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Proximal Femoral Lateral Locking Plate versus Short Cephalomedullary Nails for Treating AO/OTA 31 A3 Intertrochanteric Femoral Fractures: a Retrospective Clinical Study

Laterální zamčená dlaha proximálního femuru vs. krátký proximální femorální hřeb pro léčení AO/OTA 31 A3 intertrochanterických zlomenin: retrospektivní klinická studie

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ABSTRACT

PURPOSE OF THE STUDY

In this study we aimed to investigate the clinical and radiographic results of AO/OTA 31 A3 fractures operated on with either a proximal femoral lateral locking plate or short cephalomedullary nails.

MATERIAL AND METHODS/RESULTS

Medical data of patients treated with either implant were evaluated retrospectively. Patients > 55 years old sustaining an AO 31 A3 type fracture with a minimum follow-up of one year from two institutions were included in the study.

RESULTS

In all, 22 patients in the plate group and 30 patients in the nail group were included. All patients achieved union excluding the patients with failure. No significant differences in the mean duration of surgery, pre- and postoperative hemoglobin levels, duration of union time, or need for an open reduction or revision surgery were observed between the two groups. Reduction quality was better in the nail group. Failure of fixation was detected in three patients in the plate group and in four patients in the nail group. The duration of hospital stay was longer in the plate group than the nail group ($p = 0.007$). Time to independent mobilization was significantly shorter in the nail group than the plate group ($p = 0.027$). The Harris hip score results were similar between the groups after one year ($p = 0.479$).

CONCLUSIONS

Both implants had similar radiographic and clinical outcomes treat 31 A3 intertrochanteric fractures if the lateral wall of the proximal fragment was intact and anatomical medial-posteromedial restoration of the fracture is performed. Although complication rates were similar between the two groups, nails enabled early mobilization of patients.

Key words: intertrochanteric, 31 A3 fracture, fixation, PFLP, nail.

INTRODUCTION

Although introduced 3 decades ago, excluding reverse intertrochanteric fractures, dynamic hip screws (DHSs) remain the gold standard in the surgical treatment of intertrochanteric fractures (11, 14, 23). Given their biomechanical superiority, need for less soft tissue dissection, and earlier mobilization, intramedullary nails (IMNs) have been used to treat these fractures during the last two decades and have gained popularity (9, 21). However, although being one of the most frequently performed surgeries, complications with the use of these implants are a constant problem (23, 24).

Locking compression plates (LCPs) provide good to excellent results for complex fractures in different anatomic regions. However, only a few reports are available on the treatment of intertrochanteric fractures using this novel technique and after initial reports, better LCP designs have enabled better triplanar stable fixation and less invasive applications have been introduced (1, 20, 30). Also, there are limited clinical data regarding the exact indication for using LCPs to treat intertrochanteric fractures. Although early results of previous studies are promising, no study has indicated which subtype of intertrochanteric fracture can be treated with LCPs. In this study we compared the radiological and clinical results of two different fixation methods; proximal femoral locking plates (PFLP) and cephalomedullary nails in the osteosynthesis of AO/OTA type 31 A3 fractures in patients over age of 55.

MATERIAL AND METHODS

A retrospective review of a prospectively maintained database was performed after ethical committee approval (Approval ID: GOP/18-9-19/116) from participating institutions. This study was conducted in accordance with principles for human experimentation as defined in the Declaration of Helsinki. Informed consent was obtained from all individuals prior to surgery. Patients were enrolled from January 2015 to September 2018 and follow-ups continued until September 2019. We enrolled patients who underwent surgery for intertrochanteric AO/OTA type 31 A3 femoral fractures in two level II trauma centers with PFLPs or IMNs. The choice of İmplant that to be used for the surgery was at the discretion of the operating surgeon.

