Journal of Clinical Orthopaedics and Trauma 10 (2019) 290–295

Contents lists available at ScienceDirect

Journal of Clinical Orthopaedics and Trauma

journal homepage: www.elsevier.com/locate/jcot

Comparison of Intra- and Extramedullary Implants in Treatment of Unstable Intertrochanteric Fractures

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ARTICLE INFO

Article history:
Received 13 June 2017
Received in revised form 7 February 2018
Accepted 7 April 2018
Available online 10 April 2018

Keywords:
Dynamic hip screw
Proximal femoral nail
Proximal femur locking compression plate
Unstable intertrochanteric fracture

ABSTRACT

Introduction: Comparison was made of the clinical and radiological results of the surgical treatments of proximal femoral nail (PFN), dynamic hip screw (DHS) or proximal femoral locking compression plate (PF-LCP) in patients with AO 31A2.2/2.3 unstable intertrochanteric femoral fracture(ITF).
Methods: Evaluation was made of a total of 91 patients in respect of age, gender, time from fracture to surgery, operating time, amount of blood replacement, total hospitalisation, follow-up period, time to full weight-bearing, time to union, complications and Harris hip scores(HHS).
Results: A statistically significant difference was determined between the groups in respect of perioperative operating time, blood replacement and hospitalisation period with the values of the PFN group seen to be superior to those of the other two groups ($p < 0.001$). No significant difference was determined beween the DHS and PFN groups in respect of time to union and in the long-term HHS, both groups were seen to be superior to the PF-LCP group ($p < 0.001$). Full weight-bearing was statistically significantly earlier in the PFN group ($p < 0.001$). The numbers of implant failures was statistically significantly higher in the PF-LCP group ($p < 0.001$).
Conclusion: The new generation intra-medullar nails are easy to apply and have more successful clinical results compared to extra-medullar implants in the treatment of A2 unstable ITF. Due to the high rates of implant failure, PF-LCP should not be preferred in these fractures.

1. Introduction

While the surgical treatment results of stable intertrochanteric fractures (ITF) are generallly good, the most suitable surgical method for unstable fractures is still controversial.[1] As dynamic hip screw (DHS) is the traditionally accepted treatment method in stable fractures with low failure rates,[2] it is known to have high complication rates in unstable fractures.[3] As the fracture is in the posteromedial wall or the major or minor trochanter in unstable fractures, this leads to an increase in complication rates.[4]

It has been reported that the commonly seen femoral shaft medialisation because of the use of DHS in unstable ITF is reduced with the use of PFN and increased resistance is provided against excessive displacement in the proximal fragment.[5] Therefore, the use of PFN in intertrochanteric fractures increased to 67% in 2005.[6] Although both DHS and PFN have an effect mechanism similar to controlled compression in the fracture line, intramedullar nails have been shown to be superior to DHS in unstable fractures.[7]

It has been reported that proximal femoral locking compression plates can be used to provide stable fixation with options to be able to advance the screws at different angles in unstable intertrochanteric fractures.[8] It can be said that PF-LCP is theoretically superior to both PFN and DHS as there are options to advance the multiple locking head screw in the proximal femoral region, achieving stable fixation in complex and multi-fragmented fractures.[9] Several studies have reported that these plate are clinically effective.[10,11]

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https://doi.org/10.1016/j.jcot.2018.04.003
0976-5662/© 2018

The aim of this study was to make a retrospective comparison of the clinical and radiological results of PFN, DHS or PF-LCP applied in the surgical treatment of patients with unstable ITF with an intact lateral wall.

2. Materials and methods

The retrospective study included patients with AO(Arbeitsgemeinschaft für Osteosynthesefragen) 31 A 2.2 ve 2.3 unstable intertrochanteric fractures who presented as an emergency case and were surgically treated between January 2012 and June 2014. Osteosynthesis was applied with either PFN (Trigen intertan, Smith & Nephew), DHS or PF-LCP (Depuy Synhtes) and the clinical and radiological results were examined retrospectively. Patients were excluded with a stable fracture (A1, A2.1), fractures including the lateral cortex (A3), subtrochanteric fractures, pathological fractures, multiple injuries, a history of congenital or neuromuscular disease in the same hip, chronic inflammatory joint disease, developmental anomaly, severe osteoarthritis and those who died during the follow-up period. All those cases who fulfill the criteria were included, their records retrieved and those who doesn't conform to the criteria were excluded. Final evaluation was made of a total of 91 patients with acute AO 31 A 2.2/2.3 unstable intertrochanteric fractures (ITF).

