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META ANALYSIS

# A Systematic Review and Meta-analysis of Modified Cerclage Wires Versus Locked Patellar Plate for Fixation of Comminuted Fracture Patella

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**Abstract**

*Background*: **Patellar fractures are about 1% of adult fractures. A growing tendency is evident in the age-specific incidence distribution. 55% of all patellar fractures considered comminuted fractures and surgically repaired.**

*Aim of the study*: **Was to synthesise the available data addressing the safety and efficacy of modified cerclage wiring (MCW) and locked patellar plate (LPP) for the fixation of comminuted fracture patella.**

*Methodology*: **MEDLINE via PubMed, CENTRAL, and Google scholar databases were searched using the relevant keywords to discover the eligible citations. Screening, data extraction, and quality assessment were performed independently. The Open Meta-analyst software was used to perform the single-arm meta-analysis.**

*Results*: **We included 11 studies (LPP = 193 patients and MCW = 53 patients). Regarding LPP, the pooled data showed that the VAS score was 0.801, 95% CI (0.331−1.271), Knee flexion was 128.84°, 95% CI (121.05°−136.62°), Lysholm score was 92.41, 95% CI (89.24−95.57), and Tegner score was 3.29, 95% CI (2.97−3.61). In terms of MCW, the knee flexion was 128.71°, 95% CI (125.32°−132.09°), and the Böstman score was 28.37, 95% CI (27.71−29.04). The complication rate in patients treated with LPP was 3.9%, 95% CI (1.0−6.9%), whereas, in MCW patients.**

*Conclusion*: **The available evidence indicates that LPP operation safe and efficient in improving the clinical performance of cases with communicated patellar fracture, with satisfactory results, enhanced QoL, and low complication rate. MCW effectively achieved excellent performance in most treated patients, with no complications.**

*Keywords:* Cerclage, Comminuted patellar fixation, Comminuted patellar fractures, Plate, Wire

## 1. Introduction

Around 1% of adult fractures are patellar fractures.[1] A growing tendency is evident in the age-specific incidence distribution. Fifty-five percent of all patellar fractures that are surgically repaired are comminuted fractures.[2] Extensor mechanism disruption, articular step-off larger than two-three mm, and displacement higher than four mm are all indications for surgical intervention.[1] Surgeons are still having difficulty treating comminuted patellar fractures.[3] Surgical treatment for patellar fractures aims to promote early knee flexion, minimize patellar bone loss, repair the articular cartilage congruity, and restore the extensor apparatus. Circumferential cerclage fixation, modified tension band fixation, nickel-titanium patella concentrator, cable-pin system, titanium cable cerclage, plating and screws, and partial or complete patellar excision, MCW, and patellectomy are just some of the surgical options for managing comminuted patellar fractures today.[4−9]

The extensor mechanism and proper patellofemoral contact surface are compromised by partial and total patellectomy, resulting in diminished knee joint function.[10,11] As a result, this therapy is only helpful when it is impossible to decrease the comminuted bone. Open reduction and internal fixation is the best

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treatment approach for comminuted patellar fractures.[12] The internal fixation technique enables for the fragments to be firmly secured, allowing for early functional knee training. The therapeutic benefit of modified tension band fixation for comminuted patella remains debatable; however, it is effective for simple transverse patellar fracture.[13] Patellar fractures are handled with plate and screw fixations; however, transverse and inferior patellar fractures often benefit the most from biomechanical investigations.[14] A comminuted patellar fracture may be administered a circumferential cerclage wire fixation or modified cerclage wiring. When compared to tension bands and a modified tension band, biomechanical studies indicated that cerclage wire fixation was much less stable.[15] The objective of this systematic review and meta-analysis was to synthesise the available data about the safety and efficacy of MCW and locked patellar plate (LPP) for the fixation of comminuted fracture patella.

## 2. Methods

In publishing this work, we have adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist and the Cochrane handbook for systematic reviews of therapies.[16,17]

### 2.1. Eligibility criteria

The studies met the following inclusion criteria: Research that involved individuals with a comminuted patella fracture. Intervention and comparator: Studies that reported MCW or LPP results. Outcomes: Research have published data on the safety and effectiveness of various treatments for handling patients with comminuted patella fractures. Study Design: Observational cohort, case-control, or case-series studies. Case reports, conference abstracts, and non-English research were eliminated.

