

Valgus Intertrochanteric Osteotomy for Salvage of Failed Femoral Cervicotrochanteric Fracture Fixation

Rabea M Odeh

ministry of health

Yu-Der Lu

Chang Gung Memorial Hospital Kaohsiung Branch

Cheng-Ta Wu

Chang Gung Memorial Hospital Kaohsiung Branch

Pei-Hsun Sung

Chang Gung Memorial Hospital Kaohsiung Branch

Yi-Ting Lin

Chang Gung Memorial Hospital Kaohsiung Branch

Hon-Kan Yip

Chang Gung Memorial Hospital Kaohsiung Branch

Mel S. Lee (✉ bone@doctor.com)

Chang Gung Memorial Hospital Kaohsiung Branch

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Abstract

Background

Femoral cervicotrochanteric fracture fixation failure often requires a salvage procedure to preserve the hip. To understand its limitations, this study investigated the use of intertrochanteric osteotomy for this purpose and analyzed causes of failure.

Methods

During 2001 – 2017, 21 patients (males:females = 12:9; 47 ± 17 years) with failed femur cervicotrochanteric fracture fixation were treated with intertrochanteric osteotomy. All patients were followed-up using functional assessment according to the Harris hip score (HHS) and radiological assessment. The clinical end-point was conversion to hip arthroplasty for any reason or acquiring a symptomatic hip with a HHS < 80.

Results

With a follow-up duration of 124 ± 63 months, success was achieved in 16 patients, whereas 5 patients developed fixation failure. Early failure was associated with fixation loss in 2 hips with subcapital fractures, while late failure was related to progression of pre-existing osteonecrosis of the femoral head (ONFH) in 3 hips. Aside from the 2 early failure hips, the osteotomy healed uneventfully in all cases, and the original fracture sites healed within 17.2 ± 6.3 weeks. Of the 5 hips converted to arthroplasty, standard femoral implants were used without the need to re-perform an osteotomy to align the medullary canal. At the final follow-up, significant improvements in limb-length discrepancy (LLD), neck-shaft angle (NSA), and HHS were observed. The valgus osteotomy angle for correction was $21.9^\circ \pm 8.4^\circ$, and this was maintained at $21.1^\circ \pm 10.5^\circ$ during follow-up.

Conclusions

Intertrochanteric osteotomy is a useful operation and can promote fracture-healing in cases of failed cervicotrochanteric fracture fixation. Subcapital fracture with limited bone to enable secure purchase of the fixation device and pre-existing ONFH were associated with high failure rates. In such cases, salvage should not be attempted using this procedure alone, and arthroplasty or other salvage procedures may be necessary.

Background

Management of failed internal fixation of femoral cervicotrochanteric fractures can be very challenging. The fractures can be intra-capsular, or may have extra-capsular involvement. While joint replacement is a tempting solution for older patients,[1, 2] joint preservation surgeries remain the ideal option for patients younger than 55 in order to save the native head of the femur.[3] In intra-capsular proximal femoral fractures, the most common complications are avascular necrosis and nonunion.[4, 5] In a meta-analysis including only controlled trials, weighted-mean revision rates after internal fixation were 18.5% for non-union and 9.5% for osteonecrosis of the femoral head (ONFH).[6] Both intra-capsular and extra-capsular nonunion, malunion, and fixation failure can be managed by corrective valgus osteotomy of the proximal femur. The valgus osteotomy converts the shearing force in the vertical fracture plane into a compression force in a more horizontal plane; it also helps to improve limb length and restores the neck shaft angle, re-establishing normal biomechanics and aiding in achieving successful osteosynthesis. Several authors have reported success using such a procedure.[7–9]

We reported a technique of valgus intertrochanteric osteotomy based on preoperative templating in 21 patients with fixation failure of cervicotrochanteric fractures. We further analyzed the cases in which the procedure failed in order to

understand the limitations of this salvage procedure.

