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Review

Nail plate combination in fractures of the distal femur in the elderly: A new paradigm for optimum fixation and early mobilization?

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ABSTRACT

Distal femoral fractures in elderly or osteoporotic patients constitute a challenging injury, especially in the settings of fracture comminution or periprosthetic fractures. A recent trend in the treatment of these difficult injuries is the double fixation with a nail and a plate, a strategy that comes with advantages including faster weight-bearing and lower risk for non-union. Although biomechanical studies have demonstrated the superiority of nail-plate constructs, there is a paucity in the literature regarding the indications and results of treatment. A review of the literature to date was carried out to identify which group of patients would benefit the most from this type of reconstruction and to evaluate the clinical outcomes.

Introduction

Double-construct fixation for distal femoral fractures [1] is a practice that has recently gained popularity, especially in the context of complex or geriatric fractures [2,3]. It has been suggested that nail and plate (NP) fixation restores limb alignment and provides the patient with a stronger construct that can immediately tolerate weight-bearing [4]. The question is whether NP should be the new standard of care for elderly patients with distal femoral fractures in order to expedite full weight-bearing and fracture healing.

With a 90-day and a 1-year mortality rate of 11% and 21% respectively [5], geriatric patients with distal femoral fractures constitute a patient group that would benefit from early mobilization and weight bearing [6]. Standalone lateral plate (LP) fixation of both native and periprosthetic distal femoral fractures has recently raised concerns over non-union incidence and metalwork failure, while it does not always allow for full weight bearing postoperatively [7–11]. Another option for the fixation of these fractures is a retrograde intramedullary nail (rIMN). Although rIMN constructs have no significant biomechanical superiority over LP constructs [12], fractures with insufficient distal bone stock for nail anchorage, are traditionally treated with plates [13]. Not all rIMN treated distal femoral fractures are allowed to fully weight-bear either [14,15].

NP constructs synergistically combine the biomechanical properties of both LP and rIMN and result in much sturdier fixations [16,17]. The LP is a load-bearing construct because the plate receives the entire load. On the other hand, the rIMN is a load-sharing device that distributes the forces along the surrounding cortex and through the nail-cortex interface [18]. In a biomechanical study of a 33A3 fracture model in synthetic femurs [16], the NP construct had significantly higher torsional stability and axial strength in comparison to standalone nail or LP. The average axial displacement in the LP group was 2.3 and in the nail group 1.9 times higher than in the NP group. Similarly, the torque values were 1.7 and 1.8 times higher in the LP and the nail group respectively, while the mean load to failure decreased by 47% and 26% (LP and nail respectively) compared to NP constructs. In another study of an osteoporotic 33C fracture model [17], the results were similar; there, the NP constructs required 1.8 the amount of cycles to failure and had 100% survivability after maximum loading (cyclic loading up to 2.5 times the bodyweight), in comparison to LP. These biomechanical data show that NP combination results in a construct with enhanced axial and torsional stability that can tolerate full weight-bearing. Liporace et al. [3] recommend linking the plate and the nail distally in order to increase the overall stability of the system, this is performed by using the "perfect circle" technique with the fluoroscopy. These authors suggest using

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two linked screws in severely osteoporotic cases, and they generally recommend spanning of the entire femur with the plate.

Evidence from the literature

The number of case series in the literature that describe the use of NP constructs in distal femoral fractures is limited, but the existing publications report admirable results (Table 1). In a 2017 retrospective case series, Kanabur et al. [19] used the NP construct for primary fixation of eight periprosthetic distal femoral fractures (mean age 66 years), in the setting of THA, TKA, or both. The nail was the 200mm Stryker T2 femoral supracondylar nail and the plate was the NCB lateral locking plate from Zimmer Biomet. The patients were first allowed to partially weight-bear 4 weeks after the surgery and all of them healed uneventfully. Hussain et al. [20] treated nine cases (mean age 82 years) with interprosthetic (between THA and TKA) non-comminuted fractures just above the TKA, with a Stryker T2 retrograde femoral nail and an NCB plate. All patients were allowed full weight-bearing postoperatively and healed uneventfully, with a mean time to union of 20 weeks (from 18 to 24 weeks). Four patients lost one degree of independence, and four had a procurvatum of 2-3 degrees. Liporace et al. [3] published a case series of 15 patients (mean age 78 years) with both native and periprosthetic fractures that were fixed with NP. All of the cases were allowed to weight-bear as tolerated directly after the surgery, mean length of stay was 3.6 days, 14 patients proceeded to union and one patient died six months after the surgery due to unrelated reasons. One patient developed a superficial wound infection that healed with oral antibiotics, no other complications occurred otherwise. Eight patients lost one level of independence. Passias et al. [21] reviewed 97 distal femoral fractures that were treated for at their institution, of which eight were treated with NP, while the rest 89 were treated with either LP or rIMN. All of the NP patients healed, in comparison to the patients that received a standalone fixation where the union rate was 69%. In a retrospective control study from 2022, Garala et al. [13] compared the outcomes of 40 LP, versus 27 NP fixations in distal femoral fractures at their level 1 trauma unit (mean age 68 years). All the distal femoral fractures in the authors' trauma center from 2016 to 2018 had been treated with LP, while from 2018 to 2020 had been treated with NP. In the LP group, only 17/40 patients were allowed full weight-bearing postoperatively, compared to 26/27 patients in the NP group (one patient had ipsilateral tibial plateau fracture). In the LP group, 11/27 patients developed non-union and 11/17 experienced hardware failure, while no patient with an NP construct had non-union or failure. Interestingly, all the non-unions and failures in the LP group occurred in patients that were older than 50 years. NP has been also shown to be a viable solution for treating non-unions. In a retrospective case from 2016, Attum et al. [22] converted 10 cases (mean age 56 years) of distal femoral pseudarthroses to NP with autologous bone grafting. 8/10 patients were allowed full weight-bearing postoperatively and 10/10 patients reached union at a mean 3.9 months (range 2.3-8 months). Seven of these patients had a segmental defect and all of them received cancellous bone allograft (RIA, from 20 to 80mL). One patient developed a superficial wound infection and another a deep wound infection that required debridement and VAC, however the authors suspect that there might have been a low-grade infection already present, prior the conversion to NP.

