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Original Article

Free-gliding Screw Fixation in Slipped Capital Femoral Epiphysis: Potentially Growing Implants for Symptomatic and Prophylactic Pinning

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Abstract

Introduction: In situ fixation is the gold standard for mild and moderate slipped capital femoral epiphysis (SCFE) cases. The condition is associated with a low percentage of avascular necrosis and chondrolysis.[1] The present study examines the postoperative femoral neck remodelling and implant elongation in cases of therapeutic and prophylactic in situ fixation using the free-gliding screw system.

Aim: The aim of our study was to assess the postoperative femoral neck growth and evaluate the biomechanical evolution and complication's rate for 19 therapeutic and 11 prophylactic in situ fixations with a free-gliding screw.

Materials and methods: We measured the preoperative and postoperative articulo-trochanteric distance (ATD), alpha angle (α angle) and screw elongation in symptomatic hips and in contralateral hips with prophylactic fixation. We compared the radiographic parameters of 30 hips.

Results: ATD remains approximately the same for symptomatic cases, whereas it increases for prophylactic fixated hip. Screw elongates in both group with statistically higher value for the prophylactic group. The alpha angle remains pathological in these cases with a mean value of 67.12±4.62°, but decreases for group II. Screw elongates by a mean value of 3.14±2.74 mm for group I and 6.78±8.81 mm for group II.

Conclusions: Prophylactic in situ fixation with free-gliding screws does not affect the proximal femoral growth (ATD), and does not decrease the alpha angle significantly. Screw elongates statistically in both groups, but more significantly for group II. For symptomatic hips, the in situ fixation allows the femoral neck to grow with ATD preserved, but significantly less than in group II. The alpha angle decreases but remains pathological.

Keywords

articulo-trochanteric distance, alpha angle, growing implant

INTRODUCTION

Slipped capital femoral epiphysis (SCFE) is the most common hip disorder in adolescents.[1] In situ fixation is the gold standard for mild and moderate SCFE cases and is associated with a low percentage of avascular necrosis and chondrolysis.[1] Treatment options include K-wires, cannulated screws, Hannson hook pin (Stryker)[2] and others. In 2010, Pega Medical (Laval, Canada) introduced a new osteosynthesis: free-gliding (FG) SCFE screw. The telescoping design allows physiological proximal femoral growth and postoperative proximal femoral remodelling for most of the cases with a facilitated extraction algorithm after physeal closure.

AIM

The aim of our study was to assess the postoperative femoral neck growth and evaluate the biomechanical evolution for 19 therapeutic and 11 prophylactic in situ fixations.

MATERIALS AND METHODS

We retrospectively reviewed 19 patients treated for unilateral slipped capital femoral epiphysis with free-gliding screw over a period of 4 years between April 2017 and April 2021 at Prof. Boytcho Boytchev University Hospital, Sofia. The mean age of patients was 11.95±1.51 years. Eleven asymptomatic contralateral hips were treated according to the modified Oxford Hip Score. The hips were therefore divided into two groups: group I and group II. Group I **(Table 1)** included 19 primary in situ fixated hips and group II **(Table 2)** consisted of 11 prophylactic in situ fixations of the contralateral hip. For the purpose of the study, we reviewed preoperative medical records, preoperative radiographs, postoperative radiographs and check-up radiographs at 6 months, at 12 months and last check-up radiograph. We assessed the following radiographic parameters: pre- and last postoperative articulo-trochanteric distance **(Fig. 1A)** (the distance between the tip of the greater trochanter and the proximal femoral head border) as well as the pre- and last postoperative α angle (measured as described by Nötzli in 2002[4,5]), defined by a best-fit circle placed over the femoral head. Two lines are subsequently drawn to form the alpha angle. The first line is drawn from the center of the best-fit circle to the center of the femoral neck at its narrowest point. This line extends along the long axis of the femoral neck. Another line is drawn from the center of the best-fit circle to the point where the femoral neck intersects beyond the boundary of the best-fit circle. The angle formed between these two

