SCIREA Journal of Clinical Medicine
ISSN: 2706-8870
http://www.scirea.org/journal/CM
August 7, 2022
Volume 7, Issue 4, August 2022
https://doi.org/10.54647/cm32883

Efficacy of retrograde intramedullary femoral nailing and locking plates in the treatment of distal femoral fracture: a systematic review and meta analysis

Zhen Yang [1,*], Wei Zhang [2], Peng Fu [1], Xianfeng Meng [1]

[1] Department of traumatic orthopedics, Shengli Oilfield Central Hospital, 31#, Jinan road, Dongying District, Dongying, Shandong Province, 257000, China

[2] Department of anesthesiology, Dongying District People's Hospital, 333#, Jinan road, Dongying District, Dongying, Shandong Province, 257000, China

* Correspondence: yz0410@163.com

Abstract

The preferred treatment for distal femoral fracture was surgical reduction and internal fixation. In recent years, retrograde intramedullary nails(RIN) and locking plates were the most popular internal fixation methods in clinical practice**.** The goal of this study was to review eligible studies and compare the efficacy of retrograde intramedullary femoral nailing (RIN) and locking plates for the treatment of distal femoral fracture. A systematic search of electronic databases (PubMed, Cochrane Library and Embase) was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guideline with no language limitation. Studies were included if they compared the results of retrograde

intramedullary femoral nailing (RIN) and locking plates for distal femoral fracture in adults. Data on the study setting, blood loss, operative time, non-union, varus or valgus deformity > 5°, the excellent and good rate of knee society function score criteria. A quality assessment was performed using the Quality Index score. We included 10 studies, with a total of 240 patients in the RIN group and 230 in the locking plates group. The results found that after RIN and locking plates, no significant difference in changes of blood loss (MD: -69.55, 95% CI: − 265.98–126.89), operative time (MD: -30.23, 95% CI: − 70.97–10.51), non-union (OR: 0.99, 95% CI: 0.37–2.66), varus or valgus deformity > 5° (OR: 2.10, 95% CI: 0.93–4.74), the excellent and good rate of knee society function score criteria (OR: 1.41, 95% CI: 0.81–2.46). There was no significant difference in clinical efficacy between RIN and locking plates in treating distal femoral fracture. RIN has obvious biomechanical advantages over locking plates, but, the locking plate is better choice for the treatment of osteoporotic distal femoral fractures in the elderly. According to patient's age, bone condition, fracture types, surgeons should make individual treatment plans.

Keywords: Retrograde intramedullary femoral nail· Plate· Internal fixation· Distal femoral fracture · Meta-analysis

Introduction

Distal femoral fractures are very serious injuries and have an incidence of 10 per 100000 [1]. The anatomical structures of distal femur are complex and components of knee joint. For a long time, these types of fractures were considered difficult to heal and often led to complications of malunion or nonunion and knee joint stiffness. Especially in elderly with a high degree of osteopenia, the fracture can be caused by trivial trauma and lead to significant post-injury morbidity and mortality. These types of fractures have been treated mainly operatively over the last few decades, and with operative intervention, outcomes have been improved.

The application of the AO principles of anatomical reduction and rigid fixation produced evidence of benefit of internal fixation, and that have advocated various implants including angle blade plates, dynamic condylar screw(DCS), locking plates and less invasive stabilising system (LISS) plate. Through clinical practice in recent years, open reduction and internal fixation with plates was often associated with increased incidence of infection, and delayed or non-union due to disruption of soft tissue cover [2]. All these complications have stimulated the search for minimally invasive stabilization systems. The principles of BO with emphasis on maintenance of the soft tissue envelope around fractures leaves the fragments untouched without pursuing anatomical reduction, preserves their blood supply and have resulted in decreased rates of complications[3]. The optimal method for the treatment of distal femoral fractures remain controversial [2] and indicate the lack of a gold standard for this injury, especially in elderly patients with multiple medical comorbidities, a major surgical procedure was poorly tolerated.

Literatures are available on the treatment of distal femoral fractures by RIN or locking plates, but with different conclusions. The aim of this study was to perform a meta-analysis of all avail-able literature to obtain updated evidence to evaluate the efficacy of RIN and locking plates for the treatment of distal femoral fractures, and to provide a basis for the selection of clinical treatment.