Overall, the aforementioned studies (Table 1) included a sum of 69 patients that were treated with an NP construct, of which 100% healed uneventfully and 84% (58/69) could weight-bear directly after the surgery. There was a complication rate of 4% (3/69) with two superficial wound infections and one deep infection that required reoperation.

Discussion

Distal femoral fractures have received a lot of attention recently by both clinicians and researchers. Some authors went as far as to claim that they represent a similar injury as the proximal femoral fractures in the elderly population in terms of morbidity and mortality [23–25]. Based on this argument, a case was made to undertake distal femoral replacement in cases of comminution or bone fragility to support early mobilization of patients [26].

Overall, distal femoral fractures can be treated with rIMN, LP or distal femoral replacement. In a recent meta-analysis by Jankowski et al. [4], union rates between LP and rIMN were similar, at approximately 90% and an average time to union of 20 weeks. However, rIMN has a trend for earlier bone union over LP, lower rates of malalignment and infection, as well as higher functional outcomes, even in the case of intra-articular fractures [27]. Another recent meta-analysis by Quinzi et al. [28] did not show any differences in the frequency of major complications or reoperations for fractures treated with either LP, rIMN or distal femoral replacement; however, they had different complication profiles.

The combination of nailing and plating on the other hand, provides the double advantage of the potential for axial loading thanks to the nail along with the increased torsional resistance of the plate and their superimposed load tolerance [16,17]. In case of intra-articular fractures, an LP can compensate for the suboptimal fixation achieved with the rIMN [13]. An augmented fixation is essential in elderly, osteopenic and/or obese patients that need to mobilize as soon as possible, in order to minimize injury-related complications such as DVT, pulmonary embolism and pressure ulcers. The aforementioned double implant configuration is also favorable in cases of complex fractures, with significant comminution or segmental defects [22] and in inter/peri-prosthetic fractures [3,13,19,20], for its high union rates and low risk for complications.

The NP combination however may come with some challenges. In the cases of preexisting TKA, the use of a rIMN is only possible in femoral components with an open box. A possible complication from the rIMN in these cases is extension deformity of the femur, as measured between the two fracture fragments [28,29]; that is because the prosthesis might necessitate a more dorsal insertion of the guidewire. In case of a preexisting THA, the plate should be long enough (from flare to flare) to bridge over the stress riser between the THA stem and the proximal part of the rIMN [19].

NP fixation entails higher implant cost in comparison to standalone LP or rIMN, however, the postoperative hospital stay may be shorter in the double implant group [3], a fact that might even out the overall costs of treatment. However, not all patients with distal femoral fractures are candidates for double implant fixation, there are special factors and fracture characteristics that need to be considered in every case.

Indications for NP fixation include (Table 2):

(a) Elderly, frail patients that are ambulatory, presence of osteoporosis and osteopenia, as well as obese patients;
(b) Fractures with insufficient medial cortex due to comminution;
(c) Segmental, or periprosthetic fractures;
(d) Distal femoral fractures in patients older than 50 years with comminuted fracture patterns since hardware failure and nonunion are higher in that age group [13];
(e) Noncompliant patients [21] (e.g. dementia or drug and alcohol abusers) as they normally would not obey post-operative instructions and they weightbear early.

