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Review

Locked Plating Versus Retrograde Intramedullary Nailing in The Surgical Fixation of Periprosthetic Supra-condylar Knee Fractures: An Updated Systematic and Meta-Analysis Review

Ahmad Abdallatif *, Sherif Isaac

Worcester Roal Hospital, Charles Hastings Way, Worcester, WR5 1DD, UK; E-Mails: ahmad.abdallatif@nhs.net; sherif.isaac@nhs.net

* **Correspondence:** Ahmad Abdallatif; E-Mail: ahmad.abdallatif@nhs.net

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Abstract

Meta-analysist to evaluate impact of Surgical Methods on Outcomes in periprosthetic supracondylar knee fracture management. This study examines the rate of functional outcomes and complications associated with two distinct surgical methods for the management of periprosthetic supracondylar knee fractures in patients treated with Low Contact Locking Plates (LCP) and Retrograde Intramedullary Nails (RIMN). With the growing prevalence of total knee replacements, the incidence of periprosthetic supracondylar knee fractures has concurrently increased. While the retrograde intramedullary nail has gained recognition as a viable alternative to the locking compression plate in addressing these fractures, ongoing investigations are required to ascertain the superiority of one technique over the other. An extensive literature review was conducted in accordance with PRISMA guidelines, utilizing electronic databases through a meticulously defined search strategy. All randomized controlled trials or comparative studies meeting the inclusion criteria were evaluated using Cochrane's collaboration tool to assess methodological quality. Functional outcomes, union rates, and complication rates were employed as criteria for evaluation and comparison. A total of seven studies were incorporated into this metanalysis provide valuable

insights into the efficacy and safety of the surgical approaches currently under review. The systematic review and meta-analysis indicate no significant differences in any of the outcome measures, although further extensive studies are warranted to draw more definitive conclusions.

Keywords
Periprosthetic; fracture; meta-analysis

1. Introduction

The rising incidence of total knee replacements has critically contributed to an increase in supracondylar periprosthetic femur fractures. A substantial body of literature now addresses the most effective treatment strategies for these fractures [1].

Key factors, including poor bone stock, osteoporosis, and inadequate bone availability for fixation, combined with suboptimal biological conditions, present significant challenges in managing supracondylar femur fractures that occur post-total knee arthroplasty (TKA) [2, 3]. Surgical intervention is unequivocally the gold standard for treating periprosthetic knee fractures. Relying on nonsurgical management for these fractures dramatically heightens the risk of complications, nonunion, and the need for reoperation. Therefore, the primary goal in the fixation of these fractures is to establish a rigid and stable construct that not only promotes early mobilisation but also facilitates effective joint rehabilitation. It is essential that achieving this rigid fixation does not compromise the biological integrity of the tissue crucial for bone union [4].

Modern surgical techniques are designed to ensure a high rate of union while delivering favourable long-term outcomes, all while minimising complications and additional surgical interventions. The strategies typically employed involve surgical fixation using lateral locking plates with minimally invasive techniques or the application of retrograde nails. Although minimally invasive plate osteosynthesis with locking plates has long been recognised as the gold standard, retrograde intramedullary nailing (RIMN) is increasingly acknowledged as a formidable alternative. Each technique presents unique advantages and considerations that must be vigorously evaluated in clinical practice [5-9].

The pursuit of the optimal surgical intervention for periprosthetic knee fractures remains a hotly debated topic within the medical community. The ongoing comparison between locking plate fixation with minimally invasive plate osteosynthesis (MIPO) and retrograde intramedullary nails (RIN) continues to spark contention. While biomechanical studies indicate that retrograde intramedullary nails show superior performance over locking plates in treating periprosthetic femoral fractures (PSFS), discussions regarding the clinical advantages of retrograde nails persist [10, 11].

2. Methods

Search of comparative studies through PubMed, Embase and the Cochrane Collaboration Library till December 2022. Keywords used were: periprosthetic fracture, total knee arthroplasty, retrograde intramedullary nail, distal femur fracture and locked plate.

The eligibility criteria were as follows: 1) Comparative study, 2) Peri-prosthetic fractures above total knee replacement, 3) Comparison between LCP and RIN fixation, 4) Minimum follow up time of 12 months, 5) Primary outcome measured were union and re-operation rates.

Data analysis: 1) Statistical significance of outcomes assessed with p-value < 0.05, 2) Calculation of odds ratio with 95% confidence intervals assessed, 3) Volume of heterogeneity across studies was estimated with I2 statistics, 4) Egger's test via funnel plot symmetry used to assess potential publication bias in studies.

Outcome measures the primary outcome measures of interest for this review were: 1-union rate, 2-reoperation rate.