Methods

A registry database of cases of valgus intertrochanteric osteotomy for fixation failure of cervicotrochanteric fractures between March 2001 and June 2017 was reviewed on a retrospective basis. This study included 21 patients (12 male and 9 female) with a mean age of 47 ± 17 years. The study was approved by the Institutional Review Board (201900656B0). Data including age, gender, body mass index (BMI), medical co-morbidities, American Society of Anesthesiologists (ASA) classification, fracture pattern with mode of fixation, fracture displacement, time interval from initial treatment to salvage surgery, operative data, and complications were recorded. Radiological assessments were carried out to examine the fracture orientation in the frontal plane (Pauwel angle), limb-length discrepancy (LLD), neck-shaft angle (NSA), and maintenance of valgus-correction angle. As a preoperative and postoperative outcome measure, the Harris hip score (HHS) was recorded and compared. All measurements were taken preoperatively and postoperatively at fixed intervals (immediately postoperative, 6 weeks, 3 months, 6 months, 1 year, and at the final follow-up).

Surgical Procedure

Intertrochanteric osteotomy and dynamic hip screw (DHS) fixation was performed by one of the senior coauthors. The lateral decubitus position was used, and a direct lateral approach to the proximal femur was made. A flap of vastuslateralis muscle was fashioned, and the proximal femur at the level of the lesser trochanter was exposed subperiosteally. The quadratus femoris and short external rotators remained attached in order to preserve vascularity to the femoral head. All previous metal implants were removed, and if the initial metal implant was a DHS, the tunnel of the initial lag screw was filled with a strut allograft as necessary. A 6.5-mm partially-threaded cancellous screw was applied through the superior neck to function as a de-rotational screw. The trajectory of the lag screw was determined by preoperative templating and inserted under fluoroscopic guidance. Osteotomy of the proximal femur at the intertrochanteric region was checked by k-wires, initiated using an oscillating saw and completed using a sharp osteotome. The goal was to bring the fracture line perpendicular to the direction of the joint reaction force, which was around 16 degrees in the frontal plane according to a previous study.[10] The shearing force at the fracture site could therefore be converted to a compression force during weight-bearing. The osteotomy was of a staggered shape with asymmetrical limbs, the short limb being closer to the lateral side in order to preserve more bone on the lateral wall for secure fixation of the DHS. The long limb was fashioned for lengthening of the femoral neck (Fig. 1). A barrel side plate angled at 135° or 150° was attached to the lag screw and then levered to bring the proximal femur to the desired valgus position. Care was taken to medialize the proximal fragment to improve the femoral offset at this stage. Bone-grafting to the fracture or osteotomy sites was carried out as necessary. Postoperatively, toe-touch assisted weight bearing was initiated on the 1st postoperative day and continued for 6 weeks, then the patient progressed gradually to full weight-bearing until complete solid union of the fracture and osteotomy sites.

Outcome Assessment

Clinical and functional outcomes were determined according to the HHS. Any adverse events during the hospital course or outpatient care were identified. Radiological assessment included the NSA, Pauwel angle, LLD, union at the osteotomy site and fracture site, and ONFH. The surgery was considered successful if union developed at both the osteotomy and fracture sites after the operation, while failure was defined as conversion to arthroplasty for any reason, loss of fixation or correction, or a HHS lower than 80 during follow-up.

Statistical Analysis

Collected data were examined to determine the impact on clinical outcome using the chi-square test, t-test, or Mann–Whitney U-test. All preoperative and postoperative clinical and radiological comparisons were performed using the paired t-test or the Wilcoxon signed rank test. The results were considered significant at a p value < 0.05.

Results

Of the 21 hips, 16 (76%) were successfully salvaged (Fig. 2). Failure occurred in 5 hips (24%). The failure modes were of 2 types: early failure was recorded in 2 cases due to insufficient purchase of the fixation device to the femoral head, resulting in loss of fixation at 1.4 months and 3 months, respectively (Fig. 3); whereas late failure was noted in 3 cases with progressive collapse of the pre-existing ONFH at 2.5 years, 3 years, and 11 years, respectively.