The preoperative preparation, antibiotic prophylaxis, and other medical treatment protocols excluding the surgical technique and postoperative mobilization regimen were similar at both institutions. All surgeries were performed by five surgeons. Patients > 55 years old sustaining an AO 31 A3 type fracture, Singh index ≤ grade 4 and who could be mobilized independently prior to fracture were included in the study. The exclusion criteria were age < 55 years, pathological fracture, lack of intra and/or postoperative follow-up medical records and/or X-rays; and follow-up < one year.

Preoperative X-rays were evaluated and fractures were classified using the AO Foundation/Orthopedic Trauma Association (AO/OTA) guidelines (19). Patient age, sex, fracture pattern, American Society of Anesthesiologists score, Singh index, cause of the fracture, pre and postoperative hemoglobin levels, duration of hospital stay after surgery, duration of surgery (time from the starting the reduction before draping to closure of the wound), need and volume of transfusion, time of independent mobilization (time the patient can use the toilet at home without help) (12), modified Harris hip score(HHS) (22), completed after one year of follow-up, infection, implant failure, revision surgery, and death before one year were reviewed. Intraoperative notes regarding surgery, any technical problems, and need for open reduction of the fracture were evaluated as well. Postoperative X-rays taken on the first day were evaluated to assess the initial quality of the fracture and X-rays at follow up visits were also evaluated for any change in the reduction. A varus, valgus, anteversion, or retroversion < 5° on anterior-posterior (AP) and lateral X-rays was rated as an excellent reduction, 5–10° acceptable, and >10° displacement in any plane was rated as a poor reduction (6). Time of union was evaluated radiologically from the X-rays during follow-ups. Callus formation in at least three cortices was evaluated as union (17).

The PFLP (PERI-LOC™ PFP, Smith and Nephew, Memphis, TN, USA) was made of stainless steel. It was an anatomic, angular-stable, 4.5 mm plate designed to treat intertrochanteric and subtrochanteric fractures. The plate is anatomically contoured to the lateral aspect of the femur. A radiolucent target device is used for minimally invasive applications of the plate. The IMNs (PROFIN™ TST, Istanbul, Turkey) are made of titanium alloy and have a 6° proximal medio-lateral curvature and a neck-shaft angle of 135°. The nails are fixed proximally with two 8.5 mm in diameter lag screws and distally by two 4.5 mm in diameter screws.

Surgery was performed on a flat traction table for both groups. For PFLP group; surgery was performed using a 5 cm incision over the greater trochanter. Additional fixation of fragments with interfragmentary screws was carried out during open interventions if needed (Fig. 1). For IMN group set-up was similar and additional fixation of fragments with cables was carried out during open interventions if needed as well (Fig. 2).

Patients in the IMN group were allowed full weight bearing after the first postoperative week as much as they could tolerate. However, patients in the plate group were not allowed full weight bearing until 6 weeks. They were mobilized with the help of walkers on postoperative day 1. Progressive weight bearing was allowed if the patient was pain free and there was evidence of a callus on follow-up X-rays.

Patients in both groups were revisited at 3 weeks, 2 months, 4 months, 6 months and one year. If there was no detectable problem, the patient was advised to come for routine follow-ups every year thereafter. Clinical and radiographic assessments of the progress of healing and complications were carried out during the visits.

All statistical analyses were performed using SPSS software (ver. 22.0; IBM Corp., Armonk, NY, USA). Number of deaths for both groups have been reported to present mortality rates for both groups. The distribution of variables was measured using the Kolmogorov–Simirnov test. The Mann–Whitney *U*-test was used to analyze the quantitative independent data. The Wilcoxon test was used to analyze the dependent quantitative data. Pearson’s chi-square test was used to analyze qualitative independent data, and Fisher’s exact test was used when the chi-square test conditions were not met. Quantitative variables are expressed as mean ± standard deviation or as medians and categorical variables are given as numbers with percentages; 95% confidence intervals (CIs) were calculated. A p-value < 0.05 was considered significant.