All included studies described the surgical techniques—whether using LCP or RIMN—as percutaneous or minimally invasive. The procedures were performed in accordance with standard surgical protocols for these techniques.

2.1 Statistics

Overview: The analysis is based on fourteen studies. The effect size index is the odds ratio.

Statistical model: The random-effects model was employed for the analysis. The mean effect size is 0.590 with a 95% confidence interval of 0.220 to 1.586.

The Z-value tests the null hypothesis that the mean effect size is 1.000. The Z-value is -1.046 with p = 0.296.

2.2 Heterogeneity

2.2.1 Q Test

The Q-value is 47.058 with 13 degrees of freedom and p < 0.001. Using a criterion alpha of 0.100, we can reject the null hypothesis that the true effect size is the same in all these studies.

2.2.2 I-Squared Statistic

The I-squared statistic is 72%, which tells us that some 72% of the variance in observed effects reflects variance in true effects rather than sampling error.

2.3 Publication Bias

2.3.1 Funnel Plot

The funnel plot is a plot of a measure of study size (usually standard error or precision) on the vertical axis as a function of effect size on the horizontal axis.

In the absence of publication bias, we would expect the studies to be distributed symmetrically about the combined effect size. By contrast, in the presence of bias, we would expect that the bottom of the plot would show a higher concentration of studies on one side of the mean than the other (Figure 1).

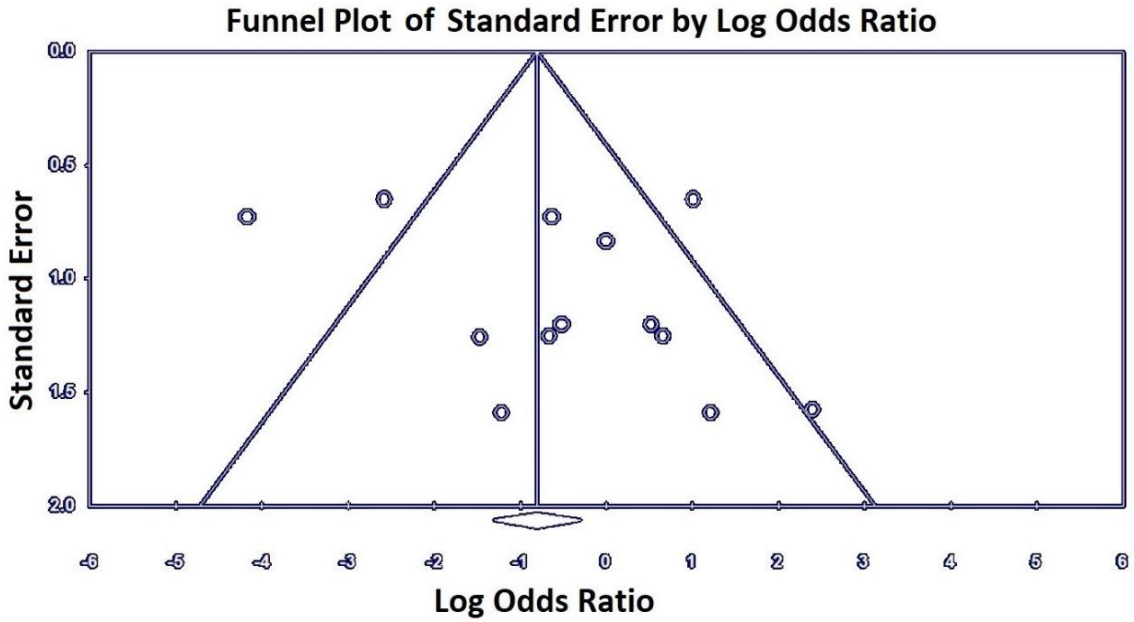

Figure 1 Fnnel plot of standard error.

2.3.2 Egger's Test of the Intercept

In our study, the intercept (B0) is 2.02262, 95% confidence interval (-1.47893, 5.52417), with t = 1.25856, df = 12. The 1-tailed p-value (recommended) is 0.11606, and the 2-tailed p-value is 0.23213. The previous values show no publication bias (Figure 2).

EGGER'S REGRESSION INTERCEPT	
Intercept	2.02262
Standard Error	1.60709
95% lower limit (2-tailed)	-1.47893
95% upper limit (2-talied)	5.52417
t-value	1.25856
p-value (1-tailed)	0.11606
p-value (2-tailed)	0.23213

Figure 2 Egger's regression intercept values show no publication bias.

