Failed internal fixation of intertrochanteric hip fractures with dynamic hip screws

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ABSTRACT
Objectives: The use of dynamic hip screws (DHS) for intertrochanteric fractures has proven to be an effective, but not infallible, fixation method. The purpose of this study was to evaluate the reason behind fixation failure in patients with this type of hip fracture treated with a DHS. **Materials and Methods:** 177 patients were treated in our center for intertrochanteric hip fractures. A DHS was placed in 151 of them. Our analysis included quality of reduction after surgery, tip-apex distance, femoral head lag screw position, and possible complications. **Results:** The series included 143 patients. The average follow-up was 18 months (range 12-48). The failure rate was 8.4% (n = 12): 7 (4.8%) cases were due to intrapelvic migration of the lag screw ("cut-out") and 2 (1.4%) were due to medial migration ("cut-through"), while 2 (1.4%) cases presented with pseudarthrosis and 1 (0.70%) with *varus* deformity after reduction. The revision rate was 7.7% (n = 11). Lag screws placed in a superior/posterior position had the highest failure rate (100% migration rate) (n = 4) (p <0.001, statistically significant difference). **Conclusions:** Superior/posterior placement of the lag screw may increase the possibility of migration and, consequently, the failure rate of the DHS system.
Keywords: Fracture; hip; plate; dynamic screw; failure.
Level of Evidence: IV

Errores de osteosíntesis en fracturas laterales de cadera tratadas con placa/tornillo deslizante

RESUMEN
Introducción: El uso de los sistemas placa/tornillo deslizante para fracturas intertrocantéricas ha demostrado ser un método de fijación eficaz, pero no está exento de fallas. El propósito de este estudio fue evaluar las causas de falla en los pacientes con fracturas laterales de cadera, tratados con placa/tornillo deslizante, puntualizando los defectos técnicos en la colocación. **Materiales y Métodos:** En nuestro centro, se trató a 177 pacientes por fractura lateral de cadera, a 151 de ellos se les practicó osteosíntesis con placa/tornillo deslizante. Se analizaron la adecuada reducción posoperatoria, la medición de la distancia punta a vértice, la posición del tornillo cefálico en la cabeza femoral y las posibles complicaciones. **Resultados:** La serie quedó conformada por 143 pacientes. El seguimiento promedio fue de 18 meses (rango 12-48). La tasa de fallas fue del 8,4% (n = 12): 7 (4,8%) por migración cefálica (*cut-out*) del tornillo proximal, 2 (1,4%) por migración medial (*cut-through*), 2 (1,4%) presentaron seudoartrosis y un caso (0,70%) de reducción inadecuada en varo. El porcentaje de una segunda operación fue del 7,7% (n = 11). La peor posición fue la superior/posterior con un 100% de migración (n = 4) (p <0,001, diferencia estadísticamente significativa). **Conclusión:** El posicionamiento superior/posterior del tornillo cefálico podría incrementar la posibilidad de migración y, en consecuencia, la tasa de falla del sistema.
Palabras clave: Fracturas; cadera; placa; tornillo deslizante; fallas.
Nivel de Evidencia: IV

INTRODUCTION

The number of proximal femur fractures has been increasing over the years. In the United States, the yearly incidence of hip fracture was 250,000 in the 90s and this number may grow to 500,000 by 2040.[1] In Argentina, one of the few epidemiological sources of information on this matter report a yearly incidence of 20,000, in 1997.[2]

Received on February 6th, 2019. Accepted after evaluation on April 18th, 2019 • LEONEL PEREZ ALAMINO, MD • leonelp95@gmail.com
How to cite this paper: Pesciallo CÁ, Pérez Alamino L, Garabano G, Del Sel Hernán. Failed internal fixation of intertrochanteric hip fractures with dynamic hip screws. *Rev Asoc Argent Ortop Traumatol* 2019;84(4):328-335. http://dx.doi.org/ 10.15417/issn.1852-7434.2019.84.4.961

Despite advances in therapeutic strategies over the past years, the 1-year mortality rate, regardless of the received treatment, was approximately 20-25%, especially in the elderly population.[1,2] All these facts evidence that hip fracture represents a public health issue as it not only affects the patient's well-being, but it also poses a socioeconomic challenge to the Health Care System and to the patient's family.