RESULTS

There were 44 patients in the plate group. Of these, 18 did not met the inclusion criteria and 4 had died before 1 year. These four of the patients had died probably due to concomitant medical problems, and the PFLP did not appear to have contributed to the deaths. The remaining 22 patients were included in the plate group. There were 115 patients in the IMN group. Of these, 77 did not met the inclusion and 8 had died before 1 year. Of these, three had transferred to the intensive care unit and died during postoperative week 1. The remaining five deaths were attributable to concomitant medical problems, and the IMNs did not appear to have contributed to the deaths. The remaining 30 patients were included in the IMN group. The demographic and clinical features of the patients were similar between the groups (Table 1).

All patients excluding the failures in both groups achieved union. The mean length of follow up time was 14.1 ± 3.4 (12–24) months in the plate group and 13.7 ± 1.4 (12–14) months in the IMN group. The length of hospital stay after surgery was significantly longer in the plate group at 5.2 ± 2 (3–12) days and 4.5 ± 3.5 (2–15) days in the IMN group (p = 0.007)

No differences were observed in preoperative mean hemoglobin level, postoperative mean hemoglobin level, mean decrease in hemoglobin level, transfusion rate, direct exposure of the fracture for reduction, length of surgery, quality of reduction or mean time to union between the two groups (Table 2).

Among 5 patients with a poor reduction in the plate group, 3 required revision surgery (Fig. 3). Two patients underwent revision surgery with nails and one patient underwent a revision with a longer plate. One patient with an anatomic reduction on the initial postoperative X-ray failed acceptable reduction 6 months postoperatively. However this patient achieved union without revision surgery. Two patients in the IMN group who had a poor reduction needed a revision surgery because of cut-out of the lag screws. Two patients with an acceptable reduction sustained a cut-out (Fig. 4). Of these four patients with a failure, two

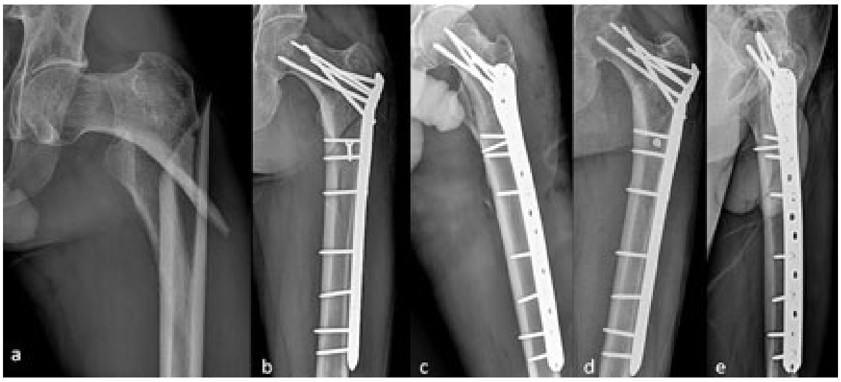

Fig. 1. (a) Preoperative X-ray of a 63-year-old male showing an AO 31 A3.3 unstable fracture. (b, c) Early postoperative anteroposterior (AP) and lateral X-rays showing excellent reduction of the fracture. (d, e) AP and lateral X-rays showing union at 15 months postoperatively.