**Information sources and search strategy:** On February 23, 2022, We examined the following databases: MEDLINE via PubMed, CENTRAL, and Google scholar using the following keywords ‘patella cerclage, patella wire, patella plate, and comminuted patellar fixation‘ to discover the pertinent references. These databases were looked up from their origin till the search date. In addition, the reference lists of all cited sources were searched. Importing the obtained citations into the EndNote X9 programme and removing any duplicates. **Selection process:** A screening sheet was developed using Microsoft Excel. Included are the study ID, publication year, title, abstract, keywords, DOI, and URL. Three independent reviewers used a two-step screening procedure to conduct the selection process. (XXX, XXY, and XYX). Phase one consisted of screening the titles and abstracts of all studies discovered through the literature search to decide which studies might move on to step 2 (Full-text screening), where reviewers would read and evaluate whether each research fulfilled the eligibility requirements. Any disagreement between reviewers was resolved by the opinion of the research supervisor (XYY).

Pieces of data and collecting method: 3 separate reviewers took the following information from the included studies and entered it into a pre-prepared offline Excel spreadsheet: Patients’ demographic information (age, gender, and country of residence), research features (study groups, length, sample size, nation, and key results), and clinical outcomes. (visual analogue scale, range of motion in flexion, Oxford knee score, Bostman score, and Lysholm score), functional outcomes (fragment gap, union, time to union, and non-union), and surgical complications.

Risk of Bias and Quality assessment: Two writers conducted quality evaluations separately (XX and YY). Inconsistencies in the evaluation were handled through debate until an agreement was established. The Newcastle-Ottawa Scale (NOS) was utilised to evaluate the danger of bias in the included studies. The 18 Newcastle-Ottawa Scale has eight items over three domains, with a maximum score of nine. A research with a score of seven-nine has excellent quality, 4−6 has reasonable quality, and 0−3 has low quality.

All statistical analyses were conducted utilising the fixed or random-effects model and a 95% confidence interval. Using the I2 statistic, we determined the proportion of heterogeneity and inconsistency among trials; values of 25%, 50%, and 75%, respectively, were classified low, moderate, and high. If the heterogeneity was substantial and I2 was above 50%, the random-effect model was adopted; otherwise, the fixed-effect model was used. Sequential sensitivity analysis was undertaken to eliminate heterogeneity by deleting one study from each scenario. In addition, subgroup analysis was handled in order to reduce the possibility of inconsistency. All analyses were performed with the Open Meta-Analyst programme. As the number of studies included in each analysis was fewer than ten, publication bias was not evaluated.

## 3. Results

Based on our search of the relevant literature, we discovered a total of 470 citations. After deleting duplicates, 408 papers were screened for their titles and abstracts. Then, 390 studies were judged ineligible based on our eligibility criteria. The full-text screening of 18 papers resulted in the exclusion of 7 investigations. In the final qualitative (systematic review) and quantitative synthesis, 11 publications (LPP = 193 patients and MCW = 53 patients) were included (meta-analysis).[18−28] The PRISMA flow diagram of included research is depicted in Fig. 1.

The publication dates of the selected studies span between 2014 and 2021. Four experiments were undertaken in the United States of America (USA), four studies were conducted in Germany, one study was conducted in Korea, one study was conducted in China, and one study was conducted in Egypt. The majority of the included research (8) were cohort studies, whereas just three studies were case series. The included patients had a mean age of 52.77 ± 8.96 years. Approximately 41% of the patients included were male (Table 1). summarises the aspects of the included studies.

63.63% of the studies were rated as 'Excellent' by the NOS quality evaluation method for observational cohort studies, whereas 27.27% were rated as 'Fair.'- and only 9.09% of the studies were deemed as 'Poor.'

Two studies reported data regarding the mean LPP operative time.[20,22] The pooled random-effect size showed that the mean operative time was 67.34 min, 95% CI (52.79−81.90; Fig. 2a). The pooled data was heterogenous ($I^2$ = 81.86%; $P$ = 0.019). Shawky et al. reported a slightly longer operative time for MCW (72.7 ± 9.1 min[24].

Three studies **Wild** ***et al.***[20], **Wurma** ***et al.***[8], **Sun** ***et al.***[25], reported data regarding the average time from injury to LPP surgery, showing that the average time was 2.218 days, 95% CI (1.515−2.920; Fig. 2b). The pooled data were homogenous ($I^2$ = 0%; $P$ = 0.377). For MCW, **Shawky** ***et al.*** said that the mean time from trauma to surgery was 2.87 ± 2.36 days.[24]

Among patients treated with LPP, the prevalence of implant removal was reported in seven studies **Taylor** ***et al.***[18], **Wild** ***et al.***[20], **Lorich** ***et al.***[21], **Moore** ***et al.***[22], **Ellwein** ***et al.***[25], **Sun** ***et al.***[25], **Tengler** ***et al.***[26], The pooled random-effect estimate was 25.1%, 95% CI (11.1%−39%; Fig. 3a). The pooled data were heterogenous ($I^2$ = 82.52%; $P$ < 0.001). Sensitivity analysis by excluding **Taylor** ***et al.*** and **Moore** ***et al.*** resulted in a slightly higher prevalence of 34.6%, 95% CI (24.6%−44.5%), with a homogenous pooled