Methods

Search strategy

This systematic review and meta-analysis is reported in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA). To identify studies pertaining to the clinical results of RIN or locking plates for the treatment of distal femoral fractures, we reviewed the PubMed, Embase, and Cochrane Library for relevant articles published through August 2021. We also reviewed the references of all identified articles to identify additional studies. Search terms were as follows: "Femoral Fractures"[Mesh] OR (((femur distal fracture[Title/Abstract]) OR (distal femur fracture[Title/Abstract])) OR (femur fracture[Title/Abstract])) OR (Supracondylar fracture of femur[Title/Abstract]) AND "Bone

Nails"[Mesh] OR (((((retrograde intramedullary nail[Title/Abstract]) OR (retro-interlocking bone nail[Title/Abstract])) OR (retro-interlocking nail[Title/Abstract])) OR (Interlocking intramedullary nail[Title/Abstract])) OR (interlocking bone nail[Title/Abstract])) OR (intramedullary interlock nail[Title/Abstract]) AND "Bone Plates"[Mesh] OR (((((anatomical plate[Title/Abstract]) OR (condylar buttress plate[Title/Abstract])) OR (condylar steel plate[Title/Abstract])) OR (locking plate[Title/Abstract])) OR (supporting steel plate[Title/Abstract])) OR (Link anatomical distal femoral plate[Title/Abstract]). The literature review was performed independently by 2 investigators, with a third resolving any disputes as needed.

Following the PICOS (Participants, Interventions, Comparisons, Outcomes and Study design) principle, the key search terms included (P) patients with distal femoral fractures; (I) patients were treated with intramedullary femoral nailing (RIN) or plates; (C/O) the outcomes including blood loss, operative time, the rate of non-union, varus or valgus deformity $>5^{\circ}$ and the excellent and good rate of knee society function score criteria.

Study selection criteria

Included studies met the following criteria: acute and unilateral fractures; patients who were able to walk without any assistance before injury; distal femoral fractures and supracondylar fractures with fracture line extension into distal third femoral shaft or articular surface.

Studies were excluded for meeting the following criteria: old fractures (definitive surgery more than 3 weeks after the injury; pathological fractures; Gustilo III open fractures; fractures associated with neurovascular injuries; fractures associated with cruciate ligament tear; patients requiring intensive care or requiring transfer to other departments for treatment; periprosthetic supracondylar femoral fractures following total knee arthroplasty.

Two investigators independently determined whether studies met the inclusion criteria, with a third resolving any disputes as needed.

Data extraction and quality assessment

For each included study, 2 categories of information were extracted: basic information and primary study outcomes. Basic information relevant to this meta-analysis included: author

names, year of publication, sample size, age, gender, and Quality Index score. Primary clinical outcomes relevant to this analysis included: blood loss, operative time, the rate of non-union, varus or valgus deformity > 5° and the excellent and good rate of knee society function score criteria. Study quality was determined on the basis of Quality Index scores, which can be used in both randomized controlled trials (RCT) and controlled clinical trials (CCT). The Quality Index list includes 5 parts and a total of 27 entries. Each question is given a detailed score according to the answer, and finally, the higher the score, the higher the quality of literature. Data were extracted independently by 2 investigators, with a third resolving any disputes as needed.

Statistical analysis

Review Manager 5.3 was used for all analyses. Heterogeneity in study results was assessed using chi-squared and I^2 tests and appropriate analysis models (fixed effects or random effects) were determined. A chi-squared $P \leq 0.1$ and an $I^2 > 50\%$ indicated high heterogeneity and the random-effects model was used. A chi-squared $P > 0.1$ and an $I^2 \leq 50\%$ indicated acceptable heterogeneity and the fixed-effects model was used instead. Continuous variables were given as mean±standard deviations and were compared on the basis of mean difference (MD); while, categorical data were given as percentages and compared based on odds ratios (OR)/ relative risk (RR). MD and 95% CI were used to analyze blood loss and operative time, the rate of non-union, varus or valgus deformity > 5° and the excellent and good rate of knee society function score criteria were analyzed by OR and 95% CI.