The average interval between the index injury and valgus osteotomy surgery was 11.6 ± 8.7 months (range, 2 weeks to 27 months). The average surgical duration was 189 minutes (range, 115 to 260 minutes). Eight patients were classified as ASA grade I (38%) and 13 as grade II (62%). The average blood loss was 436 ± 237 ml (range, 100 to 900 ml). Eight hips required additional bone grafting to the fracture or to address defects resulting from pre-existing metal implants. Aside from the 2 cases of early failure, the osteotomy site healed uneventfully within an average of 5.8 months (range, 3.3 to 8.4 months), while the cervicotrochanteric fracture healed within an average of 17.2 ± 6.3 weeks (Table 1). Pre-existing ONFH was found in 6 hips prior to salvage osteotomy, 3 of which remained functional, while the remaining 3 were converted to arthroplasty. No new onset of ONFH was noted after the osteotomy. The success rate with regards to the fracture pattern was 0% for subcapital fracture, 85.7% for mid-cervical fracture, and 100% for cervicotrochanteric fracture. Outcome measures were stratified according to success and failure pre- and postoperatively, as presented in Table 2. Among the successful cases, significant improvements in the LLD (shortening of -0.91 cm improved to -0.12 cm), Pauwel angle (from 53.9° to 30.3°), NSA (from 119.4° to 144.8°), and HHS (from 34.3 to 94.8) were noted. The valgus osteotomy angle for correction was $21.9^\circ \pm 8.4^\circ$, and this was maintained at $21.1^\circ \pm 10.5^\circ$ during follow-up (Table 3).

Table 1

Independent risk factors for achieving a Successful/Failed result of Valgus Intertrochanteric Osteotomy with statistical analysis. Significant result associated with p value ≤ 0.05 . (¥: categorical data; *: nominal data)

	Success (n=16)	Failure (n=5)	p value: (chi-square)	p value: Student's t test
Affected Side ¥			0.34	
Right	9	4		
Left	7	1		
Gender ¥			0.24	
Male	8	4		
Female	8	1		
Age *	45.5 \pm 18	52.4 \pm 16		0.92
BMI *	24.9 \pm 4.7	24 \pm 5.3		0.37
Smoker ¥	5	1	0.63	
ONFH	2	3	0.03	
Fracture Pattern ¥			0.41	
Intracapsular	12	5		
Extracapsular	4	0		
Subcapital Fracture	1	4	<0.0005	
Fracture Displacement ¥	9	5	0.0004	
Cause of Valgus Osteotomy ¥			0.30	
Nonunion	13	5		
Malunion	3	0		
Angle of Plate ¥			0.11	
135°	10	1		
150°	6	4		
ASA Grading ¥			0.34	
ASA I	7	1		
ASA II	9	4		
Surgical time (minutes) *	189.1 \pm 36	175.4 \pm 37		0.37
Intraoperative Blood Loss *	336.7 \pm 165	640.0 \pm 192		0.02
Perioperative Blood Transfusion ¥	4	3	0.15	
Bone Grafting ¥	5	2	0.92	

Osteoplasty ¥	2	1	0.68
Interval between Index Surgery (or diagnosis if no operation) & Valgus Osteotomy (months) *	10.8 ± 9	15.0 ± 10	0.38
Duration to Union (weeks) *	25.3 ± 8	22.8 ± 4	0.49

Table 2

Means or median values of outcome measures stratified along successful and failed results. p value < 0.05 is significant. Test statistic smaller than critical value is significant. (*: Leg Length Discrepancy; ^: Neck-Shaft Angle; §: Harris Hip Score)

	Preoperative			Postoperative			Mann-Whitney U-test
	Success	Failure	p value: Student's t test	Success	Failure	p value: Student's t test	
LLD *	-0.91 ± 0.7	-0.98 ± 0.4	0.77	-0.11 ± 0.3	-0.82 ± 0.4	<0.0005	
NSA ^	119.4 ± 9	111.6 ± 11	0.20	144.1 ± 8	146.4 ± 14	0.74	
Valgus Correction Maintenance	25.6 ± 10	33.6 ± 7	0.11	21.3 ± 11	22.0 ± 7		p value < 0.0005. Test statistics (5) < Critical Value (19)
HHS §	34.3 ± 12	35.8 ± 18	0.84	84.6 ± 26	94.8 ± 3	0.86	

Table 3

Preoperative and final postoperative measurements of LLD, NSA, valgus correction angles, and HHS. p value <0.05 in paired Student's t -test is statistically significant. Test statistic below critical value in Wilcoxon Signed Rank Test is statistically significant.