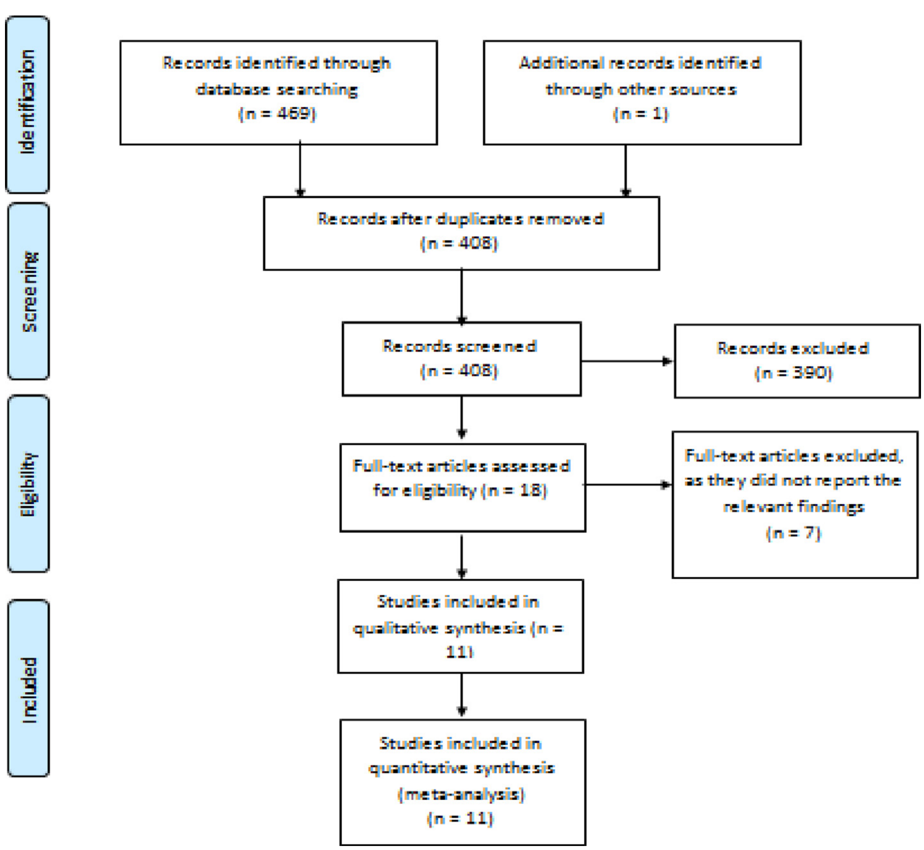


*Fig. 1. PRISMA flow diagram.*

*Table 1. Summary of included studies.*

| Study ID | Country | Study Design | Sample size | Males | Age (years) | Cause of injury | OTA classification | Time to surgery |
|---|---|---|---|---|---|---|---|---|
| **Taylor** *et al*[18] | USA | Case series | 8 | 3 (37.5%) | 47.4 ± 7.52 | NA | C1 (25%) and C3 (75%) | NA |
| **Volgas & Dreger,**[19] | USA | Retrospective Cohort | 16 | 6 (37.5%) | 47 ± 6.34 | NA | NA | NA |
| **Wild** *et al.*[20] | Germany | Cohort | 20 | 6 (30%) | 46.5 ± 8.12 | NA | C1 (50%), C2 (45%), and C3 (5%) | NA |
| **Lorich** *et al.*[21] | USA | Cohort | 58 | 8 (13.79%) | 67 ± 12.9 | NA | NA | NA |
| **Moore** *et al.*[22] | USA | Retrospective Cohort | 36 | 22 (61.11%) | 60 ± 10.8 | NA | C2 (52.78%) C3 (47.22%) | NA |
| **Wurma** *et al.*[8] | Germany | Cohort | 35 | 14 (40%) | 48.2 ± 8.94 | NA | NA | NA |
| **Jang** *et al.*[23] | Korea | Retrospective Cohort | 30 | 17 (56.67%) | 49.3 ± 9.37 | NA | A1 (30%), B1 (10%), B2 (3.33%), C1 (6.66%), C2 (30%), and C3 (20%) | 4.4 ± 9.63 |
| **Ellwein** *et al.*[24] | Germany | Case-series | 20 | 11 (55%) | 56 ± 6.88 | The activity of daily living (75%), Work (10%), Traffic accidents (10%), and Sports (5%). | A1 (5%), C1 (20%), C2 (30%), and C3 (45%) | 2.5 ± 3.3 |
| **Sun** *et al.*[25] | China | Cohort | 38 | 14 (36.84%) | 59.2 ± 7.16 | NA | NA | NA |
| **Tengler** *et al.*[26] | Germany | Case-series | 38 | 15 (39.47%) | 61 ± 14.6 | 3% had a skiing accident 11% had a traffic accident, 13% had suffered an accident at work, and 74% had a direct fall on the knee joint | One A2 fracture, seven C1 fractures, 12 C2 fractures, and 18 C3 fractures | 2 ± 2.6 |
| **Shawky** *et al.*[27] | Egypt | Cohort | 15 | 12 (80%) | 38.9 ± 5.93 | NA | NA | 2.87 ± 2.36 |

data ($I^2 = 29.35\%$; $P = 0.226$). In MCW studies, there was no mention of implant removal.