3. Results

A total of 721 references were identified that contained any of the designated keywords. An examination of the abstracts resulted in the exclusion of 714 references, which were filtered out due to their status as duplicates, unrelated articles, case reports, systematic reviews, and non-comparative studies. The remaining seven studies were subjected to a comprehensive full-text review. All included research pertains to comparative studies and retrospective analyses, presenting two primary outcomes: The union rate and the reoperation rate. Collectively, these studies

encompass a total of 372 patients, of whom 208 patients had a low-contact plate and 164 had a retrograde nail.

Hou *et al*. [12] retrospectively compared 34 patients treated with LCP against 18 patients treated with RIMN. In the LCP group, 3 patients had non-union, while 1 patient had non-union in the RIMN. Three patients in the LCP group had other complications, while one patient in the RIMN group had another complication. No statistically significant difference between the two groups regarding to union rate or reoperation incidence.

Adrian *et al*. [13] compared healing and functional outcomes between the two techniques. 48 patients had LCP, and 38 patients had RIMN. No statistically significant difference between the two methods regarding union rate (41 patients in the LCP group had bone union and 33 patients in the RIMN group had bone union), reoperation and the final Oxford knee score.

Gondaline *et al*. [14] compared the union rate and complication rate between 24 cases treated with LCP (20 patients had bone union) and 18 cases (15 patients had bone union) with RIMN. There was no significant difference between the two patient groups at the level of union, union time, reoperation and complications.

Horneff *et al*. [15] retrospectively reviewed 63 patents with supracondylar fractures which 35 patients had IMN, while 28 patients with LCP. Although the LCP group shows a statistically significantly quicker healing rate, no statistically significant difference between the two groups regarding union rate (24 patients in the LCP group and 24 patients in the RIMN group) or the reoperation rate.

Metlovic *et al*. [16] followed up 57 patients with periprosthetic supracondylar femoral fracture, 38 patients with RIMN and 19 patients had LCP. Comparing two techniques at the level of union rate (all patients in the LCP group had bony union, and 17 patients in the RIMN group had bony union), complications and reoperations did not show any significant differences. Only one patient with RIM nail showed non-union with a fracture distal to the TKA flanges.

Theofylakbs *et al*. [17] compared the union rate and the Oxford Knee Score between 31 patients who underwent locking plate (LCP) fixation, of which 29 patients achieved bony union, and 29 patients who received retrograde intramedullary nailing (RIMN), with 28 patients also achieving bony union. The analysis revealed no statistically significant differences between the two surgical techniques. This information was presented by Samet *et al*. [18]. (Table 1 and Table 2/ Figure 3 and Figure 4).

Table 1 Total number of patients with the outcome.

study	LCP Union	LCP reoperation	Total	RIN union	RIN reoperation	Total
Aldrian *et al*.	41	7 (14.6%)	48	33	3	36
Horneff *et al*.	24	4(14.3%)	28	28	7	35
Hou *et al*.	25	3(10.7%)	28	14	1	15
Matlovich *et al*.	38	1(2.6)	39	17	2	19
Kyriakidis *et al*.	29	2(6.5)	31	28	1	29
Samet *et al*.	18	2(10%)	20	12	0	12
Gondalia	20	4(14%)	24	15	3	18
	195(89.4%)	23(10.5%)	218	147(89.6%)	17(10.4%)	164

Table 2 Compare the complication rate between LCP VS RIMN.

	LCP	RIMN
Patient Number	195	147
Non-Union Rate	10.5	10.4
Superficial infection	5	3
Deep infection	0	0
malunion	2	1

Model	Effect Size and 95% Interval				Test of Null (2-Tail)		Heterogeneity		
	# of Studies	Point estimate	Lower Limit	Upper Limit	Z-value	P-value	Q-value	P-value	I2
Fixed	14	0.449	0.274	0.735	-3.186	0.001	47.06	0.00	72.37
Random	14	0.590	0.220	1.586	-1.046	0.296			

Figure 3 Comparison between two types of fixations regarding to union rate and reoperation in seven studies.

Study name	Outcome	Statistics for each study					Odds ratio and 95% CI
		Odds ratio	Lower limit	Upper limit	Z-Value	p-Value	0.01 0.10 1.00 10.00 100.00
Adrian	BONE	0.532	0.128	2.221	-0.865	0.387	
HORNEFF	BONE	2.750	0.767	9.857	1.553	0.120	
HOU	BONE	0.595	0.056	6.278	-0.432	0.666	
MATLOVIC	BONE	11.000	0.501	241.384	1.522	0.128	
KYRIAKIDI	BONE	0.518	0.044	6.037	-0.525	0.599	
SAMET	BONE	0.296	0.013	6.703	-0.765	0.444	
GANDALIA	BONE	1.000	0.194	5.154	0.000	1.000	
		1.109	0.530	2.320	0.275	0.783	
Adrian	REOPERA	0.016	0.004	0.065	-5.717	0.000	
HORNEFF	REOPERA	0.076	0.021	0.274	-3.949	0.000	
HOU	REOPERA	1.680	0.159	17.719	0.432	0.666	
MATLOVIC	REOPERA	0.230	0.019	2.711	-1.168	0.243	
KYRIAKIDI	REOPERA	1.931	0.166	22.512	0.525	0.599	
SAMET	REOPERA	3.378	0.149	76.509	0.765	0.444	
GANDALIA	REOPERA	1.000	0.194	5.154	0.000	1.000	
		0.356	0.074	1.721	-1.284	0.199	
		0.904	0.464	1.764	-0.295	0.768	