The use of dynamic hip screw (DHS) for intertrochanteric fractures became popular in 1970,[3] and has proven to be an efficient fixation method: it acts as a lateral tension band in the femur and allows for the force transmission to the medial cortex, thus promoting fracture impaction and bone union.[3]

However, this system is not without complications. The complication rate of some publications reach 30%, including complications such as sliding screw intrapelvic or medial migration (*cut-out/cut-through*), loss of fixation, nonunion, etc. The purpose of this retrospective study was to evaluate the reason behind fixation failure in patients with this type of hip fracture treated with a DHS, focusing on placement technical errors.

MATERIALS AND METHODS

Between 2012 and 2015, our center treated 177 patients for intertrochanteric hip fracture. A DHS was placed in 151 of them. The remaining 26 patients underwent non-surgical treatment (7 cases) or hemiarthroplasty with a bipolar prosthesis (19 cases).

Participant inclusion criteria included: 1) patients diagnosed with intertrochanteric fracture and treated with DHS; 2) patients operated in our center; 3) >18-year-old patients; 4) a follow-up of no less than 12 months.

Patients diagnosed with pathological fracture were excluded. Fractures were grouped according to Evan's classification of fracture type.

Postoperative *adequate reduction* was considered achieved when the angle between the axis of the femoral shaft and the axis of the femoral neck (the cervico-diaphyseal angle) measured with a goniometer was between 127-135º. When the angle was <127º, we considered it an *inadequate reduction* or a varus reduction.

We measured the tip-apex distance (TAD) in millimeters, as described by Baumgaertner.[4]

We analyzed the lag screw position by dividing the femoral head into nine zones using antero-posterior (AP) and lateral X-rays (superior, central and inferior thirds on the AP view, and into anterior, central and posterior thirds on the lateral view) (Figure 1).[4]

Serial clinical and radiographic controls were performed at 3 and 6 weeks and 3, 6, 9 and 12 months after surgery. We recorded if patients had intrapelvic migration of the sliding screw (cut-out), medial migration (cut-through), femoral head necrosis, and any other type of complication due to surgical technical errors.

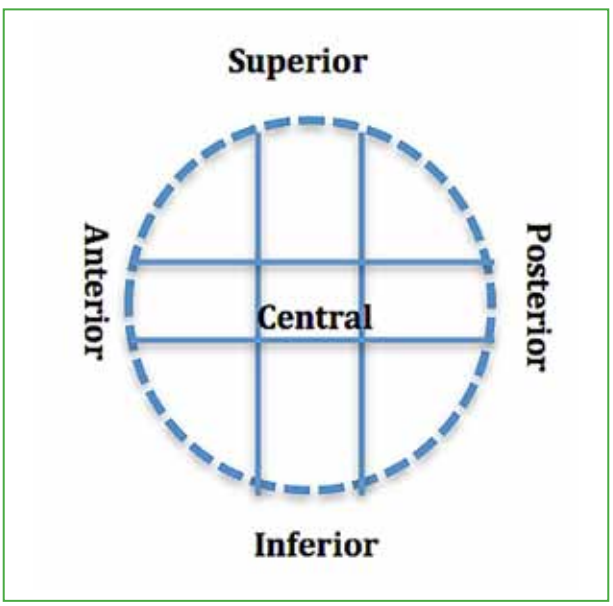

Figure 1. Distribution of the femoral head zones.

All study subjects were operated on by the same surgical team, with the same approach, under the same hypotensive spinal anesthesia, and on an extension table. Subjects received doses (1g) of IV cefazolin before, during and after surgery to prevent infection complications, and doses of low-molecular-weight heparin to prevent thromboembolic complications. Rehabilitation therapy was instituted the first day after surgery, when patients' goal is to achieve a sitting position; from the second day onwards, patients' goal was to stand and to walk using a walker, according to tolerance. Treatment failure was defined as the patient not being able to walk or having to undergo revision surgery due to surgical causes.