The incidence of implant failure was reported in six studies **Taylor** ***et al.***[18], **Lorich** ***et al.***[21], **Moore** ***et al.***[22], **Wurma** ***et al.***[8], **Ellwein** ***et al.***[24], **Sun** ***et al.***[25], **Tengler** ***et al.***[26], The pooled fixed-effect estimate revealed that implant failure was 5%, 95% of the time CI (1.6%−8.5%; Fig. 3b). The pooled data were homogenous ($I^2 = 0\%$; $P = 0.914$). In MCW studies, there was no mention of implant failure.

Three researches **Wild** ***et al.***[20], **Moore** ***et al.***[22], **Tengler** ***et al.***[26], reported data regarding the VAS score in patients treated with LPP. The pooled fixed model showed that the mean postoperative VAS was 0.801, 95% CI (0.331−1.271; Fig. 4a). The pooled data were homogenous ($I^2 = 0\%$; $P = 0.488$). VAS score was not reported in MCW studies.

Regarding the MCW, two studies **Jang** ***et al.***[23], **Shawky** ***et al.***[27], showed that the postoperative Böstman score was 28.37, 95% CI (27.71−29.04; Fig. 4b). The pooled data were homogenous ($I^2 = 0\%$; $P = 0.405$). In terms of LPP, Wild et al. showed that the Böstman score post-LPP was 27.4±3.77.[22]

Four studies reported data regarding the lysholm score post-LPP **Wild** ***et al.***[20], **Moore** ***et al.***[22], **Wurma** ***et al.***[8], **Sun** ***et al.***[25], The pooled random-effect size demonstrated that the lysholm score was 92.41, 95% CI (89.24−95.57; Fig. 4c). The pooled data were moderately heterogeneous ($I^2 = 54.99\%$; $P = 0.083$). Sensitivity analysis was unable to solve the heterogeneity. For MCW, there was no mention of the lysholm score.

Three studies reported data regarding Tegner score post-LPP **Wild** ***et al.***[20], **Moore** ***et al.***[22], **Wurma** ***et al.***[8], The pooled random-effect size demonstrated the postoperative tegner score of 3.29, 95% CI (2.97−3.61; Fig. 5a). The pooled data were moderately heterogeneous ($I^2 = 63.83\%$; $P = 0.063$). Sensitivity analysis was unable to solve the heterogeneity. For MCW, there was no mention of tegner score.

Four studies reported data regarding knee flexion post-LPP **Lorich** ***et al.***[21], **Moore** ***et al.***[22], **Sun** ***et al.***[25], **Tengler** ***et al.***[26], The pooled random-effect size demonstrated that the flexion degree post-LPP was 128.84°, 95% CI (121.05°−136.62°; Fig. 5b). The pooled data were moderately heterogeneous ($I^2 = 54.29\%$; $P = 0.087$). After resolving the heterogeneity by excluding **Jang** ***et al.***[23], the pooled effect estimate was 125.48°, 95% CI (119.90°−131.06°), and the data were homogenous ($I^2 = 29.35\%$; $P = 0.226$). Regarding the MCW, two studies **Jang** ***et al.***[23], **Shawky** ***et al.***[27], showed that the postoperative knee flexion range was 128.71°, 95% CI (125.32°−132.09°; Fig. 5c). The pooled data were homogenous ($I^2 = 0\%$; $P = 0.439$).