Combined Results	Preop	Postop	Difference	Correlation Coefficient	p value Student's t -test	Wilcoxon Signed Rank Test	Test Statistic	Critical Value	p value
LLD	-0.93	-0.29	0.64	0.99	<0.0005		19	58	<0.0005
NSA	117.6	145.2	27.6	0.98	<0.0005		0	58	<0.0005
Valgus Correction	27.5	21.3	-6.2	0.95	0.0004		14	58	0.03
HHS	34.7	83.8	49.1	0.96	<0.0005		3	58	<0.0005
Successful Results	Preop	Postop	Difference	Correlation Coefficient	p value Student's t -test	Wilcoxon Signed Rank Test	Test Statistic	Critical Value	p value
LLD	-0.91	-0.12	0.79	0.99	<0.0005		0	29	<0.0005
NSA	119.4	144.8	25.44	0.97	<0.0005		0	29	<0.0005
Valgus Correction	25.6	21.1	-4.5	0.95	<0.005		14	29	0.18
HHS	34.3	94.8	60.5	0.98	<0.0005		0	29	<0.0005
Failed Results	Preop	Postop	Difference	Correlation Coefficient	p value Student's t -test	Wilcoxon Signed Rank Test	Test Statistic	Critical Value	p value
LLD	-0.98	-0.82	0.16	0.96	0.66		7	0	0.70
NSA	111.6	146.4	34.8	0.98	<0.005		0	0	0.08
Valgus Correction	33.6	22	-11.6	0.94	0.07		1	0	0.08
HHS	35.8	48.6	12.8	0.99	0.19		3	0	0.25

Discussion

Failure of internal fixation of femoral cervicotrochanteric fractures occurs mainly due to poor fracture reduction, poor fixation techniques, incorrect implant use, or a poor biology or blood supply of the involved bone. Nonunion and malunion of femoral neck fractures in younger patients can be treated using head-preservation procedures, such as revision fixation, bone-grafting,[11, 12] or valgus osteotomy;[9, 13, 14] otherwise, joint replacement procedures can be employed. [15]

Head-preservation techniques are technically difficult and are not commonly performed. Predictors of success in head-preservation surgery include patient-related factors and surgeon-related factors. Patient-related factors include patient age, associated medical co-morbidities, bone quality (osteoporosis), degree of comminution, fracture pattern, fracture

alignment, and status of the hip joint, while surgeon-related factors include bone biology, soft-tissue handling, osteotomy method, and type of implant used in fixation. Backup plans are always required when performing such procedures. Valgus osteotomy corrects the varus deformity of a proximal femoral fracture and converts shear forces into compressive forces on the fracture plane. Certain criteria must be fulfilled when performing corrective osteotomy in order to attain a high success rate and good reproducibility for the treatment of femoral neck nonunion,[16] especially in patients of a younger age in whom joint replacement surgery may not be the best option.[17] Various fixation devices have been mentioned in the literature, consisting mostly of a DHS or blade plate. Pre-operative planning is essential in order to calculate the correction angle for the intended osteotomy.

Valgus osteotomy fixation with blade plates has been described in the literature by several authors.[7, 18–20] Blade plates have excellent rotational control but are technically difficult to use. Varghese et al.[18] studied 32 patients who developed femoral neck non-unions and were treated using valgus osteotomy and blade-plate fixation. Although there was radiographic evidence of ONFH in 13 cases, only 2 required conversion to arthroplasty, illustrating that this complication is not always functionally devastating. Use of a DHS allows controlled dynamic collapse at the fracture site, and counteracts the shear forces and varus displacement; however, it does not resist rotation during insertion, which can be managed using a de-rotational screw.[21] In our study, some, but not all, intracapsular fractures required the use of a de-rotational screw, probably owing to callus formation at the fracture site. Several authors have described valgus osteotomy and DHS fixation.[22–25]