The patients were separated into 3 groups according to the surgical method applied of PFN, DHS and PF-LCP. Evaluation was made of all the patients in respect of age, gender, time from fracture to surgery (days), operating time (mins), amount of blood replacement (units), total hospitalisation (days), follow-up period (months), time to full weight-bearing (months), time to union (months), complications and Harris Hip scores. The preoperative, early postoperative and final follow-up hip anteroposterior (AP) and lateral radiographs of all the patients were examined. The AO/OTA classifications were used for all the fractures.[12]

When the general status of the patient was stable following the injury, the operations were performed by consultant orthopaedic surgeons. Prophylactic antibiotic was administered to all patients 30 min preoperatively as first generation cefalosporin and this was continued for 3 days postoperatively. In addition, low molecular weight heparin (Clexane, 4000 U, administered subcutaneously) as thromboembolism prophylaxis was administered 12 h preoperatively and was continued for 14 days postoperatively.

2.1. Surgical approaches

The decision of type of anaesthesia to be applied was left to the anaesthesia specialist. All the patients were operated on in a supine position on a traction table under C-arm fluoroscopy guidance. Anatomic reduction was obtained by obtaining valgus alignment AP and cervical anteversion in the lateral. Manual traction and reduction was achieved with the traction table locked throughout the operation or on a radiolucent operating table in a supine position with the lower extremity free. Trigen intertan nails were used for PFN (Fig. 1). Lag screw was used at an angle of 135 for DHS (Fig. 2). An addition, in PF-LCP applications, 7.3 m m cannulated screws (first and second) were advanced at 95° and 120° from the proximal locking holes and 5.00 m m cannulated locking screws were advanced at 135° (Fig. 3).

2.2. Follow Up

Postoperatively, all the patients were started on a progressive physiotherapy program. Quadriceps strengthening exercises and hip and knee joint range of motion exercises were started immediately after surgery. Partial weight-bearing was allowed with a walking frame and crutches. In the first 6 weeks postoperatively, partial weight-bearing was planned to be as tolerated. Full weight-bearing was permitted as tolerated when callus was observed on follow-up radiographs. The fracture reduction was classified according to the Baumgaertner et al classification on the radiograph taken immediately postoperatively.[13] Clinical and radiological follow-up was made in the 2nd and 6 t h weeks, then at 3, 6 and 12 months until radiographic and clinical healing. Intraoperative and postoperative complications were compared.

Any change in the implant position or complications were examined. If there was no union at the end of 36 weeks, it was evaluated as non-union. Shortening in the femoral neck and the shaft neck angle were compared between the first postoperative radiographs and those at the 1-year follow-up and femoral shortening and varus were measured. Malunion was defined as > 20 m m femoral shortening compared to the contralateral side or varus collapse of >15°. In addition to femoral shortening and varus collapse, reduction loss was also evaluated. The Harris Hip Score was used for the postoperative clinical results.[14]