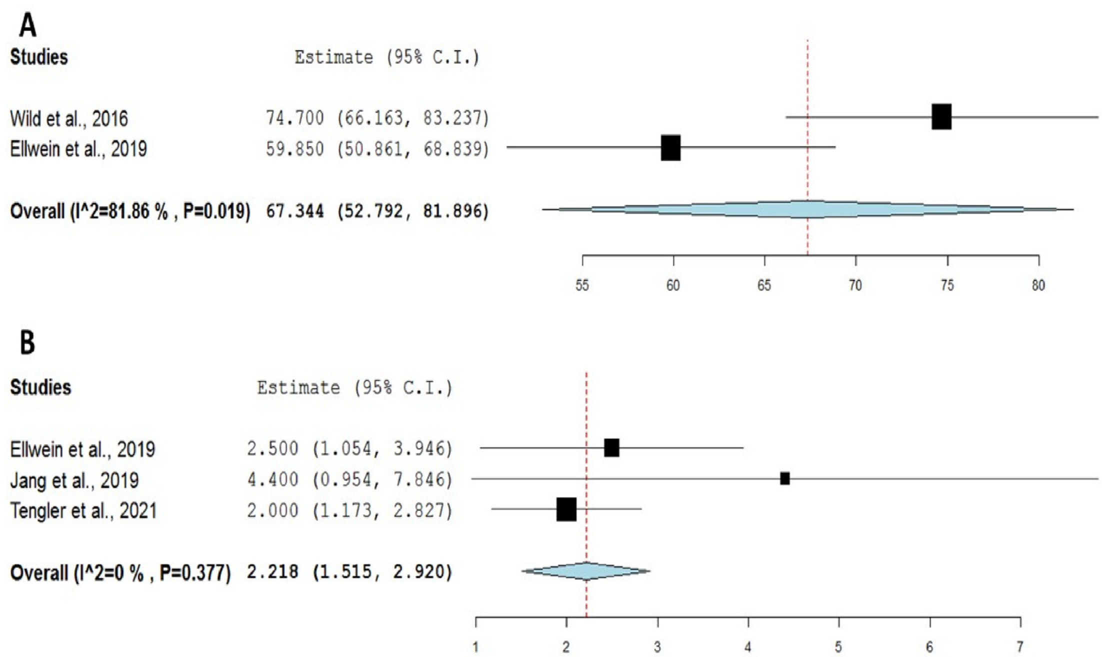


*Fig. 2. Forest plot of operational time and time to surgery from injury.*

The postoperative complication rate among patients treated with LPP was reported in seven studies **Taylor *et al.***[18], **Wild *et al.***[20], **Moore *et al.***[22], **Ellwein *et al.***[24], **Sun *et al.***[25], **Tengler *et al.***[26], The pooled fixed-effect model showed that the overall complication rate was 3.9%, 95% CI (1.0%–6.9%; Fig. 6a). The pooled data were homogenous ($I^2 = 0\%$; $P = 0.448$). For MCW, Sun et al. reported no complications postoperatively.[27]

Only two studies reported data regarding the QoL post-LPP **Lorich *et al.***[21], **Moore *et al.***[22], The pooled random-effect estimate showed that the