The collected data was added to an Excel 2011® worksheet. Results were compared using the Student's t-test and the Fisher's Exact Test to establish significant associations. Values were considered to be statistically significant at $P < 0.05$.

RESULTS

Eight patients were excluded for not meeting the minimum follow-up criteria. After exclusion, the series population was composed of 143 patients (43 males and 100 females) aged on average 71.26 years (range 49-91). The average follow-up was 21 months (range 12-48). Table 1 shows the types of fractures. Seventy-six (53.14%) had right hip fractures and 67 (46.86%) had left hip fractures.

Out of the 143 patients, 139 had an adequate reduction. In one case, the reduction resulted in a varus reduction; nevertheless, at the last follow-up, the patient had no difficulty walking, reason for which the follow-up was extended. Three patients had a cervico-diaphyseal angle >135º (138º, 145º y 148º), which were not associated with increased failure rates.

Table 1. Distribution according to Evans' classification

Classification	n	Percentage values (%)
Evans I	1	0.70%
Evans II	52	36.30%
Evans III	31	21.80%
Evans IV	12	8.40%
Evans V	47	32.80%
Total	143	100.00%

The most common placement of the lag screw was in the central/anterior zone (n = 27). Figure 2 shows the distribution of all fracture positions. Lag screw loosening and migration occurred in 9 cases. The cross-analysis of migration and placement revealed 3 cases of central/anterior position (2 cut-outs, 1 cut-through; P = 0.3), 2 cases of inferior/posterior position (Figure 3) (1 cut-out, 1 cut-through; P = 0.1), and 4 cases of superior/posterior position (4 cut-outs). This last position was the only one that had a statistically significant difference (P<0.001).

Five of the patients with lag screw migration had TAD values <25 mm, and only 2 had TAD values >25 mm (Figure 4). There is no significant differences between the TAD values from the patients without migrations and those who suffered a cut-out (22.06 ± 5.1 vs. 26.4 ± 13.5; P = 0,7).

The failure rate was 8.4% (12 patients). The most common complication was the intrapelvic migration (cut-out) of the proximal screw (7 patients, 4.8%). Other complications were medial migration (cut-through) (2 patients, 1.4%), pseudarthrosis (2 patients, 1.4%), varus deformity after reduction (1 patient, 0.7%) (Table 2).

The revision rate was 7.7% (n = 11). Three patients required a conversion hip arthroplasty, 2 underwent a cemented total hip replacement and 3 were treated with hybrid replacements. All patients survived the first year after hip fracture.