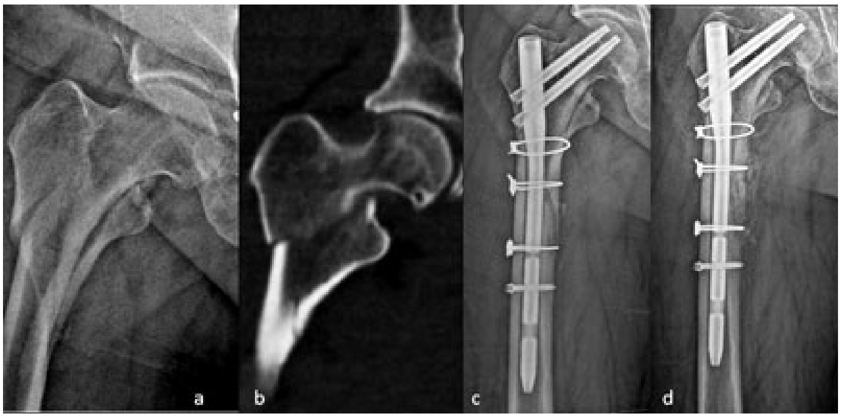

Fig. 2. (a) Preoperative X-ray of a 60-year-old male showing an AO 31 A3.3 unstable fracture. (b) Computed tomography image verifying the A3.3 type fracture. (c) Early postoperative anteroposterior (AP) X-ray showing excellent reduction obtained via an open intervention of the fracture. (d) AP X-ray showing union at 13 months postoperatively.

Table 1. Preoperative patient characteristics

		Plate group (n=22)		IMN group (n=30)		p	
		mean±sd/n-%	median	mean±sd/n-%	median		
Age		72.4 ± 19.6	74.0	74.3 ± 12.2	76.5	0.970	m
Sex	female	17 77.3%		16 53.3%		0.077	X^2
	male	5 22.7%		14 46.7%			
Fracture patterns	AO type A3I	14 63.6%		19 63.3%		0.871	X^2
	AO type A3II	2 9.1%		4 13.3%			
	AO type A3III	6 27.3%		7 23.3%			
Trauma pattern	low energy	19 86.4%		24 80.0%		0.819	X^2
	high energy	3 13.6%		6 20.0%			
ASA	II	6 27.3%		7 23.3%		0.947	X^2
	III	11 50.0%		16 53.3%			
	IV	5 22.7%		7 23.3%			
Singh index		2.7 ± 0.8	3.0	2.8 ± 0.9	3.0	0.913	m

m Mann-Whitney U test; X^2 – Chi-square test (Fischer exact)

Table 2. Postoperative patient data

		Plate group (n=22)		IMN group (n=30)		p	
		mean±sd/n-%	median	mean±sd/n-%	median		
Follow-up time (months)		14.1 ± 3.4	12.0	13.72 ± 1.4	13	0.121	m
Need for open reduction		5 22.7%		4 13.3%		0.376	χ^2
Surgery time (minutes)		74.4 ± 27.2	67.5	71.3 ± 17.1	65.0	0.910	m
HGB levels (g/dL)							
preoperative		10.8 ± 0.6	10.7	11.5 ± 1.4	11.5	0.086	m
postoperative		9.6 ± 0.9	9.7	9.9 ± 1.5	9.8	0.553	m
Need for transfusion (unites)		7 31.8%		12 40.0%		0.545	χ^2
Hospital stay (days)		5.2 ± 2.0	5.0	4.5 ± 3.5	4.0	0.007	m
Time to union (weeks)		10.9 ± 2.1	11.0	9.6 ± 2.4	9.0	0.054	m
Initial postoperative reduction quality	anatomic	11 50.0%		21 70.0%		0.189	χ^2
	acceptable	6 27.3%		7 23.3%			
	bad	5 22.7%		2 6.7%			
Reduction quality at follow-ups	anatomic	10 45.5%		18 60.0%			
	acceptable	7 31.8%		4 13.3%		0.165	χ^2
	bad	3 13.6%		3 10.0%			
Failure		3 13.6%		4 13.3%		0.975	χ^2
Revision surgery		3 13.6%		3 10.0%		0.685	χ^2
Harris hip scores		76.5 ± 11.7	75.0	73.8 ± 13.7	74.0	0.479	m
Time of independent mobilisitation (weeks)		8.9 ± 2.1	9.0	7.1 ± 2.6	7.0	0.027	m
Living dependent		2 9.1%		5 16.7%		0.429	χ^2
Exitus before one year*		4 15%		8 21%		0.176	χ^2

m – Mann-Whitney U test; χ^2 – Chi-square test (Fischer exact); w – Wilcoxon test
* – among 26 patients in plate group and 38 patients in IMN group

were revised with an endoprosthesis, 1 obese patient was revised with a plate, and one did not want revision surgery. No failed reduction was detected in the remaining patients in the IMN group. Patients in both groups who sustained a failure, had had a lateral communition and/or medial- posteromedial support had not restored sufficiently, and all patients who sustained failure had postoperative varus malalignment (Fig. 3 and 4).