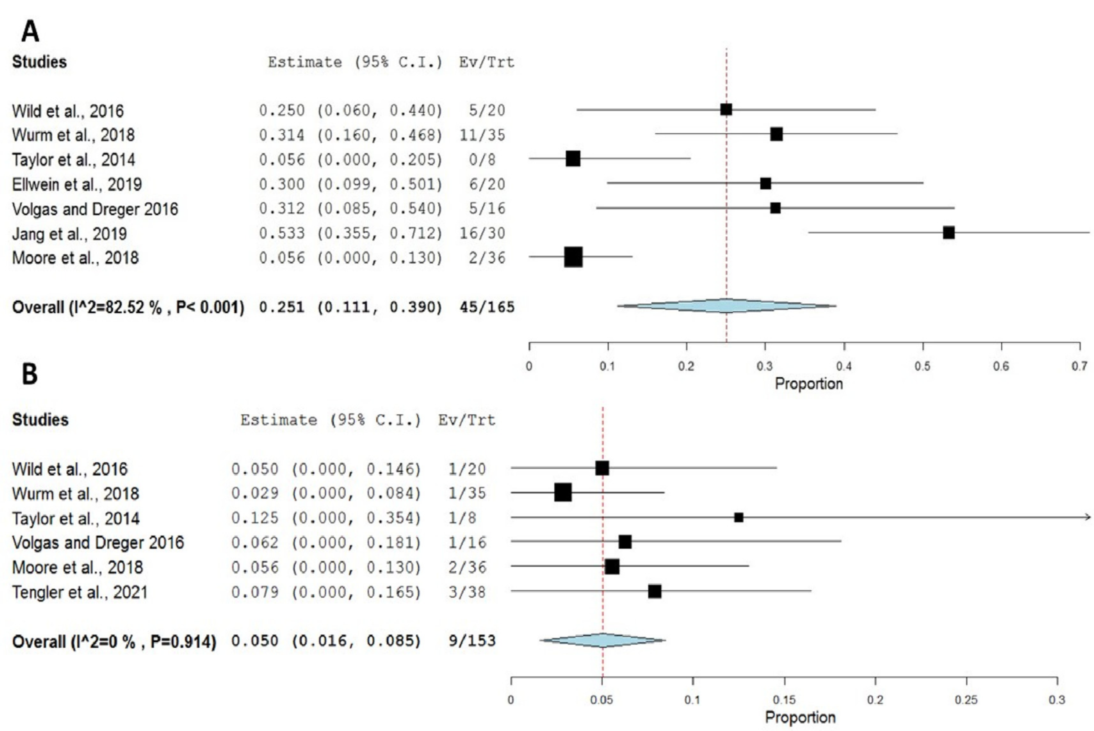


*Fig. 3. Forest plot of implant removal and failure.*

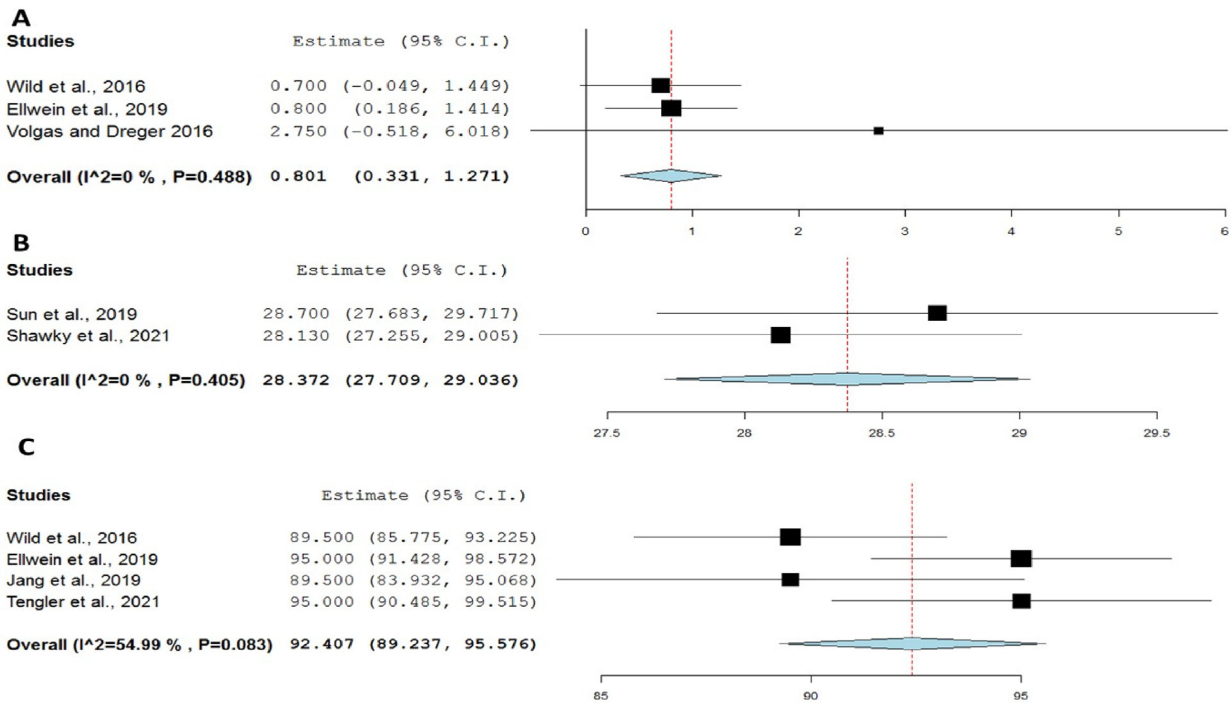


*Fig. 4. Forest plot of VAS, Böstman, and Lysholm scores.*

postoperative QoL-ADL was 68.69, 95% CI (53.80−83.57; Fig. 6b). The pooled data were heterogenous ($I^2 = 89.2\%$; $P = 0.002$). Wild et al. showed that the overall KOOS was 144.85 ± 15.85, the pain score was 23.95 ± 3.56, the symptoms score was 34.05 ± 4.22, and the Sports score was 12.50±4.92.[20]

The return to work was only reported by Taylor et al., who showed that 75% of the patients treated with LPP returned to work.[18] In terms of HSS, Turba, Oxford, and Lowa scores post-LPP, it was 92 ± 12.5, 2 ± 1.41, 41.5 ± 5.1, and 87.7 ± 9.7, respectively, according to **Wild *et al*.**[20]