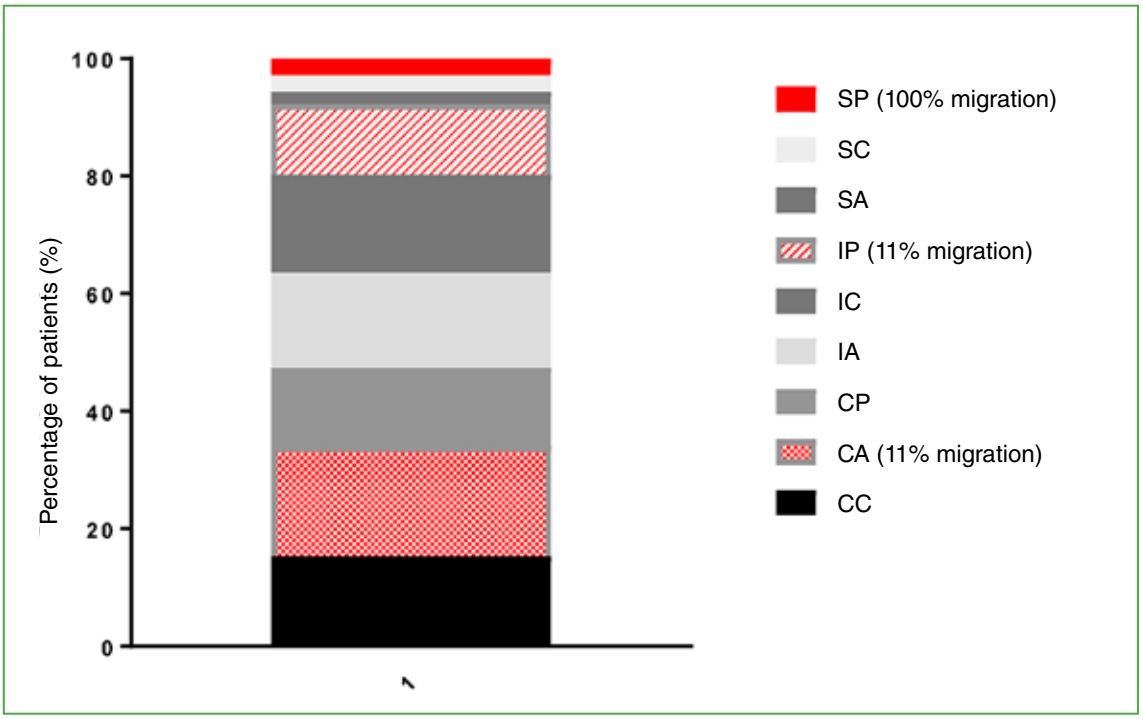

Figure 2. Distribution of the fracture positions. SP = superior/posterior, SC = superior/central, SA = superior/anterior, IP = inferior/posterior, IC = inferior/central, IA = inferior/anterior, CP = central/posterior, CA = central/anterior, CC = central/central.

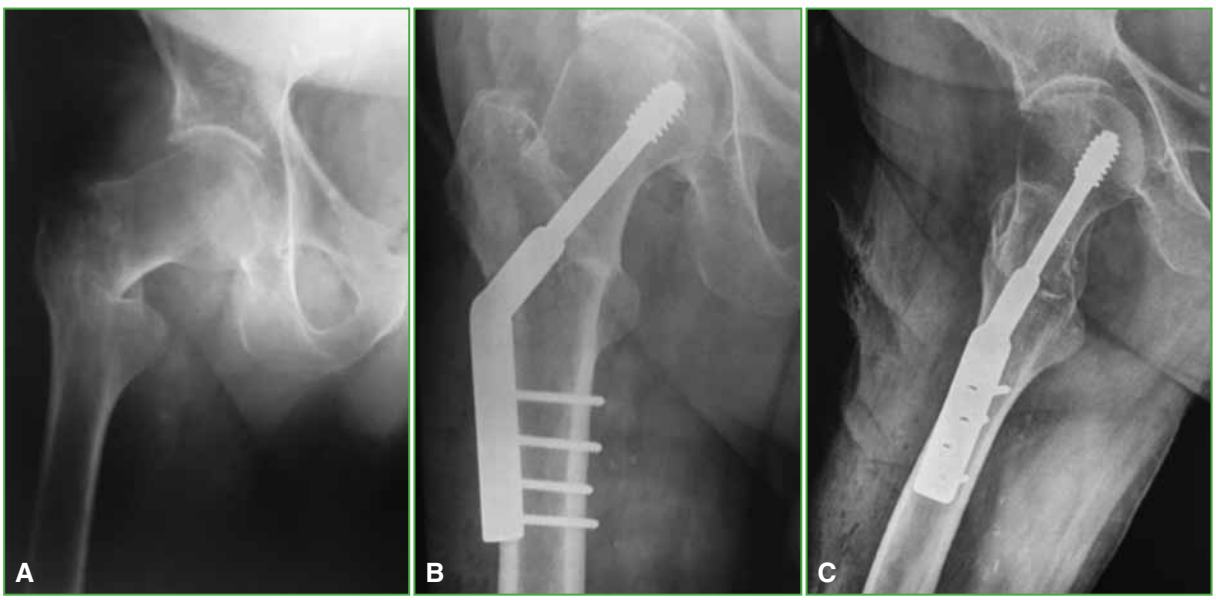

Figura 3. X-rays of a 71-year-old patient. **A.** Right intertrochanteric fracture. **B.** AP view. DHS internal fixation. X-ray shows the sliding screw in inferior position. **C.** Lateral view. X-ray shows the sliding screw in posterior position.