Table 1. Group I. SCFE cases initially treated with free-gliding screw

Patient number	Follow-up months	Age at time of surgery years	Articulo-trochanteric distance (ATD) preoperative mm	Articulo-trochanteric distance (ATD) postoperative mm	α angle pre-operative	α angle post-operative	Screw lengthening mm
1	29	11	25.8	23.8	99°	60.7°	9.76
2	29	10	26.6	25	30.7°	32.3°	9.64
3	31	12	23.9	10.4	85.9°	60.3°	3.2
4	12	13	19.9	22.5	76.9°	72°	2.5
5	22	13	25.1	25.3	56.5°	64°	3.4
6	26	13	18.7	20.8	47.1°	46.6°	0.94
7	12	10	23.	21.2	82.3°	73.2°	0.1
8	17	12	23.2	24.6	95.5°	69.7°	2.47
9	12	12	19.3	20.1	79.7°	68.4°	2.01
10	18	13	19.3	20.4	80.7°	67.4°	3.3
11	14	13	19.2	20.0	81.4°	74.1°	3.1
12	21	14	14.2	12.1	71°	61.1°	3.5
13	17	11	23.5	22.6	100°	93.6°	1.2
14	14	10	17.4	18.6	105°	85.9°	2.59
15	21	9	25.1	22.5	101.1°	72°	3.47
16	13	14	15.4	17.3	103°	72.5°	0.2
17	11	11	15.3	18.1	90°	64°	0.2
18	15	14	9	11	84°	51.7°	5
19	15	12	15	21	105°	87°	2

Table 2. Group II. Prophylactic in situ pinning

Patient number	Follow-up months	Age at time of surgery years	Articulo-trochanteric distance (ATD) preoperative mm	Articulo-trochanteric distance (ATD) postoperative mm	α angle pre-operative	α angle post-operative	Screw lengthening mm
1	27	11	23.9	28	40. 8°	38.5°	13.00
2	27	10	14.2	14.6	88.9°	58.9°	1.0
3	24	13	18.00	19.6	52.4°	44°	2.31
4	17	12	27.1	31.7	54.5°	53°	30.6
5	18	13	28.3	29.3	44.5°	44°	1.0
6	19	14	20.1	16.3	42°	42°	2.5
7	15	11	27.4	34.7	49.4°	47.1°	5.08
8	13	11	20.4	22.5	42.7°	40°	0.92
9	20	10	25.4	21.6	61.5°	48°	9.16
10	11	14	5	6.2	90°	83.4°	7
11	14	12	17	26	54°	51°	2

lines is defined as the alpha angle – an objective measurement of femoral head-neck junction convexity[12] **(Figs 1B, 1C)**. The screw elongation was accessed at the last check-up. Mean preoperative articulo-trochanteric distance for group I was 19.99±4.91 mm, with a mean preoperative alpha angle of 82.88±20.25°. The mean preoperative articulo-trochanteric distance for group II was 20.62±6.97 mm with a mean preoperative α angle of 57.99±17.63°. A comparison of the postoperative outcome was performed individually for each group.

Statistical analysis

Statistical methods validated for medical science were used. Descriptive analysis: number of cases (N), arithmetic mean, standard deviation, median, minimum and maximum value. Hypothesis testing: Student's t-test in related groups, hypothesis testing for equality of means for the different groups. The accepted level of significance is 5%.

Surgical technique

The patient is placed in a lateral position on a radiolucent operative table with a sterile draping over the affected lower extremity. A 2.4-mm cobalt-chrome guide wire is inserted in the anatomic centre of the capital epiphysis through the lateral femoral cortex. The guide wire should end 3 mm short of the subchondral bone. In moderate cases, the K-wire penetrates the lateral femoral cortex anterolaterally, in the femur-neck junction, for a better epiphyseal placement. The appropriate implant size (6.5 mm or 7.3 mm) is chosen based on the patent's age and bone diameter.[3] After reaming the guided wire with a 5.0-mm drill, we insert the telescoping screw in the epiphysis, 4-6 mm in the subchondral bone. The distal part of the screw is then locked in the lateral femoral cortex. Postoperative protocol includes early verticalization with unrestricted range of motion for all stable SCFE's. Prophylactic in situ fixation is performed on the contralateral hip based on the modified Oxford Hip Score.[6,7] Extraction of the osteosynthesis is advised for all cases post skeletal maturity.