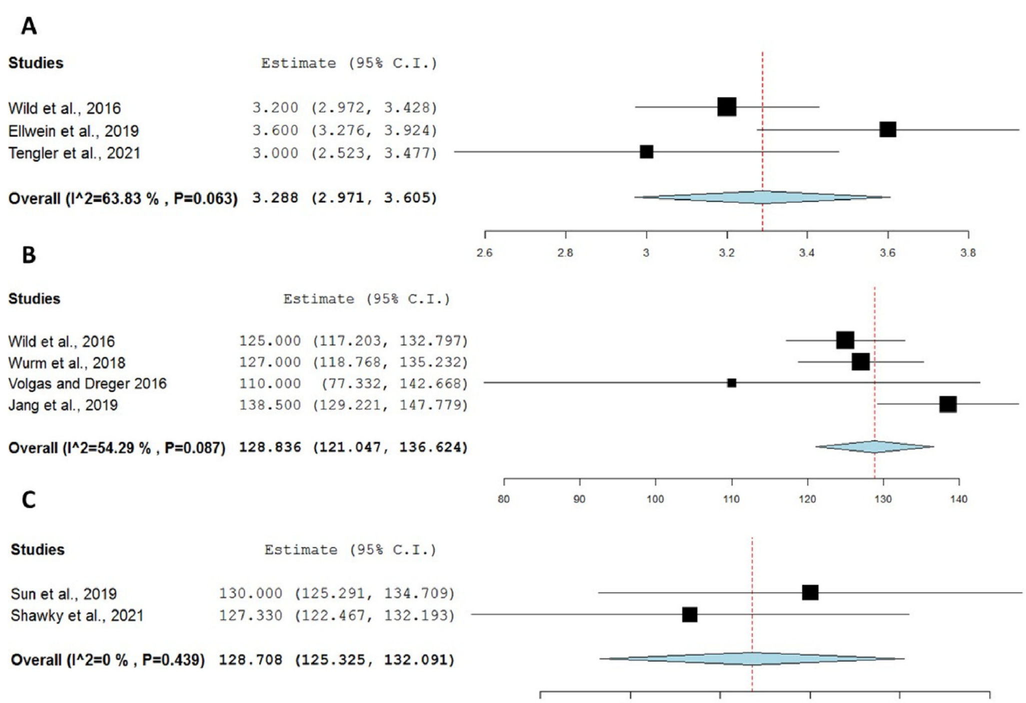


*Fig. 5. Forest plot of Tegner score and knee flexion.*

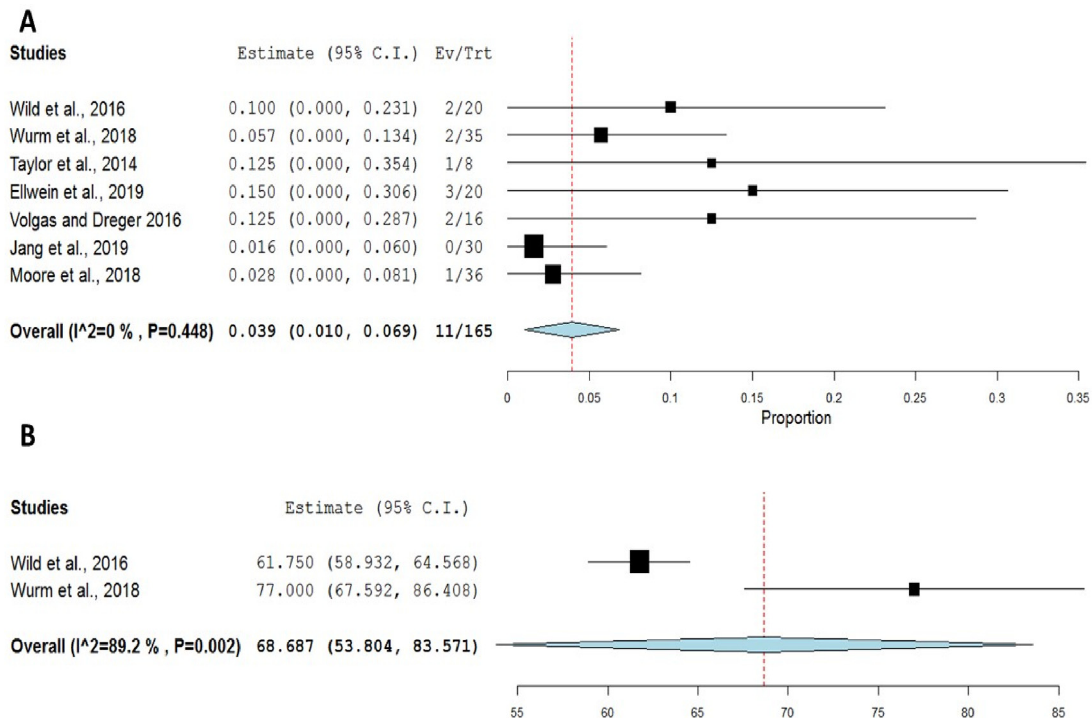


*Fig. 6. Forest plot of complication rate and QoL.*

## 4. Discussion

In this systematic review and meta-analysis, the evidence suggests that LPP was associated with good functional outcomes with a very low complication rate and acceptable QOL. On the other hand, the available data regarding the MCW were inadequate to generate reliable evidence; however, in terms of functional recovery, the flexion range postoperatively was comparable to the LPP.