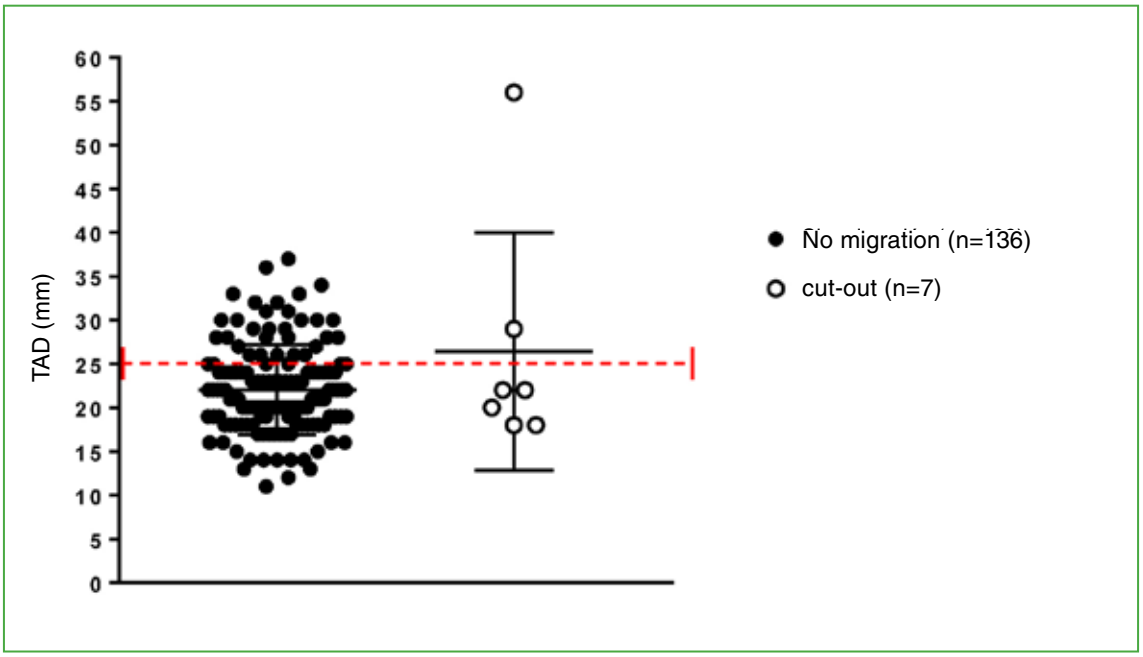

Figure 4. Patients' distribution according to the tip-apex distance (TAD). The dotted line demarcates the number of patients with TAD values above and below 25 mm.

Table 2. Complications

Complication	Sex	Age	Classification	Cervico-diaphyseal angle	TAD	Revision surgery
Cut-out	F	81	Evans V	129º	30	Hybrid THR
Cut-out	F	73	Evans V	132º	22	Hybrid HTR
Cut-out	F	62	Evans V	130º	20	THR
Cut-out	M	70	Evans II	129º	18	Hybrid HTR
Cut-out	M	65	Evans II	135º	56	THR
Varus reduction	F	66	Evans V	132º	31	-
Pseudarthrosis	F	81	Evans V	132º	18	Hemiarthroplasty
Cut-through	M	77	Evans V	135º	16	Hybrid HTR
Cut-through	M	80	Evans II	129º	11	Hemiarthroplasty
Pseudarthrosis	F	69	Evans V	135º	18	Hybrid HTR
Cut-out	F	68	Evans V	130º	23	Hybrid HTR
Cut-out	F	74	Evans V	135º	29	Hemiarthroplasty

F = female, M = male, TAD= tip-apex distance, THR = total hip replacement.