The time of independent mobilization was significantly earlier in the IMN group. However, the HHS at postoperative one year was similar between the groups. Patients mobilized independently at a mean postoperative 8.9 ± 2.1 (6–14) weeks in the plate group and at 7.1 ± 2.6 (2–11) weeks in the IMN group (p = 0.027). Two patients in the plate group and five patients in IMN group could not mobilize (p = 0.429). These patients were living totally dependent on their caretakers.

No infections or deep vein thrombosis were detected in any of the patients.

DISCUSSION

Fixation of 31 A3 fractures with locking plates is a relatively new concept that is also used for trochanteric and sub trochanteric fractures. These plates provide greater stability than other plates because they are locking and allow for the placement of screws at different angles, which allows multiplanar fixation and relief at the fracture site (25). Thus, the biomechanical aspects of the implant used for these fractures need to be considered. The best device for each specific fracture pattern should be selected to increase the likelihood of a favorable outcome (29). The orthopedic literature contains contradictory evidence on the use of PFLPs in patients with unstable intertrochanteric femur fractures, and few studies have compared IMNs and PFLPs (2). Although several studies comparing nails and plates have been published there is no study that compares the both nails and plates in a homogeneous patient group over age 55 with AO 31 A3 fractures. Previous studies comparing two implants have mostly included the either young patients with good bone quality or subtrochanteric fractures, which can confound the results in favour of plates (Table 3). Thus, we present our results from two different institutions, particularly for 31 A3 fractures. Our clinical and radiological results were comparable for 31 A3 fractures between the groups.

Previous studies supporting the advantage of plates have claimed that plates provide anatomical reduction with locking capability (2). A minimally invasive insertion technique of new plate designs makes them an attractive alternative because it minimizes soft tissue compromise and vascular insult to the injured bone in an attempt to optimize clinical results (5). We found no differences in postoperative mean hemoglobin level, mean decrease in hemoglobin level, transfusion rate, length of surgery, or mean time to union between the two groups. Authors supporting IMNs claim that early mobilization reduces the morbidity/mortality rates associated with prolonged immobilization (30). However, our results revealed that the HHS after one year was similar between the groups despite the fact that the IMN group was mobilized more quickly after the operation. Patients in the plate group remained in the hospital for a longer time, indicating that surgeons had hesitated to encounter a wound problem despite the fact that there was no infection, deep vein thrombosis, or wound dehiscence. Although statistically not significant, the mortality and morbidity rates tended to be higher in the IMN group, possibly due to the patient factors (bone quality and comorbidities) affecting mortality and morbidity. In contrast to the current literature no infections or deep vein thrombosis were detected in any of the patients in our series. Cautious and early mobilisation of the patients with appropriate antibiotic prophylaxis may have prevented these complications. However DVT or sub-clinic infections may have trigger the deaths before one year in both groups.