The biomechanical basis of valgus reorientation osteotomy is the conversion of the nonunion plane to a more horizontal plane, rendering it perpendicular to the axis of load transmission, and thus creating a more favorable fracture-healing environment.[26] For valgisation osteotomy, full-wedge, half-wedge and no-wedge techniques have been described. Hartford et al.[27] used a full-thickness laterally-based wedge. Schoenfeld et al.[28] removed a partial-thickness wedge to minimise limb length, but noted that partial-thickness wedge osteotomy may decrease the surface area of contact and increase the chances of implant failure. Both techniques require extensive pre-operative sketching and templating to achieve the desired result. The LLD in the series of Hartford et al. was 1 cm, probably owing to use of the full-thickness wedge technique. Gavaskar and Chowdary[29] described a new technique of sliding subtrochanteric osteotomy and DHS fixation, with no wedge removal. They explained that their technique involved an oblique osteotomy just below the lesser trochanter with no wedge removal, and therefore there was no need for preoperative templating. They claimed that removing wedges may hinder limb-length restoration, requires careful planning and templating, and increases the surgical duration and blood loss. They added that their osteotomy technique can achieve a larger degree of correction with a wide contact area, and involves minimal lateral displacement of the distal fragment. In addition, they recorded a shorter operating duration and less blood loss as compared with the series of Hartford et al. and Schoenfeld et al. Valgisation osteotomy performed at the intertrochanteric area has several advantages: osteotomy at this level provides an adequate bone bridge between the osteotomy and the implant footprint; the technique is easier than osteotomy in the subtrochanteric area; and bone-healing is faster at the intertrochanteric cancellous osteotomy site.[25] Furthermore, it is easier after employing this technique to set the femur stem in a total hip arthroplasty than following subtrochanteric osteotomy in cases of advanced ONFH or failed valgus osteotomy. Our basically no-wedge technique involved osteotomy of the proximal femur at the intertrochanteric region closer to the original fracture plane, which improved the drawbacks associated with subtrochanteric osteotomy, such as limitations in the correction angle and leg-lengthening.[30]

Our osteotomy was of a staggered shape with asymmetrical limbs. The short limb on the lateral aspect of the proximal femur facilitated medialization of the femoral head, while the long limb on the medial aspect was used to correct the LLD and preserve more calcar bone for mechanical stability after the osteotomy. The shape of the osteotomy enabled the proximal fragment to buttress against the distal fragment to avoid translation. Our aim was to make the original fracture plane perpendicular to the direction of the joint reaction force. Applying such a valgus correction indeed converted the shear force on the fracture plane to a compression force during weight-bearing and enhanced fracture-healing.[23, 24]

Indeed, we observed that the original fracture healed (average, 17.2 ± 6.3 weeks) faster than the osteotomy site (average, 5.8 months).

All our osteotomies were fixed with a DHS angled at either 135° (11 patients) or 150° (10 patients). The original fracture and the osteotomy site healed uneventfully, with the exception of the 2 cases of early failure. The blood supply to the femoral head appeared not to be violated by the osteotomy. Before the salvage osteotomy, 6 hips showed evidence of the presence of ONFH with either cystic lesions or sclerotic change of the femoral head. Of the 6 cases of ONFH, 3 hips slowly progressed to advanced collapse after 3 years, 11 years, and 15 years, respectively; the other 3 hips were stabilized with acceptable functional results. No new onset of ONFH was noted. Subcapital fracture presented another risk of failure. Early failure was experienced in 2 hips, in which the capital fragment had an inadequate bone stock for secure purchase and fixation. The other hip had an inadequate blood supply for revascularization. It is worth noting that the medullary canal of the proximal femur was not markedly distorted after this intertrochanteric osteotomy. Re-osteotomy was not needed to realign the medullary canal in the 5 failed cases when hip arthroplasty was performed, and a standard cementless press-fitting hip prosthesis could be used. No surgical difficulties were encountered in applying femoral stems through the osteotomized bone.