Results

Overview of the included studies

We reviewed a total of 846 articles identified by our search terms, of which 808 were excluded following title/ abstract review. The remaining 38 articles were subject to a complete full-text assessment, leading to 28 articles being excluded for failing to meet the study inclusion criteria. Reasons for exclusion of these studies were: no function evaluation (n=5),

follow up period ＜ 6 months (n=9), theoretical research (n=8), no clinical outcomes (n=6). We finally identified a total of 10 studies including 4 RCTs [4-7] and 6 retrospective studies [8-13], 240 patients in the RIN（nails）group and 230 in the locking plates group. The study selection process was outlined in Fig. 1.

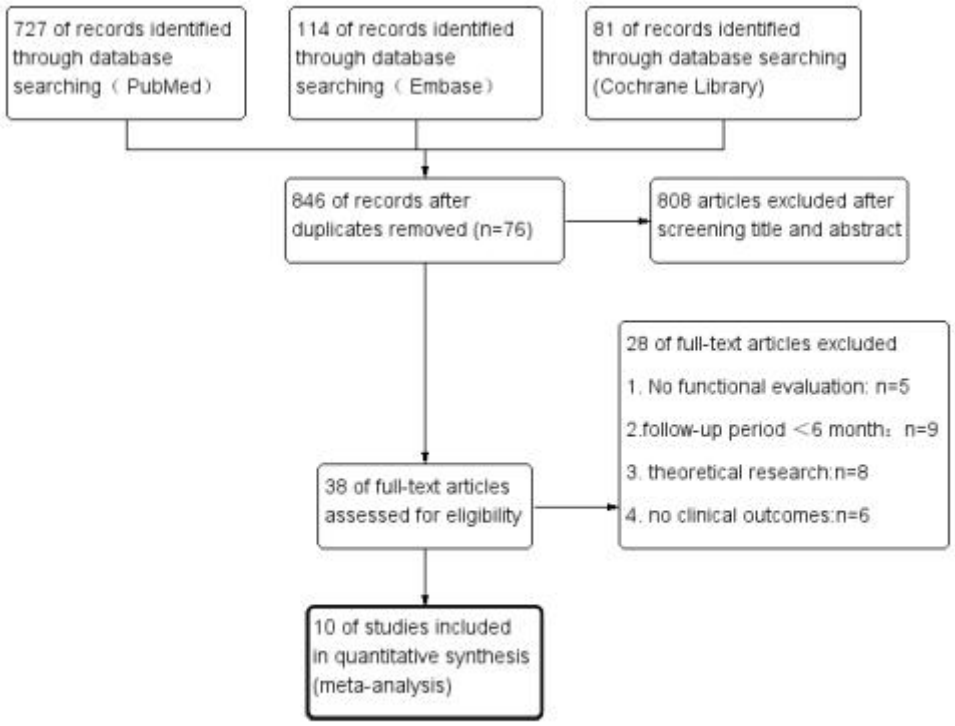

Fig. 1. Literature search and selection strategy

Table 1 The basic characteristics description of included studies. DCS: dynamic condylar screw; ABP: fixed-angle blade plate fixation; LP: Locking plate fracture fixation; LISS: Less invasive stabilising system plate; ADP: Anatomical distal femur plate.

Study	No. of patient		Age(years)		Gender (male/female)		AO/ASIF classification		Implant		Quality Index score
	Nails	Plates	Nails	Plates	Nails	Plates	Nails	plates	Nails	Plates	
Christodoulou, A (2005) [4]	35	37	70.2	73.2	24/47		A:31 C:4	A:32 C:5	RIN	DCS	RCT 25
Hartin, N. L (2006) [5]	12	11	66.3	70.1	4/8	3/8	A:3 C:9	A:3 B1:1 C:7	RIN	ABP	RCT 26
Dar, G. N. (2009) [6]	37	31	47	49	33/14	18/13	A:33 C:4	A:25 C:6	RIN	DCS	RCT 27
Henderson, C. E. (2010) [8]	12	12	63.7	65	4/8	3/9	A:7 C:5	A:7 C:5	RIN	LP	CCT 21
Pavel Mukherjee (2010) [9]	9	24	75.88	82.13	1/8	1/23	A:6 B1:2 C:1	A:18 B1:2 C:4	RIN	LISS	CCT 23
Niyazi, M. (2012) [10]	35	31	48	50	25/10	21/10	A:15 C:20	A:12 C:19	RIN	ADP	CCT 21
Kanda Gao (2013) [11]	17	19	50.6	54.7	13/4	12/7	A:17 C:0	A:19 C:0	RIN	LP	CCT 21
Demirtaş, A. (2014) [12]	13	15	31.1	36	11/2	13/2	A:13 C:0	A:15 C:0	RIN	LP	CCT 22
Yang, K. H. (2014) [13]	59	38	39.8	39.5	34/25	22/16	A:47 C:12	A:22 C:16	RIN	LP	CCT 21