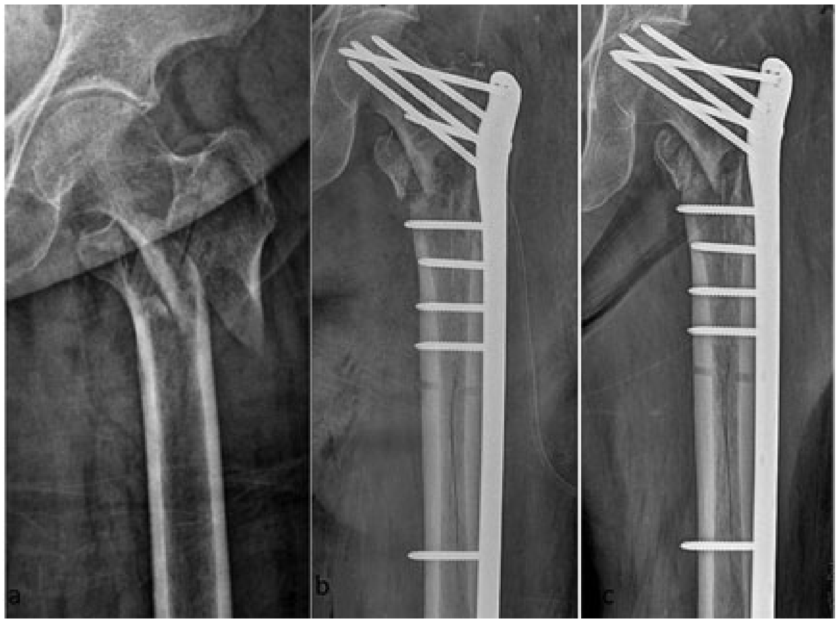

Fig. 3. (a) Preoperative X-ray of a 78-year-old woman showing an AO 31 A3.2 unstable fracture. (b) Initial post-operative X-ray showing mild varus, inadequately restorated medial-posteromedial region and lateral communition of the fracture. (c) Postoperative X-ray at week 16 reveals an implant failure due to protrusion of the proximal locking screws.

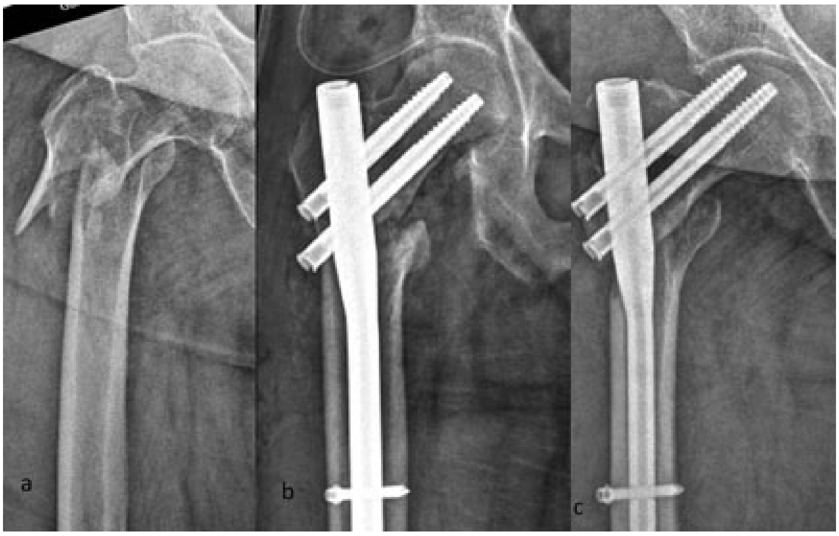

Fig. 4. (a) Preoperative X-ray of a 72-year-old woman showing an AO 31 A3.1 unstable fracture. (b) Early post-operative X-ray showing slight varus malalignment with inadequately restorated medial-posteromedial region. (c) Postoperative X-ray at week 8 reveales an implant failure due to cutting out of the lag screws and displaced lateral communition of the proximal fragment.

Several failure modes and complications, including cut-out, nonunion, screw breakage, screw back-out, screw bending, plate bending, plate breakage, and plate lift-off are associated with use of PFLPs (Table 3). Female sex, older age, major comorbidities, fixation in varus malalignment > 5°, using an early- or later-generation Synthes PFLP, patient factors as well as technical factors are major reasons of failure after use of PFLPs (2, 8, 5, 20). Collinge et al. (2). reported that the rate of failed treatment with locking plates was 41.4% (46 patients) among 111 patients treated with different locking plate designs. The authors claimed that fixation of unstable intertrochanteric (A2 and A3) fractures with plates was ineffective. Moreover, the authors stressed that varus malalignment and implant design were major factors affecting the results. We used the same plate that was favored in a previous study and agree that plate design can be very effective for preventing failures, as implant failure rates in the plate group in our series were lower than those reported in the literature (Table 3).