Limitations of our study were due to the fact that it was a cohort study of a small group, and did not include a comparison group. A comparison group of patients who underwent a different osteotomy for failed femoral cervicotrochanteric fractures might be required in order to justify our technique as a valid salvage option. Nevertheless, patients suffering from malunion or nonunion of a proximal femoral fracture should be managed using a salvage hip procedure whenever this is feasible. Attempting to save the native hip joint in patients of a younger age (under 55) should be the priority whenever this can be performed safely, efficiently, and with little adverse sequelae. Patient selection is crucial when considering such a treatment option.

Conclusions

This study clearly demonstrated that intertrochanteric osteotomy is a useful operation and can promote fracture-healing in failed cervicotrochanteric fractures; this procedure did not cause ONFH and did not hinder prosthesis implantation if conversion to arthroplasty was required. However, subcapital fractures with limited bone to enable secure purchase of the fixation device and pre-existing ONFH were found to be associated with high failure rates. Such cases may not be salvaged using this procedure alone, and may demand other complex procedures, or conversion to arthroplasty.

Abbreviations

ONFH: osteonecrosis of the femoral head; HHS:Harris hip score; LLD:limb-length discrepancy; NSA:neck-shaft angle; DHS:dynamic hip screw; BMI:body mass index; ASA:American Society of Anesthesiologists

Declarations

Acknowledgements

Not applicable.

Authors' contributions

RO and YL participated in the design and conception of the study and wrote the manuscript, these 2 authors contribute equally in this study. CW and YL anticipated the patients' follow-up and helped to draft the manuscript. RO and

YL analysed the data. ML performed surgeries and revised the manuscript. PS and HY participated in the design of the study. The manuscript has been read and approved by all authors.

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Availability of data and materials

Data from the Department of Orthopedic surgery, Chang Gung Memorial Hospital. The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Study approval was obtained from the Institutional Review Board of Chang Gung Memorial Hospital (201900656B0).

Consent for publication

All patients participating in this study declared in a written informed consent to agree to the use of their data for clinical investigations.

Competing interests

All authors hereby declare that they have no conflicts of interest.