Griffin, X. L. (2019) [7]	11	12	70.1	78.7	7/4	9/3	A:10 C:1	A:8 B1:1 C: 3	RIN	LP	RCT	28

Table 1 summarizes the basic information for each study, including author names, years of publication, sample, age, gender and Quality Index score. The mean Quality Index score for the studies was 23.5 indicating that the included studies were of high quality.

Blood loss

In total, 3 studies were included, containing 110 patients in the RIN（nails） group and 94 patients in the locking plates group. Based on a chi-squared $P<0.00001$ and an $I^2=99\%>50\%$, the random-effects model was chosen to assess blood loss. The results showed no significant difference in changes of blood loss after RIN(nails） and locking plates (MD: -69.55, 95% CI: − 265.98–126.89). The results are presented in Fig. 2.

Operative time

In total, 3 studies were included, containing 111 patients in the RIN（nails） group and 94 patients in the locking plates group. Based on a chi-squared $P<0.00001$ and an $I^2=98\%>50\%$, the random-effects model was chosen to assess operative time. The results showed no significant difference in changes of operative time after RIN（nails） and locking plates (MD: -30.23, 95% CI: − 70.97–10.51). The results are presented in Fig. 3.

Non-union

In total, 5 studies were included, with 111 patients in the RIN（nails） group and 123 patients in the locking plates group. Based on chi-squared test $P=0.78 > 0.1$ and $I^2=0\%$, the fixed-effects model was chosen to assess non-union. The results showed no significant difference in change of the non-union after RIN（nails） and locking plates (OR: 0.99, 95% CI: 0.37–2.66). The results are presented in Fig. 4.

Varus or valgus deformity＞5°

In total, 7 studies were included, with 126 patients in the RIN（nails） group and 142 patients in the locking plates group. Based on chi-squared test $P=0.22 > 0.1$ and $I^2=27\%$, the fixed-effects model was chosen to assess varus or valgus deformity > 5°. The results showed no significant difference in change of the varus or valgus deformity > 5° after RIN（nails） and locking plates (OR: 2.10, 95% CI: 0.93–4.74). The results are presented in Fig. 5.

The excellent and good rate of knee society function score criteria

In total, 6 studies were included, with 188 patients in the RIN（nails） group and 176 patients in the locking plates group. Based on chi-squared test P=0.81 > 0.1 and I^2=0%, the fixed-effects model was chosen to assess the excellent and good rate of knee society function score criteria. The results showed no significant difference in change of the excellent and good rate of knee society function score criteria after RIN（nails） and locking plates (OR: 1.41, 95% CI: 0.81–2.46). The results are presented in Fig. 6.

Quality and bias assessment

An assessment of study quality and risk of bias was performed by STATA v12.0 using multiple complementary methods including: funnel plots, Begg's and Egger's test. There was clear symmetry in the log RR funnel plot for complication of varus or valgus deformity > 5° for these studies, suggesting a low publication bias risk (Fig. 7). The results of Begg's test (Z=1.20, p=0.230) and Egger's test (p=0.281) both suggested that there was not any significant risk of bias among the study results.