Until now, only a few multicenter studies have conclusively compared the clinical and radiological results of unstable intertrochanteric fractures treated with

Table 3. Reported previous outcomes with locking plates

Author, year	Patients (n)	Implant design (n)	Fracture type (AO/OTA) (n)	Age. Years mean (min–max)	Fixation failure (n)	Screw back-out (n)	Other complications (infection, nonunion etc.) (n)	Overall complications (n)	Revision surgery (n)
Wieser, 2010 (27)	14	Std. PF-LCP	AII,AIII, subtrochanteric	*	4 (all proximal screw breakage)	0	0	4	4
Glassner, 2011 (5)	10	Std. PF-LCP	B1,B2,A2,A3	57 (36–72)	2 (proximal screw breakage) 2 (plate breakage) 3 (cut-out)	0	1	7	7
Zha, 2011 (30)	110	*	AI,AII,AIII, subtrochanteric	75 (48–93)	1 (implant breakage)	0	1	2	2
Conelly, 2012 (3)	10	Std. PF-LCP (3) Peri-Loc (7)	AI,AII,AIII, subtrochanteric	49 (25–81)	1 (cut-out)	0	0	1	1
Wirtz, 2013 (28)	19	Std. PF-LCP	AI,AII,AIII	59 (19–96)	7	0	0	7	8
Johnson, 2014 (8)	32	Hooked PF-LCPs(6) Standart PF-LCP(26)	AII, subtrochanteric	75.6 (20–100)	2 (plate fracture) 6 (bending of proximal screws and plate) 5 (cut-out and prximal screw fractures)	3	0	12	*
Kumar, 2014 (13)	30	Std. PF-LCP	AII,AIII, subtrochanteric	65 (36–82)	0	0	1	1	1
Lee, 2014 (15)	27	Std. and Hokked PF-LCP	AII,AIII, subtrochanteric	49 (22–85)	0	4	3	7	4
Struebel, 2016 (26)	31	Std. PF-LCP	AIII	57 (21–92)	12	*	8	20	8
Collinge, 2016 (2)	111	Std. PF-LCP(53) Hooked PF-LCPs(44) Peri-Loc(24)	AII,AIII	*	12 (screw breakage) 1 (screw bending) 1 (plate bending) 8 (screw bending and breakage) 8 (plate breakage) 2 (plate lift-off)	7	24	46	44
Medda, 2019 (18)	59	Peri-loc(35) Std. PF-LCPs(33)	AI,AII,AIII, subtrochanteric	25–68	7 (screw breakage plate breakage, plate lift-off) 2 (cut-out) 5 (hardware irritation needing implant removal)	*	2	16	7

* – have not been mentioned appropriately
n – number of individuals
Peri-Loc – proximal femur plate (Smith & Nephew, Memphis, TN)
Standard PF-LCP – (Synthes, West Chester, PA)
Hooked PF-LCPs – later version of PF-LCP (Synthes, West Chester, PA)

PFLPs or IMNs. Furthermore, a subgroup (particularly A3) assessment of unstable fractures has not been previously feasible due to the heterogeneous patient populations studied (table 3). In pure subtrochanteric fractures, without fracture extension in the trochanteric region, one can take advantage of the real advantage of PFLP functioning as a locking compression plate. Achieving either axial compression with absolute fracture stability leading to primary bone healing or used as a bridging plate with angular stability in the case of comminuted fractures, gaining fracture healing with callus formation. However, osteoporotic fractures with lateral communition are totally different entities and fixation of these fractures either with plates or IMNs is not promising as presented in the above studies. Fixation failures with either plates or nails are most commonly characterized by varus collapse of the fracture with hardware failure due to loss of posteromedial support (27).