Figure 4 Effective size, Z and P value and heterogenicity of all studies.

4. Discussion

Surgical fixation of periprosthetic femur fractures demonstrates superiority over conservative treatment, which is associated with a notable incidence of non-union. The urgency for surgical intervention in these fractures should be on par with the urgency associated with neck of femur fracture surgeries, with the primary goal being the early mobilization of patients [14].

This meta-analysis comprehensively examines the effectiveness of retrograde intramedullary nail (RIM) fixation versus locking plate fixation (LCP) for treating periprosthetic supracondylar knee fractures. The results indicate that there are no significant differences in union rates or revision rates between the two fixation methods. This highlights the necessity for ongoing research in this

area, as the treatment of periprosthetic supracondylar femur fractures poses considerable challenges for both patients and surgeons. Numerous complications can arise during and after the surgical fixation of these fractures, with factors such as patient age and surgeon experience being primary contributors to complication rates [19].

The Retrograde Intramedullary Nail (RIM) method offers theoretical benefits over the Locking Compression Plate (LCP), including reduced soft tissue disruption and improved mechanical weight distribution. However, the findings from this study do not indicate a clear advantage of RIM over LCP. It is worth noting that the latest generation of LCP has been engineered to address the deficiencies of earlier models, which suffered from inadequate contact between the plate and bone. Moreover, advancements in minimally invasive techniques used with LCP have significantly decreased soft tissue disruption [20, 21].

The retrograde intramedullary nail (RIMN) has a significant drawback: it does not adequately stabilise the metaphyseal flare. This can result in the toggling of the distal segment and associated rotational instability. As a result, this limitation warrants careful consideration when determining clinical treatment options. On the other hand, locking compression plates (LCP) have been demonstrated to offer better rotational stability and effectively prevent the toggling of the distal fragment.

Previous studies comparing these two fixation methods have been conducted through meta-analyses. Initial reviews suggested that LCP is associated with a lower complication rate; however, more recent meta-analyses indicate that the rates of union and complications may be comparable between both techniques, consistent with the findings in our recent meta-analysis study [22, 23].

It is important to recognise the limitations posed by small sample sizes and the quality of the data in these studies. All the included studies were retrospective cohort studies lacking randomisation, which can negatively impact data quality. Additionally, the choice of fixation method and implant was frequently determined by the operating surgeon's experience and familiarity with particular techniques and materials, as well as institutional trends and the specific type of fracture. Unfortunately, we were unable to gather reliable data to ascertain whether fracture patterns or bone quality influenced the choice of fixation method. One of the limitations of this study is the absence of data on postoperative weight-bearing status and the level of decline in daily activities. This is due to the fact that the studies included in this meta-analysis did not consistently report these outcomes.

Management of periprosthetic fractures involves a variety of departments and surgeons with differing levels of expertise, largely due to the steep learning curve associated with these procedures. Recent innovations for treating peri-prosthetic distal femur fractures have introduced techniques such as the nail-plate method and distal femur replacement (DFR), which have shown promise as effective alternatives. Fractures that present with inadequate distal bone stock, unstable implants, and compromised ligaments may not respond well to treatment with LCP or RIMN, making DFR a suitable option in such cases.

Moreover, contemporary literature suggests that DFR offers favourable outcomes, particularly for elderly patients, as it promotes early mobilisation and weight-bearing, consequently reducing hospital stays and minimising the risks tied to prolonged immobilisation. Ongoing research into DFR is crucial to a more comprehensive understanding of its effectiveness as a treatment option.

We recommend future Level I studies to directly compare single-device fixation techniques (such as LCP or RIMN) with double fixation methods or distal femoral replacement (DFR). Such high-

quality evidence is essential to determine the most effective surgical approach for managing these complex fractures.

Author Contributions

Mr A. Abdallatif conceptualised the study, wrote the original draft, reviewed, and edited the manuscript and supervised the research. Mr S Isaac collected the data and assisted in the analysis.

Competing Interests

The authors have declared that no competing interests exist.

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