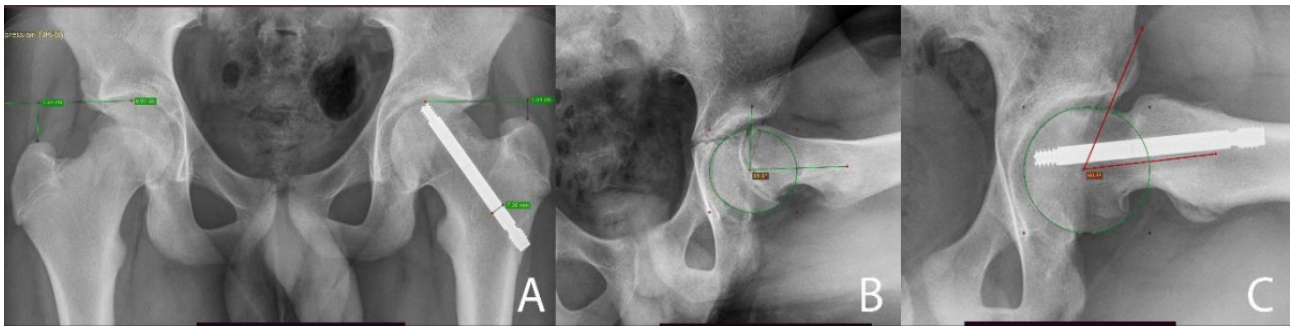

Figure 1. A) articulo-trochanteric distance, **B)** Preoperative alpha angle, **C)** postoperative alpha angle evaluation.

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RESULTS

Group I

The average follow-up period of the study was 18.78±6.34 months for the therapeutic group I **(Table 1)**. ATD did not demonstrate statistically significant radiographic changes ($p>0.05$). Mean postoperative ATD was 19.99±4.91 mm whereas the mean preoperative value was 19.86±4.47 mm. Statistically significant improvement was found for the alpha angle. The alpha angle decreased from 82.88±20.25° to a mean value of 67.12±14.62° ($p<0.05$), but remained pathological. Mean screw elongation for the group was 3.14±2.74 mm.

Group II

For a mean postoperative follow-up of 18.64±5.46 months in group II, the mean value for ATD pre- and postoperatively increased statistically significantly from 20.62±6.97 mm to 22.77±8.35 mm ($p>0.05$) at the last check-up **(Table 2)**. The mean postoperative alpha angle was 57.99±17.63° (from 57.99±17.63°) and remained statically equal. Screw elongation occurred in all cases with a mean increase for both components of 6.78±8.81 mm **(Fig. 2)**.

For the postoperative period, our team observed two complications: one case of avascular necrosis and one screw penetrating into the articular surface.

DISCUSSION

In situ fixation with AO-screws significantly decreases ATD.[8] K-wires are recommended as the safest method with a low postoperative complication's rate regarding avascular necrosis and compared to the Smith-Peterson nail.[9,10] König et al. observed significantly better long-term results in terms of femoral head sphericity, neck-diaphyseal angle, and leg length discrepancy when using K-wire. They are atraumatic, but the femoral neck growth could potentially overgrow the osteosynthesis. Early onset