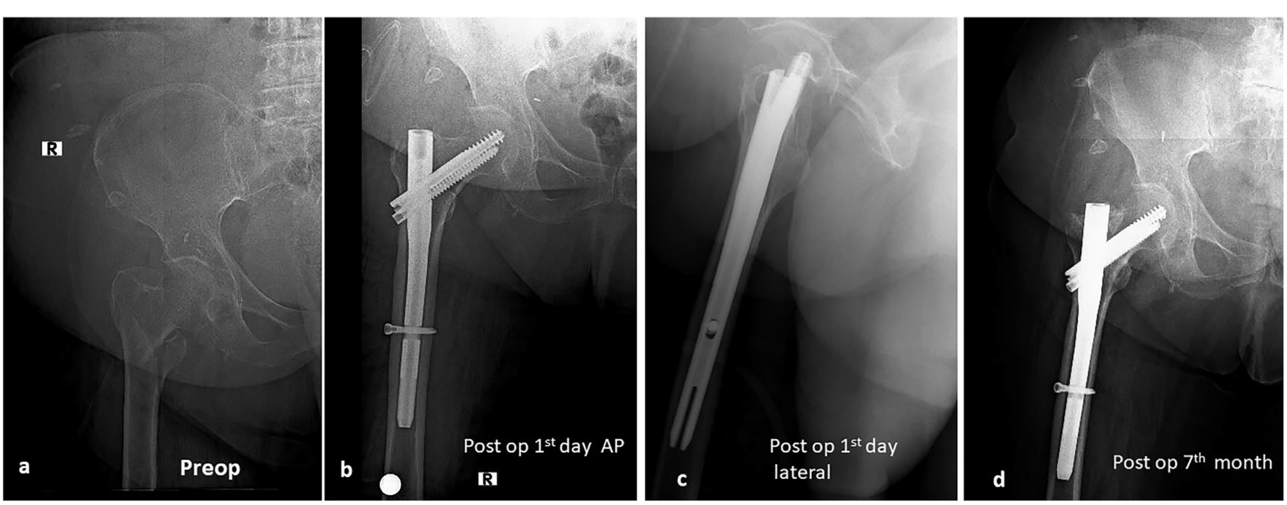

Fig. 1. (a) 81-year old female patient with a right hip AO 31 A 2.2 ITF. (b,c) Surgery was applied with PFN and postoperative early AP/Lateral x-rays show good reduction. (d) Radiograph showing union at 7-month follow-up. The double integrated screw mechanism has helped avoid failure.

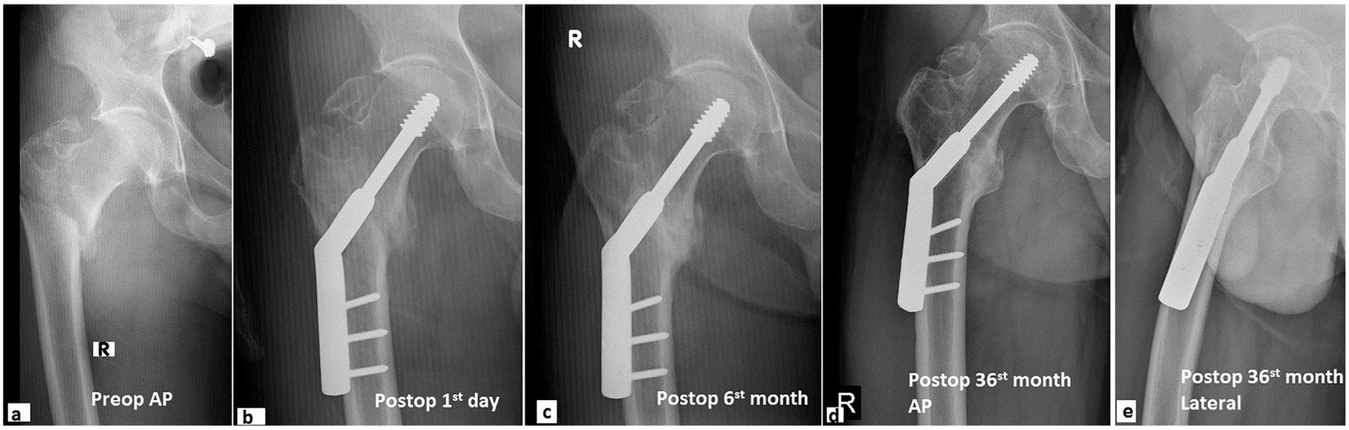

Fig. 2. 65-year old male patient with right hip AO 31 A 2.3 ITF. (b) Surgery was applied with DHS and postoperative early AP/Lateral x-rays show good reduction. (c) 6-month follow-up AP radiograph (d, e) radiograph showing union at 36-month follow-up.