DISCUSSION

In the 1960s, the development of the DHS system revolutionized the treatment of intertrochanteric fractures. Over the years, studies showed that there was a considerable number of failures associated with the use of DHS in reverse oblique pattern fractures. This problem was supposed to be overcome at the beginning of the 1990s, when the cephalomedullary nails were perfected.[6]

Despite the still ongoing debate on deciding the proper implant for an internal fixation, there is a general agreement that "stable" fractures should be treated with the DHS system, while "unstable" fractures" would be better treated with cephalomedullary nails.[6] However, in their recent prospective randomized trial, Barton *et al*. failed to found statistically significant differences between the two treatments.[7] The most commonly reported complications associated with the DHS system include intrapelvic migration of the sliding screw (cut-out), screw medial migration (cut-through), detachment of the plate from the femoral shaft (pull-out), fractures, and pseudarthrosis, among others.

According to Kim *et al*., the failure rate for unstable fractures is 10-16%,[8] while more recent series report a failure rate of 6.8%.[9] Our study failure rate was 8.4%, in line with the literature values. Several publications report different incidence rates for the sliding screw migration, from 9.5%,[10] in earlier publications, to 1.3%,[11] in the most recent ones. The drop in the incidence rate may be due to the advance and improvement of the surgical technique. In our series, we had a 4.8% incidence of intrapelvic migration (cut-out), which rises to 6.2% if the cases of migration through the femoral head (cut-through) are taken into account, which is a high value when compared to the most recent series.

One way to assess the adequate placement of the sliding screw is the method described by Baumgaertner *et al*.,[4] in 1997. In their study, they decided to measure the TAD and defined it as the sum in millimeters of the distances from the tip of the sliding screw to the apex of the femoral head on AP and lateral X-rays. They reported that the incidence of mechanical failures (cut-out, cut-through) decreased in patients with TAD of under 25 mm, thus establishing a direct relation between satisfactory outcomes and the adequate screw placement. Another key element to consider regarding migration is the lag screw position. In 1996, Wu *et al*. reported that the best position was inferior/central.[12] Other authors reported that superior locations resulted in higher failure rates.[13,14] In a series published in 2009, Hsueh *et al*.[9] studied the position in 937 patients treated with sliding screw and reported that the best position was central/central. In our study, migrations occurred in the central/anterior and inferior/posterior positions, which are theoretically safe positions since they involve a greater amount of trabecular bone, thus allowing for a stronger fixation of the screw. The position where more complications were found was the superior/posterior with 100% migration (n = 4), with a statistically significant difference (P <0.001), while the other positions had no statistically significant differences.

Notwithstanding the substantial evidence supporting that the TAD and the lag screw position are major elements to be construed as predictive factors, there are others, such as age, type of fracture, reduction and bone quality, that also play a role in the outcomes.[15,16]

In our series, 5 out of the 7 (3.4%) of the cut-out cases were type V fractures (according to Evans' classification), involving the posteromedial wall of the proximal femur, which were considered as unstable fractures. Both cases of medial migration (cut-through) involved elderly female patients with poor bone quality. In one of them, postoperative X-rays revealed that the screw penetration had exceeded the suggested trajectory; therefore, we advise to monitor the screw placement throughout the range of motion using intraoperative fluoroscopic imaging (Figure 5).

One case varus deformity after reduction (<127º) was postoperatively confirmed. We currently know that varus fracture reductions must be prevented, because the femoral neck becomes more horizontal, thus increasing its length and the body-weight lever arm. Also, this condition could result in the proximal screw position being more cephalad than intended, thus promoting its migration (cut-out).[17,18] However, at the last follow-up, the patient had no difficulty walking and the fracture had healed, reason for which the follow-up was extended.

Several authors[19] reported low pseudarthrosis rates using this system. In our study, on the basis of the literature consulted, we had 2 cases (1.4%). Both patients had an 18 mm TAD and the lag screw in central/posterior position. During the surgery, we observed inadequate bone quality, possibly in relation to a long-standing chronic renal failure. Infection was discarded by serial lab tests, which always came back normal.