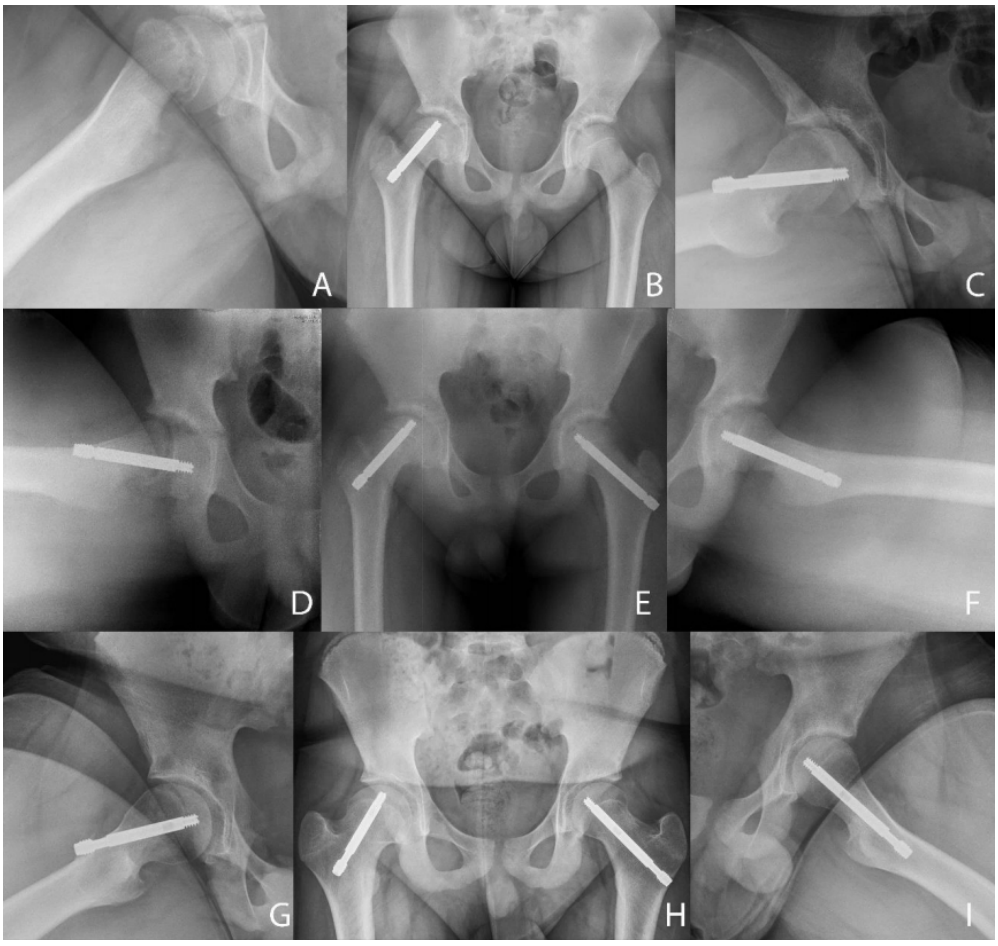

Figure 2. A) preoperative moderate SCFE frog leg view; **B)** postoperative radiograph; **C)** 12 postoperatively; **D)** left hip 5 months following prophylactic pinning; **E)** AP view 5 months after prophylactic pinning; **F)** right hip 5 months following prophylactic pinning; **G)** right hip last check-up frog-leg view; **H)** AP both hips 18 months after surgery; **I)** screw elongation in prophylactic pinning 18 months follow-up.

physeal closure with AO-screw fixation is a risk factor for femoral head deformity due to the asymmetric growth. Articulo-trochanteric distance remains relatively unaffected or slightly increased, which proves the effectiveness of the self-glided screw concerning the abduction deficit in the hip and thus long-term prophylaxis for extraarticular impingement.

In the series of Morash et al.[11], telescoping screws provided better remodelling based on the α angle: 12.9±19.2° improvement in their series of 32 cases. They reported an ATD-decrease of 4.2±4.6 at the end of the second year. We do not report significant reduction of the ATD in both groups. Femoral head-neck remodelling is similar in both studies. Screw elongation of 6.78±8.81 mm in the prophylactic fixation group compared to the therapeutic (3.14±2.74 mm) in our study is consistent with the results reported by Morash et al.[11] (4.8±3.4 mm for the prophylactic and 1.7±1.8 mm for the therapeutic cases). Free-gliding screw fixation allows anatomical femoral neck growth and does not result in clinically significant decrease in the ATD: remains constant or does not decrease in all groups.