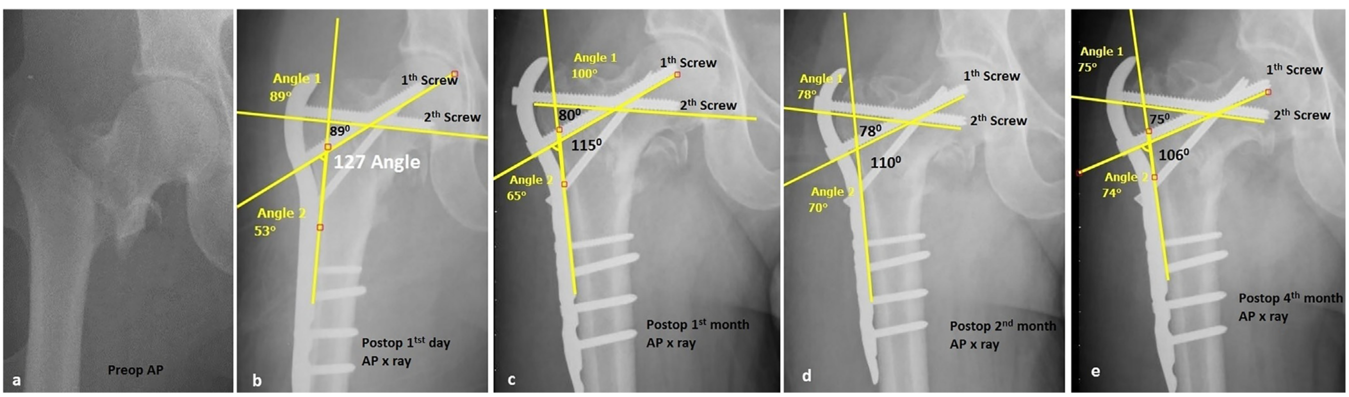

Fig. 3. 51-year old male patient with right hip AO 31 A 2.2 ITF. (b) Surgery was applied with PF-LCP. Postoperative early AP x-rays show the angle of the 1 st screw between the plate and head screw to be 127°, and the 2nd screw 89°. (c,d) On the radiographs, the angles between the plate and the 1 st and 2nd screws is seen to be reducing and implant failure is seen. In the 4th month the angle between the 1st screw and the plate is seen to have decreased to 106° and between the 2nd screw and the plate to 75°. Revision with DHS was applied to this patient in the 4 t h month(Fig. 4).

2.3. Statistical methods

The statistical analyses of the study were made using SPSS 19.0 (SPSS Inc, Chicago, IL) statistics software. Continuous variables were stated as mean ± standard deviation, median, minimum and maximum values. Categorical variables were stated as number (n) and percentage (%). The conformity to normal distribution of continuous variables was examined with the Shapiro Wilk test. In the comparison of 2 groups not showing normal distribution, the Mann Whitney U-test was used and in the comparison of 3 or more groups, the Kruskal Wallis test. For the comparison of 2 sub-groups with significant variables, the Bonferroni corrected Mann Whitney U-test was used. In the intragroup comparison of dependent variables, the Wilcoxon test was applied. A value of $p < 0.005$ was considered statistically significant.

3. Results

No statistically significant difference was determined between the groups in respect of age and gender. The time from fracture to surgery was similar in all the groups ($p = 0.797$) (Table 1).

A statistically significant difference was determined between the groups in respect of the perioperative operating time, blood replacement amounts and hospitalisation period ($p < 0.001$). In all the perioperative comparisons shown in Table 2, the PFN group was seen to have statistically significantly better values than the DHS and PF-LCP groups. The DHS group was seen to have better values than the PF-LCP group in respect of operating time but no difference was seen between the two goups in respect of hospitalisation period and blood replacement (Table 2).

Table 1
The demographic distribution of the patients in all the groups and the times from fracture to surgery.

		PFN, n(%)	DHS, n(%)	PF-LCP,n(%)	P
*Age (year)(Mean ± SD)		71.66 ± 10.59	72.13 ± 9.06	69.17 ± 6.48	0.069
#Gender	Male	13 (40.6%)	16 (53.3%)	10 (34.5%)	0.326
	Female	19 (59.4%)	14 (46.7%)	19 (65.5%)	
*The time from fracture to surgery(day)(Mean ± SD)		3.69 ± 2.66	3.00 ± 1.84	3.14 ± 1.90	0.797

Pearson Chi-square test.
* Kruskal Wallis test.

Table 2
Comparison between the groups of intra-operative variables.

	PFN Mean ± SD Med(Min–Max)	DHS Mean ± SD Med(Min–Max)	PF-LCP Mean ± SD Med(Min–Max)	Ki-kare	p
Surgery Time(minute)	37.66 ± 19.05 32.5(15-85)	68.07 ± 19.89 60(46-120)	86.03 ± 15.72 80(60-120)	51.036	**<0.001**
Blood Replacement(Unit)	0.44 ± 0.62 0(0-2)	1.97 ± 1.10 2.0(0-3)	2.41 ± 0.68 2.0(1-4)	46.657	**<0.001**
Hospital stay (day)	9.94 ± 4.24 10(5–18)	14.00 ± 4.48 14(7–22)	14.59 ± 4.88 15(7–25)	14.893	**0.001**

*KruskalWallis test.