The strengths of our study include that all patients were operated on in the same center, by the same surgical team, with the same approach, and that the number of patients was suitable to establish a statistical association. The limitations of our study were those derived from the retrospective nature of the analysis. Measures were done manually, with a goniometer, which may have been influenced by a precision bias.

Although the same surgical team conducted all the surgeries, it usually included a resident in training under the direct supervision of a department specialist. This fact must be taken into account since surgical dexterity is always a conditioning factor in performing an adequate internal fixation.

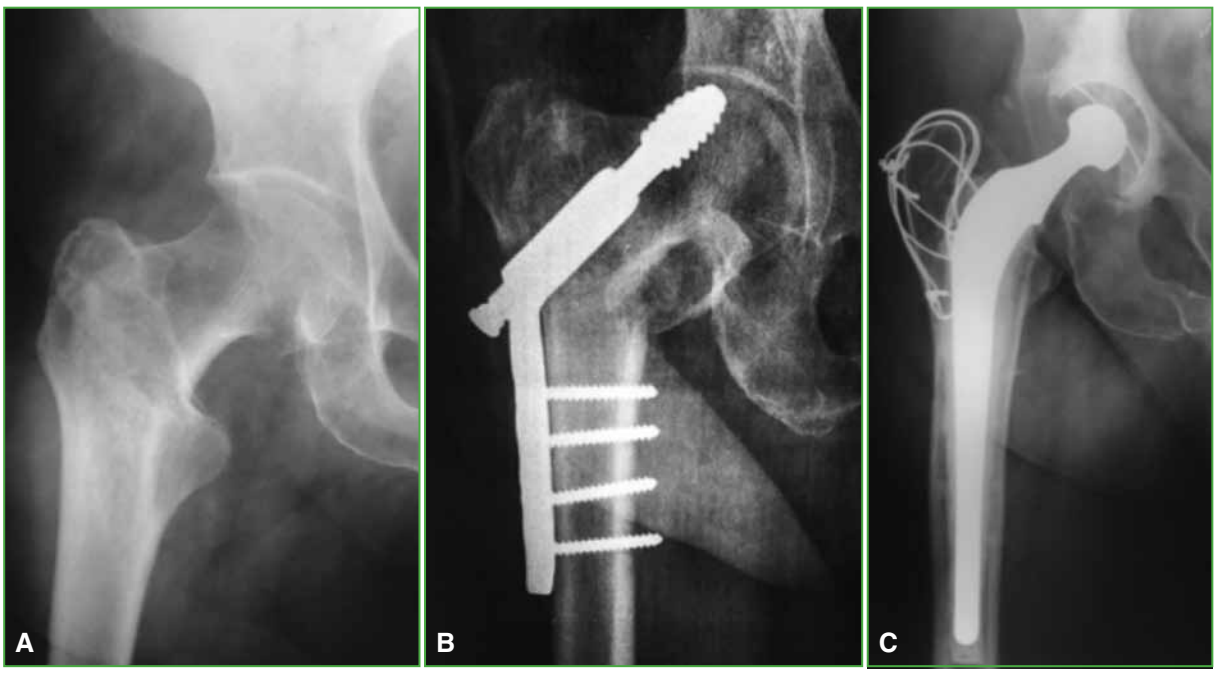

Figure 5. X-rays of a 65-year-old patient. A. Right intertrochanteric fracture. B. Imaging revealed cephalad migration of the sliding screw. C. Cemented total hip replacement.

CONCLUSIONS

Our study suggests that superior/posterior position of the lag screw may increase the possibility of migration and, consequently, the failure rate of the DHS system. This system should currently be applied only in stable intertrochanteric hip fractures, where an adequate reduction, an appropriate lag screw placement (central/central or central/posterior) and a TAD <25 mm are essential for a good evolution.

Conflict of interest: Authors claim they do not have any conflict of interest.

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