subtrochanteric osteotomy        | 4     | 1       |
| Valgus-flexion intertrochanteric osteotomy                               | 4     | 1       |
| Extracapsular base of neck osteotomy versus and Southwick osteotomy     | 4     | 1       |
| Subtrochanteric osteotomy                                                | 4     | 1       |
| Extracapsular vs intracapsular reduction and epiphysiodesis             | 4     | 1       |
| Open bone peg epiphysiodesis                                            | 4     | 1       |
| Sugioka’s modified Hungria-Kramer intertrochanteric osteotomy           | 4     | 1       |
| Percutaneous, opening wedge subtrochanteric femoral osteotomy           | 4     | 1       |
originated in North America, we accept that limiting our search to the English language may introduce bias in our categorization by not considering the quantity and quality of research published outside English speaking countries. JPO is the leading journal in SCFE publications and accounted for 22.6% of all studies. It also provided 50% of the level 2 and level 3 studies in the top eight pediatric orthopaedic journals.

SCFE has potentially life changing implications for patients. This is the first review to examine critically the quality of evidence available to aid in treatment decisions. It highlights the paucity of high-level evidence available to guide those, treating this challenging problem. We hope that this work will provide motivation for further considered and ethical study on this important and challenging topic.

References

1. Loder RT, Skopelja EN. The epidemiology and demographics of slipped capital femoral epiphysis. ISRN Orthop 2011;2011:486512.
2. Larson AN, Yu EM, Melton LJ, et al. Incidence of slipped capital femoral epiphysis: a population-based study. J Pediatr Orthop B 2010;19:9-12.
3. Kocher MS, Bishop JA, Weed B, et al. Delay in diagnosis of slipped capital femoral epiphysis. Pediatrics 2004;113:e322-5.
4. Green DW, Reynolds RAK, Khan SN, et al. The delay in diagnosis of slipped capital femoral epiphysis: a review of 102 patients. JSS J 2005;1:103-6.
5. Madan SS, Cooper AP, Davies AG, et al. The treatment of severe slipped capital femoral epiphysis via the Ganz surgical dislocation and anatomic rotation: a prospective study. Bone Joint J 2013;95-B:429-4.
6. 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.
7. Beck M, Kalhor M, Leunig M, et al. Hip morphology influences the pattern of damage to the acetabular cartilage: femoroacetabular impingement as a cause of early osteoarthritis of the hip. J Bone Joint Surg Br 2005;87:1012-8.
8. Sackett DL, Rosenberg WMC, Gray JAM, et al. Evidence based medicine: what it is and what it isn’t. Brit Med J 1996;312:71-2.
9. OCEBM Levels of Evidence Working Group. The Oxford Levels of Evidence 2. Oxford Centre for Evidence-Based Medicine. 2014. Available from: http://www.cebm.net
10. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med 2009;151:264-9.
11. Ostlie DJ, St Peter SD. The current state of evidence-based pediatric surgery. J Pediatr Surg 2010;45:1940-6.
12. Samuelsson K, Desai N, McNair E, et al. Level of evidence in anterior cruciate ligament reconstruction research: a systematic review. Am J Sport Med 2013;41:924-34.
13. Obremskey WT, Pappas N, Attallah-Wasif E, et al. Level of evidence in orthopaedic journals. J Bone Joint Surg Am 2005;87:2632-8.
14. Hanzlik S, Mahabir RC, Baynosa RC, et al. Levels of evidence in research published in the Journal of Bone and Joint Surgery (American volume) over the last thirty years. J Bone Joint Surg Am 2009;91:425-8.
15. Cashin MS, Kelley SP, Douziech JR, et al. The levels of evidence in pediatric orthopaedic journals: where are we now? J Pediatr Orthop 2011;31:721-5.
16. Meakins JL. Innovation in surgery: the rules of evidence. Am J Surg 2002;183:399-405.
17. Stirrat GM. Ethics and evidence based surgery. J Med Ethics 2004;30:160-5.
18. Brubaker L, Moalli P, Richter HE, et al. Challenges in designing a pragmatic clinical trial: the mixed incontinence - medical or surgical approach (MIMOSA) trial experience. Cln Trials 2009;6:355-64.
19. Zaidi R, Abbassian A, Cro S, et al. Levels of evidence in foot and ankle surgery literature: progress from 2000 to 2010? J Bone Joint Surg Am 2012;94:e1121-10.
20. Fu FH, Schulte KR. Anterior cruciate ligament surgery 1996. State of the art? Clin Orthop Relat Res 1996;325:19-24.