Table 3
Comparison of the radiological and clinical results between the groups in the postoperative follow-up periods.

	PFN Mean ± SD Med(Min–Max)	DHS Mean ± SD Med(Min–Max)	PF-LCP Mean ± SD Med(Min–Max)	Chi-square	p
Coronal(degrees)	125.38 ± 9.69 126(100-142)	133.80 ± 10.55 132.5(104-160)	137.14 ± 12.96 137(121-160)	14.898	**0.001**
Sagittal(degrees)	17.19 ± 8.11 18(0-35)	16.93 ± 11.53 13.5(0-60)	14.86 ± 9.80 12.0(0-30)	1.811	0.404
Full Weight-bearing time (Month)	1.25 ± 0.40 1.0(1-2)	1.63 ± 0.61 1.5(1-3)	2.93 ± 0.75 3.0(2-4)	52.752	**<0.001**
Bone Union Time(month)	4.18 ± 0.69 4.0(3-5)	4.33 ± 1.00 4.0(2-7)	6.72 ± 1.36 7.0(4.0-10.0)	46.877	**<0.001**
Harris 6 t h month	79.75 ± 11.85 82.5(40-96)	72.83 ± 12.34 74.5(36-95)	66.66 ± 14.56 67(34-92)	16.168	**<0.001**
Harris 12 t h month	84.53 ± 10.39 86(42-100)	82.13 ± 10.35 84(50-98)	75.34 ± 12.22 75(42-96)	13.938	**<0.001**
Harris 6 month change (%)	0.07 ± 0.09 0.05(-0.17 – 0.23)	0.14 ± 0.13 0.12(-0.13-0.50)	0.15 ± 0.17 0.12(-0.14-0.57)	8.407	**0.015**
Follow-up, month	25.77 ± 4.76 25(18-35)	27.57 ± 7.84 26(15-47)	24.83 ± 4.15 25(19-34)	1.724	0.422

*KruskalWallis test.

The postoperative follow-up periods were similar between the groups ($p = 0.422$). The time to union was similar in the DHS and PFN groups with no statistically significant difference and both were seen to be at a statistically significantly better level than the PF-LCP group ($p < 0.001$). A statistically significant difference was determined between all the groups in respect of full weight-bearing in the follow-up period, with the shortest time in the PFN group and the longest time in the PF-LCP group ($p < 0.001$). The 6-month Harris Hip Scores of the DHS and PF-LCP groups were similar and the scores of the PFN group were seen to be better than both the other groups. In the long-term follow-up, no difference was found between the PFN and DHS groups and both were statistically significantly better than those of the PF-LCP group ($p < 0.001$) (Table 2). Within all the groups, a statistically significant increase was seeen in the Harris scores between 6 and 12 months ($p < 0.001$) (Table 3).

In respect of complications in all the groups, no difference was seen in the rates of malunion, poor reduction, femoral shortness, and superficial or deep infection. There were 8 patients with malunion in PFN group, 9 pateints in DHS group and 6 patients in PF-LCP group. There were 7 patients with femoral shortness in PFN group, 9 pateints in DHS group and 8 patients in PF-LCP group. The rates of non-union and implant failure and the number of re-operations were seen to be higher in the PF-LCP group (Table 4). Re-operations in the PFN, DHS and PF-LCP groups were applied with partial or total endoprosthesis. In 1 patient in the PF-LCP group, revision was applied with DHS (Fig. 4).

Table 4
Complications developing in the postoperative period.

	PFN(n:32) n(%)	DHS(n:30) n(%)	PF-LCP(n:29) n(%)	P
Superficial infection	1(3%)	4(13%)	4(14%)	
Deep infection	0(0%)	1(3%)	1(3%)	
Nonunion	0(0%)	2(7%)	8(28%)	**0.018**
Malunion	8(25%)	9(30%)	6(20%)	
Poor reduction	3(9%)	3(10%)	4(14%)	
Implant Failure	1(3%)	2(7%)	8(28%)	**<0.001**
Femoral shortness	7(21%)	9(30%)	8(28%)	
Sliding of screw	5(16%)	7(23%)	0(0%)	
Cutting of lag screw	3(9%)	4(13%)	————	
Reoperation	4(12%)	5(17%)	9(31%)	

#Pearson Chi-square test, n: number of case.