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Figures

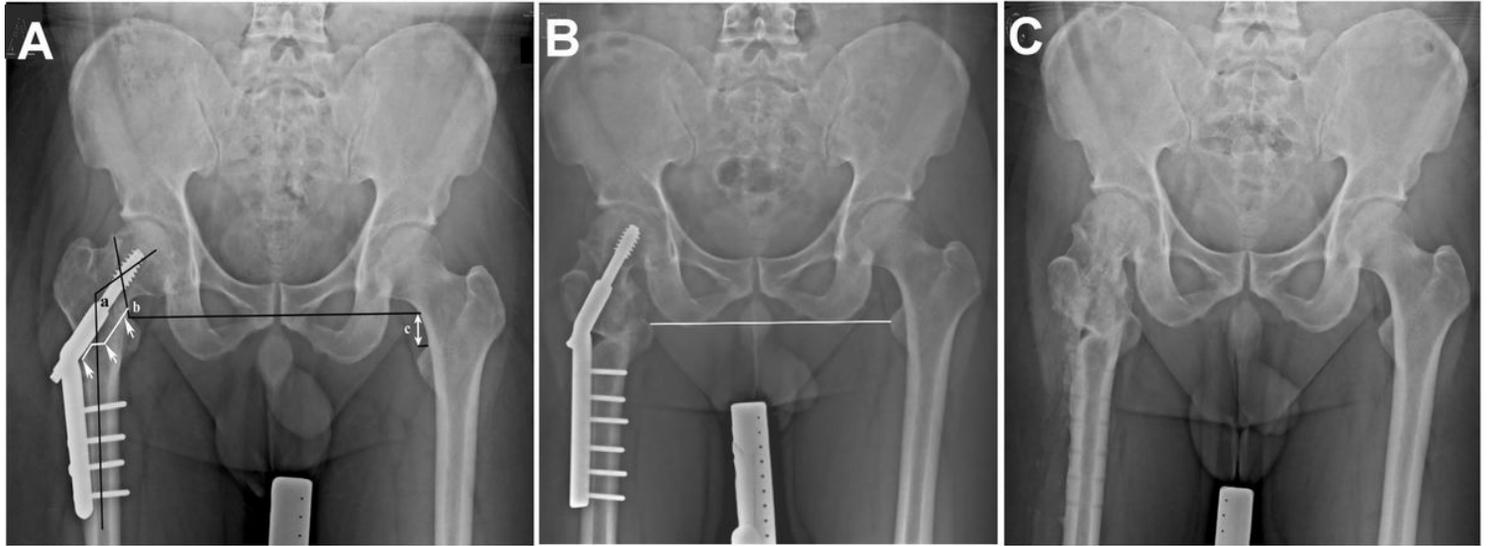


Figure 1

38-year-old male patient received a sliding hip screw 13 months ago for mid-cervical fracture of right hip. (A) Radiological parameters included NSA (a), Pauwels angle (b), and LLD (c). The osteotomy was fashioned with asymmetrical limbs (white line with arrowheads). (B) A valgus osteotomy fixed with DHS. (C) DHS was removed 3 years postoperatively.

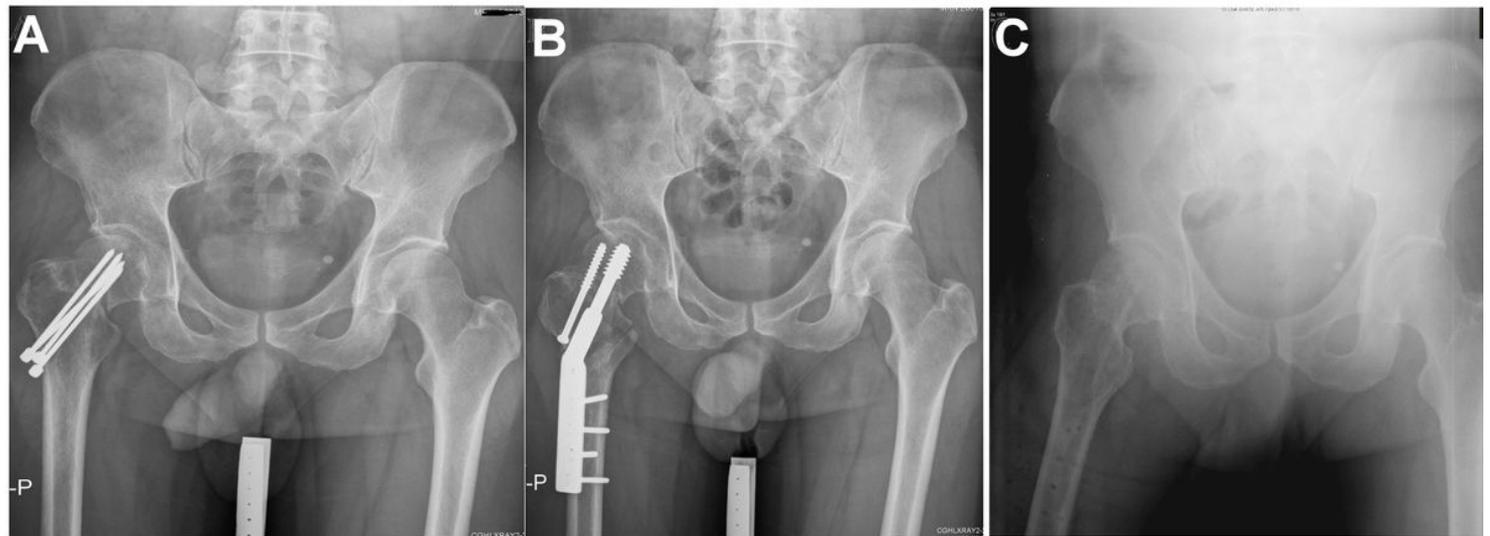


Figure 2

49-year-old male patient (A) He was treated with Knowles pins 6 months before. (B) Valgus osteotomy was fixed with a 150° DHS augmented with a de-rotational screw. (C) Implant was removed 6 years postoperatively.