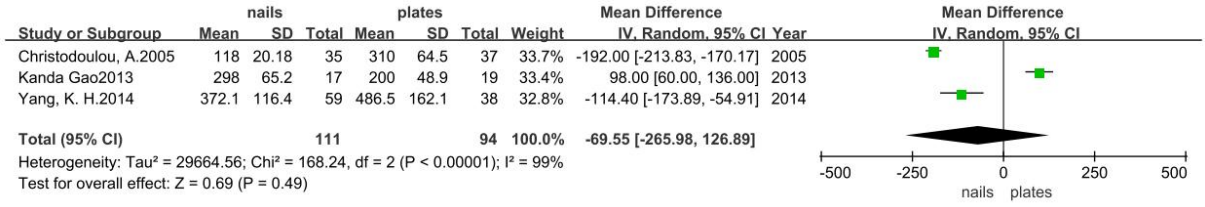

Fig. 2. Forest plot for blood loss

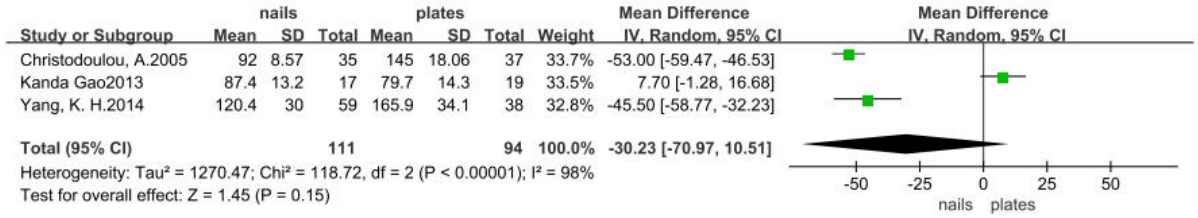

Fig. 3. Forest plot for operative time

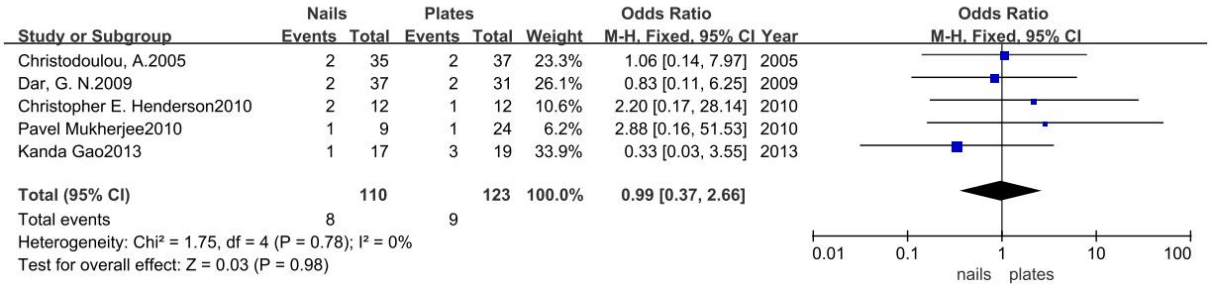

Fig. 4. Forest plot for non-union

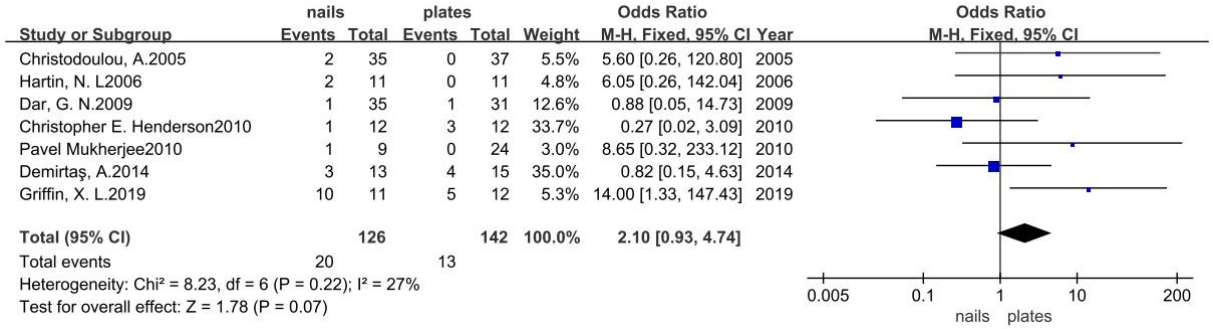

Fig. 5. Forest plot for varus or valgus deformity > 5°

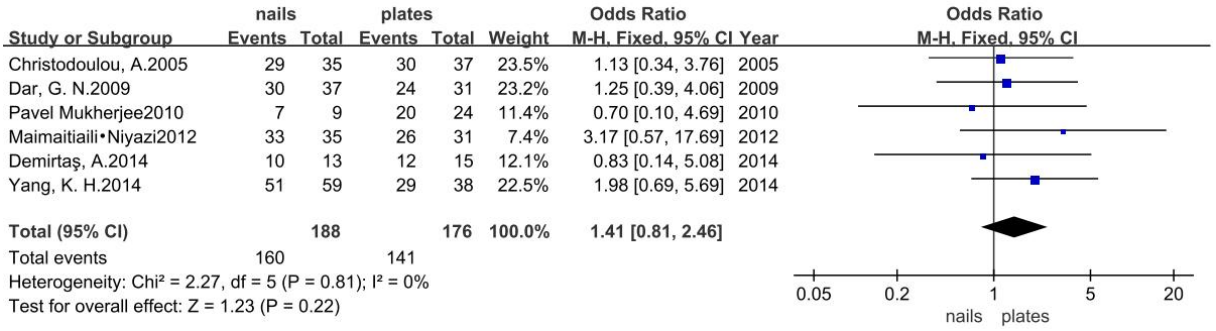

Fig. 6. Forest plot for excellent and good rate of knee society function score criteria

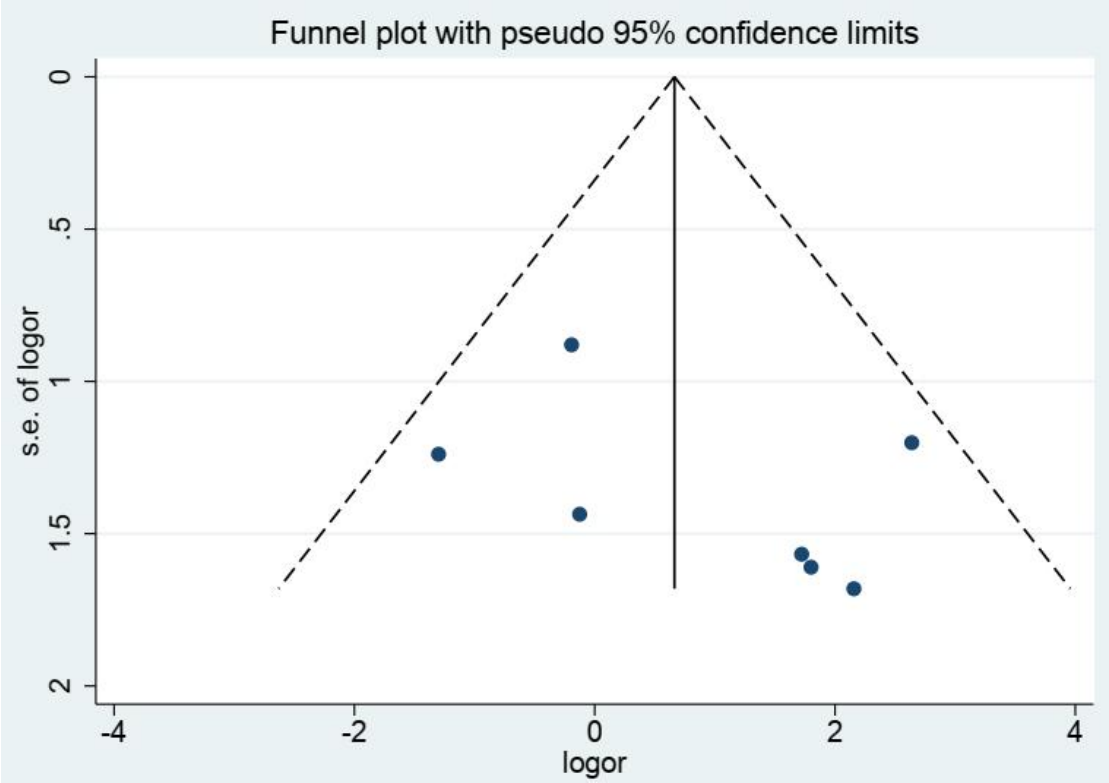

Fig. 7. Funnel plot analysis of the included studies

Discussion

It is widely accepted that RIN technology has the advantage of being a simpler and faster operative technique than plates [14], causing less damage to the blood supply of fragments, and reducing in operative blood loss and operating time [15]. However, some studies found that operative time and blood loss were similar for both RIN (nails) and locking plates [5]. In our study, we compared RIN with locking plates in the treatment of distal femoral fracture, we found that no significant difference in changes of operative time (MD: -30.23, 95% CI: − 70.97–10.51) and blood loss (MD: -69.55, 95% CI: − 265.98–126.89). Surgical skills varied between surgeons and difficulties in establishing length, alignment and anatomical reduction of comminuted intra-articular fracture would impact the operative time and blood loss.