4. Discussion

Only AO 31 A2.2 and 2.3 unstable fractures with an intact lateral wall were included in this study, because it was considered that any of the 3 different implants (PFN, DHS, PF-LCP) could be selected for treatment in these fractures. During intra-operative application of the implant, as there is a risk with DHS in respect of iatrogenic fracture in the lateral wall, even though poor results have been reported from large diameter drilling leading to fractures,[15] no such complication was encountered in the current study. Langford et al reported a higher rate of iatrogenic lateral wall fractures in DHS compared to PF-LCP in ITF fractures.[16]

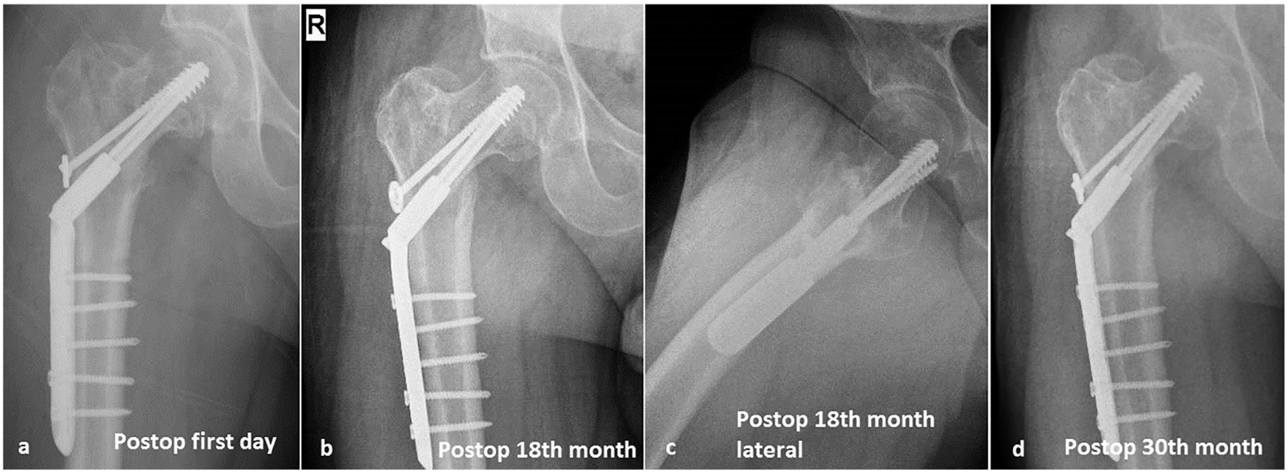

Fig. 4. (a) 51-year old male patient with right hip AO 31 A 2.2 ITF. Revision with DHS was applied due to failure of the PF-LCP implant(Fig. 3). Postoperative radiographs (b,c) AP/Lateral radiograph showing union at 18 months(d) radiograph showing good union at 30 months.

It is though that in comparison with PFN, DHS has the disadvantages of the risk of both creating a fracture in the lateral wall and of weakening the lateral wall, and of axial loading causing lateralisation with distancing from the physiological axis. Therefore, biomechanically, PFN are superior to DHS.[17] In contrast, in respect of complications, there are studies which have reported that DHS has lower rates of complications and re-operation compared to intramedullar nails.[18,19] However, those comparisons were made using gama nails and not new generation nails. Due to the wide diameter, short length and high valgus curvature of gama nails, the high stress on the end of these first intramedullar nails led to the formation of fractures in the lateral wall. However, in the new designs of nails, the reduced valgus curvature, longer length and smaller diameter have led to lower complication rates and better results.[20] In the current study, very good results were seen to be obtained with new generation PFN. Similarly, Ruecker et al reported good results in ITF cases treated with Intertan nails.[21] In the current study, although no difference was determined between DHS and PFN in the long-term clinical results, both were found to be much superior to PF-LCP. Matre et al reported no difference between DHS and Intertan in respect of the Harris clinical scores.[22]