On the other hand, heavy instrumentation should be avoided in the setting of a concomitant infection, or in open fractures that are severely contaminated, as that might predispose to a relapsing infection. Another contraindication for NP would be in the setting of non-ambulatory and wheelchair-bound patients, who in princi-

Table 1
Studies on NP fixation of distal femoral fractures and non-unions in the literature.

Attum 2016	Retrospective, fracture non-union revision with NP and RIA graft, 4-36 months from index surgery. Union defined radiologically (3/4 cortices) and clinically (no pain with ambulation).	*n*=10 (mean age 56 years).	Distal femoral pseudarthroses that were converted to NP with RIA graft (20-80mL).	Mean FU 9 months (2.5-22).	1/18 deep wound infection; 1/18 superficial wound infection.	8/10 were fully weight-bearing postop. All patients healed with a mean time to union of 3.9 months (2.3-8).
Kanabur 2017	Retrospective, NP fixation. Osteopenic patients or/and BMI > 25. Union defined as a RUSH score >15.	*n*=8 (mean age 66 years).	Periprosthetic femoral fractures in the setting of TKA (n=3), THA (n=2), or both (n=3).	Mean FU 20.59 months (13.5–29.8).	-	All patients were non-weight-bearing the first four weeks postop. 8/8 patients healed, mean RUSH score 23,75.
Hussain 2018	Retrospective, fracture fixation with NP. Union defined radiologically.	*n*=9 (mean age 82 years).	Non-comminuted interprosthetic fractures (A2), immediately above TKA.	Mean FU 11.4 months (8-14).	-	All patients were allowed full weight-bearing postop, all healed at a mean of 20 (18-24) weeks. 4/9 lost one level of independence.
Liporace 2019	Retrospective, NP fixation.	*n*= 15 (mean age 74.8 years).	9/15 periprosthetic fractures and 6/15 fractures in native femurs.	FU 19.2 ± 6.7 weeks (mean ± sd).	Superficial wound infection in 1/15.	All patients were allowed full weight-bearing postop, average length of stay was 3.6 days. 14/15 patients healed, 1/15 deceased. 8/15 lost one level of independence.
Passias 2021	Retrospective, fractures treated with either NP, LP or rIMN.	*n*=97 (8/97 NP, 67/97 LP and 22/97 rIMN)	Distal femoral fractures.	-	-	100% of the patients in the NP group healed vs 69% in the standalone fixation group. Statistically significant longer fluoroscopy time and procedure duration for the NP group.
Garala 2022	Retrospective, cases treated with either LP or NP. Union defined radiologically (orthogonal xrays) and clinically (full weight-bearing on the operated side after 6 months).	*n*= 67 (mean age 68 years). 40 LP versus 27 NP.	Fractures with little or no intra-articular involvement, simple open fractures (OTS); no fractures with segmental bone loss.	Mean FU 29 months (6-56).	-	LP group; 17/40 full postop weight-bearing, 7/40 metalwork failure, 11/40 non-union. NP group; 26/27 full postop weight-bearing, all fractures healed.

*FU = follow-up, average time (range); LP = lateral plate; NP = nail-plate.

Table 2
Indications and contraindications for NP fixation of distal femoral fractures.

Indications	Relative indications	Contraindications
Elderly, frail patients, 4-6 score in the clinical frailty scale Osteoporosis/osteopenia BMI > 25 Medial comminution Inter/periprosthetic fractures Fractures with segmental defects	Age > 50 Patient profile (eg drug/alcohol abuse, psychiatric disease, dementia) Ambulatory patients that are terminally ill Oblique fractures spanning the distal diaphysis and metaphysis	Gravely infected open fracture Concomitant soft tissue infection/abscess near fracture site Wheelchair-bound patients Poor potential for ambulation after the surgery

*NP = nail-plate

ple require a rudimentary fixation that will facilitate their nursing conditions.

Conclusion

Geriatric distal femoral fractures represent a similar injury as proximal femoral fractures, thus requiring prompt surgery, with a fixation that is stable enough to allow for immediate weight bearing. There are multiple fixation options, such as LP, rIMN, or a combination of implants such as NP, or even distal femur replacement. NP constructs combine the load-bearing and the load-sharing properties of LP and rIMN respectively, expediting weight-bearing and minimizing the risks for hardware failure and non-union. The evidence from the literature to date, although sparse, show promising results for NP fixation in both native and periprosthetic fractures, where all of the patients reached bone union and were able to weight bear sooner, in comparison to fixations with a standalone implant. Geriatric, as well as osteoporotic patients or obese patients could benefit from a double implant fixation in terms of achieving early mobilization and minimizing the risk for non-union. In addition, periprosthetic fractures, fractures with medial comminution and engagement of the metaphysis could be an indication for NP. Further studies are warranted for the cost implications of nail and plate fixation, while larger randomized controlled trials will provide eventual evidence for the superiority of that treatment.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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