The crucial factor influencing the healing of distal femoral fracture was the severity of soft-tissue envelope injury [16]. Open reduction and internal fixation with locking plates was associated with unavoidable iatrogenic trauma to the soft tissues of the fracture site and high

rate of non-union, pseudarthrosis and infection, especially the chronic infection would resulte in amputation [17]. With the application of Retrograde intramedullary femoral nails (RIN) , studies have reported improved rates of union [18], decreased rate of wound infection[19], reduced the requirement for primary bone grafting[20] . In our study, we found that no significant difference in changes of the non-union (OR: 0.99, 95% CI: 0.37–2.66) after RIN and locking plates.

Retrograde intramedullary femoral nails (RIN) avoiding unnecessary incisions and soft dissection helps the patients to mobilize earlier. However, some studies have shown that RIN influenced the knee function due to articular cartilage wear, articular surface defect and residual bone debris in knee joint cavity[21]. In our study, we found that no significant difference in changes of the excellent and good rate of knee society function score criteria (OR: 1.41, 95% CI: 0.81–2.46) after RIN and locking plates.

Angular malunion after RIN was a known complication[22], and the most common source of implant failure was varus loading [4]. To the elderly patients with thin cortical and osteoporotic bone, the osteoporotic nature of bones and poor hold of the screws make the stability of the osteosynthesis more difficult to achieve[23]. Studies reported that intramedullary nailing method was less stable to varus–valgus loading in comparison with locking plates [24]. Locking plates were 3 times stiffer in lateral bending (poor valgus) and 1.2 times stiffer in valgus compression than RIN [25]. In our study, we compared RIN with locking plates in the treatment of distal femoral fracture, we found that no significant difference in changes of varus or valgus deformity > 5°(OR: 2.10, 95% CI: 0.93–4.74).

Strengths of this meta-analysis include: the systematic nature of this analysis makes the results more convincing than those of individual studies, given that these results rely on a large pooled sample size; strict inclusion and exclusion criteria were used to select qualified studies; all the data were analyzed by standard statistical analyses to ensure accuracy.

However, the present analysis has certain limitations, which are as follows: the number of included studies is limited; individual studies had variations in exclusion/ inclusion criteria; surgical skills varied between studies; severity of distal femoral fracture varied among studies;

pooled data were analyzed, as individual patient data was not available, precluding more in-depth analyses.

In conclusion, there was no significant difference in clinical efficacy between RIN and locking plats in treating distal femoral fracture. These two implants have their own advantages, RIN has obvious biomechanical advantages over locking plates, but, the locking plate is better choice for the treatment of osteoporotic distal femoral fractures in the elderly [26]. According to patient's age, bone condition, fracture types, surgeons should make individual treatment plans. there was still a need of large-sample, high-quality, long-term randomized controlled trials to confirm the clinical efficacy of RIN and locking plates.

References

[1] Court-Brown CM, Caesar B: Epidemiology of adult fractures: A review. Injury 37:691-7, 2006

[2] Thomson AB, Driver R, Kregor PJ, et al: Long-term functional outcomes after intra-articular distal femur fractures: ORIF versus retrograde intramedullary nailing. Orthopedics 31:748-50, 2008

[3] Chrisovitsinos JP, Xenakis T, Papakostides KG, et al: Bridge plating osteosynthesis of 20 comminuted fractures of the femur. Acta Orthop Scand Suppl 275:72-6, 1997

[4] Christodoulou A, Terzidis I, Ploumis A, et al: Supracondylar femoral fractures in elderly patients treated with the dynamic condylar screw and the retrograde intramedullary nail: A comparative study of the two methods. Archives of Orthopaedic and Trauma Surgery 125:73-79, 2005

[5] Hartin NL, Harris I, Hazratwala K: Retrograde nailing versus fixed-angle blade plating for supracondylar femoral fractures: a randomized controlled trial. ANZ J Surg 76:290-4, 2006