Biomechanical studies have also reported that in unstable ITF, PFN are more stable than proximal anatomical plates and care should be taken against the risk of implant failure in cases where PF-LCP are to be used.[23] A statistically significant rate of implant failure was determined in the PF-LCP group of the current study. In some patients, there was seen to be progressive loss of angulation of the proximal cannulated head screws, which resulted in implant failure (Fig. 3). Biomechanically it has been shown that as a result of vertical loading on head-locking screws in PF-LCP, a deviation of 2° from the axis of the screw can lead to implant failure.[24] The high rate of implant failure in the current study could be related to osteoporosis, patient incompatibility or early weight-bearing or technically it could show incorrect implant placement, long head locking screws or insufficient compression in the fracture line. Many studies have reported a high rate of implant failure in the application of PF-LCP.[25–27]

The loads causing this high rate of complication could not be physiologically compared and because of the long lever arm and exposure to high stress between the plate and the head screws, it could be considered to be biomechanically insufficient. When PF-LCP is selected for an unstable fracture, great care must be taken in respect of early weight-bearing. In PFN application, vertically loading body weight is transferred from the femoral head central axis to the femoral shaft intramedullar physiological axis with the thick lag screw of the implant design. Although there is a low possibility of failure associated with the implant PFN, the reasons for the failures seen are generally poor reduction, incorrect positioning of the implant in placement, osteoporosis and loss of posteromedial support because of the fracture.[28] In a biomechanical comparison of Intertan (PFN) and PF-LCP in unstable AO A2.2 ITF fractures, Intertan were superior and it was emphasised that Intertan should be preferred in these fractures.[26] PF-LCP can be considered to have several deficiencies in respect of strong biomechanical efficacy. As the cannulated head-locking screws placed in the femoral head are fully grooved and the first screw is placed at 95°, sufficient compression is not made on the fracture line in unstable A2.2 and A2.3 fractures. After reduction, the first head screw should not be sent from the 95° hole, but from the 135° or 120° holes to make a 90° angle to the fracture line and there should be strong compression capacity. The use of locking and fully-grooved screws for rigid fixation and not to disturb the screw angle at the point of loading and screw-plate, prevents compression. If unlocked or half-grooved screws are selected to apply compression, the angle between the plate and the screw can be easily disrupted as a result of load bearing. Thus it can be seen that there are unanswered questions in respect of providing strong biomechanical effectiveness. It is noticeable that there is inadequate maintenance of strong compression in the fracture line and stable fixation when there is weight-bearing. Therefore, the application of plate-screw in unstable A2 fractures causes problems in early weight-bearing and may result in implant failure. PFN is highly advantageous in respect of early weight-bearing.[29]

There can be said to be several limitations to this study. First, the study was retrospective. Without randomization, likelihood of the bias in the form of surgeon's decision making in implant choice is very high. Also, as the levels of osteoporosis of the patients were not known, this could have led to heterogeneity in respect of bone quality. In recent years, the literature has showed evidence of altered fracture healing in osteoporotic.[30] In the elderly with concomitant osteoporosis, the healing time is long and there is a high risk of varus malunion and low functional results.[31] Kim et al stated that direct partial endoprosthesis could be applied even in osteoporotic unstable ITF patients because of the high rate of implant failure, while Lee et al reported that DHS could be applied with cement augmentation.[32,33] The second limitation of the study is that the intraoperative evaluation criteria of PF-LCP applied with open surgery led to an increase in the significance compared to PFN. Percutaneous application could have increased the clinical success but we do not think it would have affected the clinical superiority of PFN. Finally, the low number of patients limited the statistical power, particularly in the comparison of complications. There is a need for large-scale, multi-center, prospective randomised studies for more effective results. However, the results of the current study can be considered to be valuable in respect of providing useful information for the selection of implants and practice.

5. Conclusion

This study supports new generation, intramedullar nails (Intertan) provide more successful results than extramdullar implants in the treatment of A2 unstable ITF. PF-LCP should not be the first choice of treatment because of the high rates of implant failure, or when they are used, there must certainly not be early weight-bearing before callus is observed.

Authors' Contribution

TMD and **SA** made substantial contributions to the conception and design of the study. **TMD and BD** have been involved in drafting the manuscript or revising it critically for important intellectual content **SM, SA and İU** contributed to acquisition of data and performed the statistical analysis. **TK and LA** were involved in analysis and interpretation of data. All authors read and approved the final manuscript.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Source of funding

There was no external funding for this study.

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