Surgeons who have used PFLPs for unstable osteoporotic fractures have reported various results. Johnson et al. (8). reported a 41.4% failure rate after fixation with PFLPs among 29 patients. The complications were backing-out, fracture, cut-out of the proximal screws, and fracture of the plate. Streubel et al. (26). compared the results of PFLPs and IMNs and reported failure in 11 of 29 (37%) patients treated for AO/OTA 31-A3 fractures with a PFLP. They claimed that a higher rate of reoperation and mechanical failure could be expected for 31A3 femoral fractures when treated with PFLPs than with IMNs. Wirtz et al. (28). reported a high failure rate (7 of 19 patients) with the use of PF-LCP to treat unstable intertrochanteric fractures. However, Kraus et al. (10). compared the clinical and radiological results of patients treated either with IMNs or PFLPs and found that PFLPs were more effective for terms of less postoperative pain, mortality, and intraoperative blood loss. Operation time and the number of complications were comparable. In contrast with previous literature Hasenboehler et al. (7). had claimed that PFLPs are a feasible alternative to treat unstable intertrochanteric fractures with acceptable complication rates. Also our results revealed a total of 13.6% (3 of 22 patients) failure rate in plate group which was quite comparable with IMN group(13.3%). Moreover, we did not encounter screw backing-out, screw fracture and fracture of the plate in any of the patients. In our series, we also evaluated the reduction quality and poor reduction was more common in the plate group. This can be attributed to the corrective effects of the intramedullary placed nail and we believe that proper reduction can be achieved in most cases with the use of IMNs and a cautious and meticulous technique. However, in the plate group after the initial reduction with maneuvers on the traction table, further reduction during surgery was obtained only via the compression effects of the screws (3, 5, 8).

Three of the five patients in the plate group and two of two patients with a poor reduction in the IMN group required revision surgery. This reveals that although plates enable a multiplanar fixation choice, this may have less of an effect on preventing failure if anatomic reduction is not obtained. Lateral communition of proximal fragment and/or inadequate restoring the medial, or posteromedial support (je area of the Adams´ arch) (16) that often results in the failure of osteosynthesis in case of varus dislocation of the proximal fragment. Floyd et al. (4). reported a 46% failure rate after surgical fixation of intertrochanteric fractures among 13 patients with locking plates and the authors stressed the importance of appropriate reduction (avoiding varus malalignment) and addressing the metabolic bone dysfunction. After a meticulous assessment, we detected lateral communition of the lateral cortex and/or insufficient restoration of medial-posteromedial fracture region in all failures in both groups in our series as well (Fig. 3 and 4).

The major limitation of our study was the relatively small number of patients and the fact that it was not a controlled prospective study. However, only 31 A3 fractures were considered to be included in the study rather than all intertrochanteric fractures. Thus, it can be seen that the number of patients is comparable with the previously published studies. Another limitation was that a preoperative CT was not performed for all of the patients to detect possible lateral wall communitions. Thus, the real effect of lateral communition on implant failure may have not been detected. Other limitations was that exposure to radiation was not recorded. A prospective multicenter study including more cases over a longer period of time is required to derive more exact results.

CONCLUSIONS

As far as we know, this is the first study that has compared clinical and radiological results of PFLPs and IMNs to treat particularly 31 A3 intertrochanteric fractures for osteoporotic fractures. Our study revealed that clinical and radiological results were comparable for both implants to treat osteoporotic 31 A3 intertrochanteric fractures, if the lateral wall of the proximal fragment is intact and anatomical medial-posteromedial restoration of the fracture is performed. Most of the failures occurred due to loss of posteriomedial support and inappropriate reduction during surgery in both groups. Although complication rates were similar in the groups, nails enabled early mobilization of the patients and a shorter hospital stay.

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