[6] Dar GN, Tak SR, Kangoo KA, et al: Bridge plate osteosynthesis using dynamic condylar screw (DCS) or retrograde intramedullary supracondylar nail (RIMSN) in the treatment of distal femoral fractures: comparison of two methods in a prospective randomized study. Ulus Travma Acil Cerrahi Derg 15:148-53, 2009

[7] Griffin XL, Costa ML, Phelps E, et al: Intramedullary nails versus distal locking plates for fracture of the distal femur: results from the Trial of Acute Femoral Fracture Fixation (TrAFFix) randomised feasibility study and process evaluation. BMJ Open 9:e026810, 2019

[8] Henderson CE, Lujan T, Bottlang M, et al: Stabilization of distal femur fractures with intramedullary nails and locking plates: differences in callus formation. Iowa Orthop J 30:61-8, 2010

[9] Mukherjee P, Bovell C, Davis J: Less invasive stabilising system plate versus retrograde intramedullary nail for osteoporotic distal femoral fracture. European Journal of Orthopaedic Surgery and Traumatology 20:281-284, 2010

[10] Niyazi M, Wumair A, Maimaiti M, et al: Comparison of retrograde intramedullary nail and plate implantation for internal fixation for the treatment of distal femur fractures. Chinese Journal of Tissue Engineering Research 16:8201-8205, 2012

[11] Gao K, Gao W, Huang J, et al: Retrograde nailing versus locked plating of extra-articular distal femoral fractures: comparison of 36 cases. Med Princ Pract 22:161-6, 2013

[12] Demirtaş A, Azboy I, Özkul E, et al: Comparison of retrograde intramedullary nailing and bridge plating in the treatment of extra-articular fractures of the distal femur. Acta Orthop Traumatol Turc 48:521-6, 2014

[13] Yang KH, Yang J, Yang GZ: Comparison of the stability of three internal fixators for distal femoral fracture. Chinese Journal of Tissue Engineering Research 18:565-570, 2014

[14] Henry SL: Supracondylar femur fractures treated percutaneously. Clin Orthop Relat Res:51-9, 2000

[15] Handolin L, Pajarinen J, Lindahl J, et al: Retrograde intramedullary nailing in distal femoral fractures--results in a series of 46 consecutive operations. Injury 35:517-22, 2004

[16] Schatzker J, Mahomed N, Schiffman K, et al: Dynamic condylar screw: a new device. A preliminary report. J Orthop Trauma 3:124-32, 1989

[17] Moore TJ, Watson T, Green SA, et al: Complications of surgically treated supracondylar fractures of the femur. J Trauma 27:402-6, 1987

[18] Huang HT, Huang PJ, Su JY, et al: Indirect reduction and bridge plating of supracondylar fractures of the femur. Injury 34:135-40, 2003

[19] Saw A, Lau CP: Supracondylar nailing for difficult distal femur fractures. J Orthop Surg (Hong Kong) 11:141-7, 2003

[20] Seifert J, Stengel D, Matthes G, et al: Retrograde fixation of distal femoral fractures: results using a new nail system. J Orthop Trauma 17:488-95, 2003

[21] Johnson EE, Marroquin CE, Kossovsky N: Synovial metallosis resulting from intraarticular intramedullary nailing of a distal femoral nonunion. J Orthop Trauma 7:320-4; discussion 325-6, 1993

[22] Ostrum RF, Maurer JP: Distal third femur fractures treated with retrograde femoral nailing and blocking screws. J Orthop Trauma 23:681-4, 2009

[23] Anakwe RE, Aitken SA, Khan LA: Osteoporotic periprosthetic fractures of the femur in elderly patients: outcome after fixation with the LISS plate. Injury 39:1191-7, 2008

[24] Ito K, Grass R, Zwipp H: Internal fixation of supracondylar femoral fractures: comparative biomechanical performance of the 95-degree blade plate and two retrograde nails. J Orthop Trauma 12:259-66, 1998

[25] Firoozbakhsh K, Behzadi K, DeCoster TA, et al: Mechanics of retrograde nail versus plate fixation for supracondylar femur fractures. J Orthop Trauma 9:152-7, 1995

[26] Kiyono M, Noda T, Nagano H, et al: Clinical outcomes of treatment with locking compression plates for distal femoral fractures in a retrospective cohort. J Orthop Surg Res 14:384, 2019