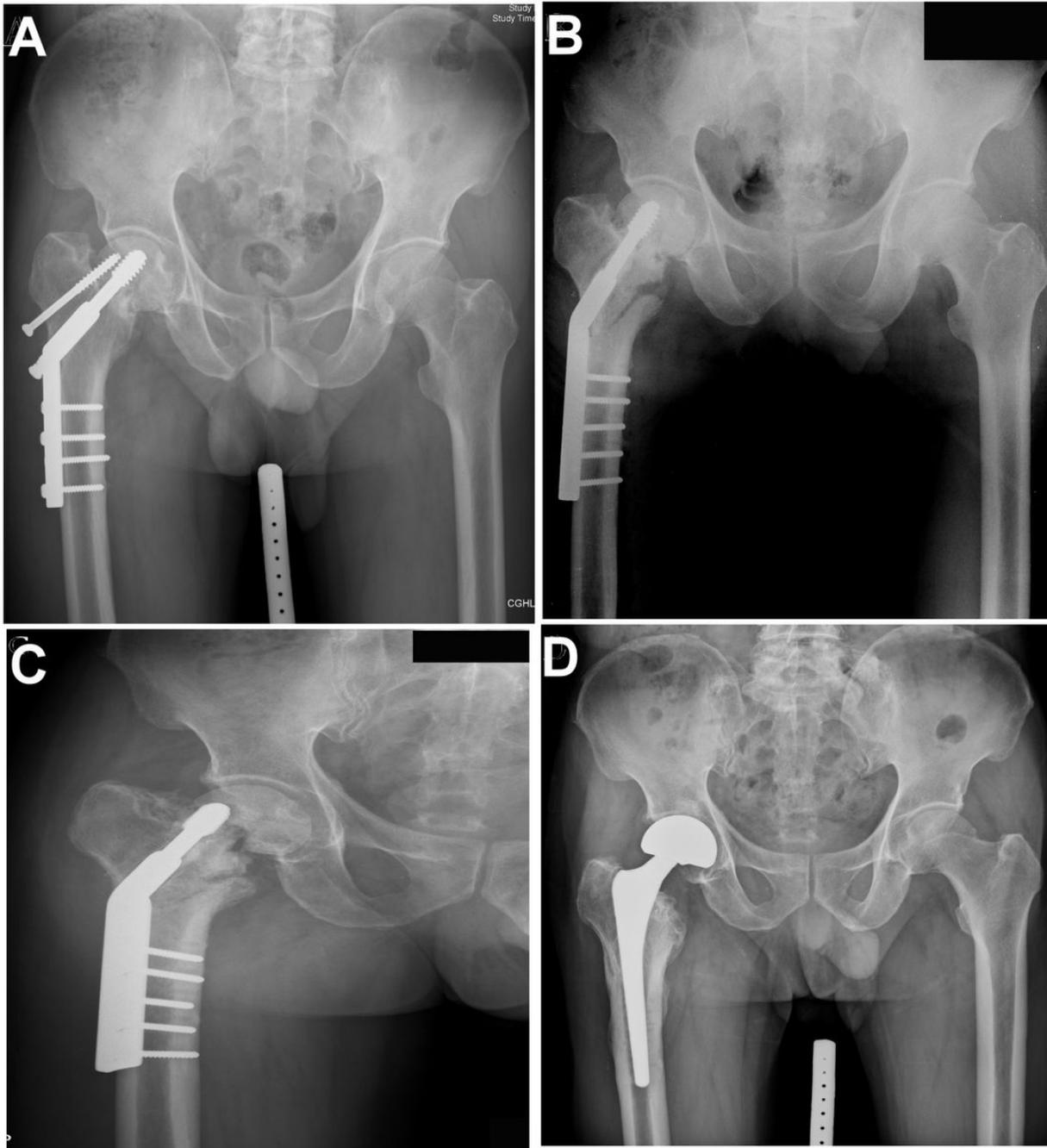


Figure 3

68-year-old male patient (A) He sustained persistent pain after subcapital fracture fixation for 23 months. (B). Previous implant was removed and a valgus osteotomy was done. (C) Fixation failure occurred due to inadequate purchase of the lag screw to the femoral head 3 months postoperatively. (D) A standard cementless proximal porous coated stem coupled with bipolar hemiarthroplasty was done.