The alpha angle represents the sphericity of the femoral head. A pathologically increased alpha angle is a sign of pre-epiphysiolysis and is likely to result in long-term femuro-acetabular impingement.[12] Boyle et al.[13] concluded that asphericity of the femoral head is an underlying factor for mechanical stress over the physis, which leads to SCFE. Similar changes were recorded in a study by Gelberman et al.[14] in patients with pathologically increased retroversion of the femoral neck. It is possible that pre-epiphysiolysis is present in patients with increased alpha angle, and therefore could manifests clinically as symptomatic or not. Lehman et al. radiographically evaluated 2072 hip joints and documented pre-epiphysiolysis in 6.6%: Southwick angle 13.[15] Statistically significantly decreased alpha angle of the patients with SCFE in our series is likely to lower the future risk for FAI.

In a biomechanical study, Leblanc et al.[16] reports that the mechanical stability of the free-glided screws is similar for the cannulated screws, but they preserve the physiological growth of the femoral neck and do not affect the ATD. AO screws, on the other hand, affect the proximal femoral growth.

CONCLUSIONS

The free-gliding screw technique used in our series provides stable fixation and improvement in the epiphysis/metaphyseal morphology by allowing mid-term proximal femoral growth, femoral neck remodelling and ATD.

The disadvantages of our study are the short follow-up period and the number of patients for the prophylactic group. Long-term follow-up would provide clinical data for extra-articular impingement in both series.

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Свободноскользящая фиксация эпифиза головки бедренной кости с помощью винтов со скольжением: потенциально растущие имплантаты для симптоматического и профилактического закрепления

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Резюме

Введение: Фиксация *in situ* является золотым стандартом для случаев лёгкого и умеренного смещенного эпифиза головки бедренной кости (SCFE). Это состояние связано с низким процентом асептического некроза и хондролиза.[1] В настоящем исследовании изучается послеоперационное ремоделирование шейки бедренной кости и удлинение имплантата в случаях лечебно-профилактической фиксации *in situ* с использованием свободноскользящей винтовой системы.

Цель: Целью нашего исследования было оценить послеоперационный рост шейки бедренной кости и оценить биомеханическую эволюцию и частоту осложнений для 19 терапевтических и 11 профилактических фиксаций *in situ* свободноскользящим винтом.

Материалы и методы: Измеряли предоперационное и послеоперационное артикуло-вертельное расстояние (ATD), угол альфа (угол α) и удлинение винтов в симптоматических тазобедренных суставах и в контралатеральных тазобедренных суставах с профилактической фиксацией. Мы сравнили рентгенологические параметры 30 тазобедренных суставов.

Результаты: ATD остается примерно на том же уровне для симптоматических случаев, тогда как для профилактической фиксации тазобедренного сустава она увеличивается. Винт удлиняется в обеих группах со статистически более высоким значением для профилактической группы. Угол альфа в этих случаях остается патологическим со средним значением 67.12±4.62°, но снижается для II группы. Винт удлиняется в среднем на 3.14±2.74 мм для I группы и 6.78±8.81 мм для II группы.

Заключение: Профилактическая фиксация *in situ* винтами со свободным скольжением не влияет на рост проксимального отдела бедренной кости (ATD) и не приводит к значительному уменьшению угла альфа. Винт статистически удлиняется в обеих группах, но более значительно во II группе. При симптоматических тазобедренных суставах фиксация *in situ* позволяет шейке бедренной кости расти с сохранением ATD, но значительно меньше, чем во II группе. Угол альфа уменьшается, но остаётся патологическим.

Ключевые слова

суставно-вертельное расстояние, угол альфа, растущий имплантат