Our findings showed that among patients treated with LPP, the prevalence of implant removal was 25.1%, 95% CI (11.1%–39%). During the healing process of a patellar fracture, the patella is affected by compressive, tensile, and bending forces. The combination of these stresses and persistent patella-femoral mobility may cause implants to loosen or fail. This has been demonstrated clinically in several case series, with high failure rates of tension bands in early rehabilitation programmes.[28–30] Similar to other unstable periarticular fractures, the pressures felt by the patellar fixation due to motion may be more effectively neutralised when locked fixed-angle technology is used for complex patellar fractures.[31,32]

Our data on LPP showed excellent clinical function, as measured by the range of motion, low pain levels, high patient satisfaction, and QoL, as well as excellent functional scores. The results strongly suggest that LPP is an effective treatment for even the most severe patellar fractures. There are several different scores that may be used to evaluate a patient after a knee injury, but no one score has been validated for use after a patellar fracture. LPP seems to be clinically better than tension band fixation when evaluating the number of unsatisfactory results. Seventeen percent of patients treated with modified tension band fixation had adequate to poor clinical results, according to **Mehdi *et al.***[33] and **Hung *et al.***[34] Clinical results ranged from satisfactory to poor, according to a study by **Levack *et al.***[35] Poor results from anterior tension band fixation led to the development of other related procedures and revisions. Partial patellectomy as salvage surgery, augmented arthroscopic procedures, titanium-nickel shape-memory patellar concentrators, patellar rings, mesh plates, bilateral plating, screw-only fixation, non-metal fixations with polyethylene sutures, and modified tension banding with cannulated screws are all viable options for treating patellar fractures.[8] Initial investigations showed that non-metal fixing using polyethylene and FibreWire suture material reduced the complication rate of interfering fixation material, but its clinical usage remained restricted to transverse fractures.[36,37] LPP provides a low implant profile and stable monocortical fixation of fracture fragments, making it ideal for the treatment of multipart and comminuted fractures. Optimal fixation of numerous pieces is achieved by inserting as many as seventeen locking screws through the locking plate and into the anterior cortex. If necessary, the soft tissue may also be fixed to the plate's edge. LPP is an alternative to hook fixation for treating fractures involving pole fragments, thanks to its development and availability.[38] The plate may be flipped over and utilized for fractures of the superior pole; the hook can be adjusted to accommodate different structures. According to Wild et al., the LPP is most effective for treating simple transverse and T-shaped fractures, which together account for 50−60% of all patella fractures.[1,20] The LPP has shown in recent biomechanical investigations to be better in stability even in these sorts of patella fractures where modified anterior tension wire or cannulated screws with anterior tension wiring are indicated. The LPP is also useful in cases of three- or four-part fractures, provided that the pieces are big enough to be held in place by a single screw. Avulsion fractures of the patella are not good candidates for the LPP.[20] Fixation using a transosseous patello-tibial McLaughlin cerclage is recommended for inferior pole avulsion fractures and inferior comminuted fractures to alleviate stress on the extensor mechanism.[39]

The postoperative complication rate among patients who were treated with LPP was 3.9%, 95% CI (1.0%−6.9%). Hardware penetration, infection, wire migration, and fixation failure are the main causes of complications.[38] Preventing post-traumatic complications requires prompt implementation of functional follow-up treatment.[40] The low implant profile and high primary stability achieved by platings make such follow-up treatment possible. It is unclear whether or not a middle ground can be found between long-term knee immobilization and functional rehabilitation following complicated fracture fixation.

Regarding MCW, the available data regarding its safety and efficacy in treating patients with comminuted fracture patella is inadequate to generate reliable evidence. Shawky et al. showed that MCW was able to achieve a fracture union within 2−3.5 months with no postoperative complications. Moreover, they demonstrated that the clinical performance assessed by the Böstman score was satisfactory, as 12/15 patients had excellent performance and 3/15 patients had a good performance. The mean knee flexion was $127.33 \pm 9.61^{\circ}$. Similarly, Sun et al. showed that MCW was associated with a mean union time of $2.92 \pm 0.25$ months, with no postoperative complications. Based on the Böstman score, 84.2% of the patients had excellent performance, and 15.8% had a good performance, with a knee flexion range from 110 to 140. These findings support the effectiveness of this operation in patients with comminuted fracture patella. However, further studies with a larger sample and prospective design are required to validate these findings.

Injuries to the articular surface, failure of internal fixation, and re-displacement of fracture fragments owing to loosening and failure of internal fixation all hinder patients from initiating early rehabilitative activities as anticipated. Atrophy of the quadriceps femoris muscle and knee joint stiffness are examples of early problems that may contribute to impaired joint function in the long run.[2] The treatment of comminuted patellar fractures by **Caballero-Lozada *et al.***[41] included both soft tissues and cerclage, with an 80% union rate. Patellar comminuted fractures were treated by Yang et al. using a titanium cable cerclage technique. One hundred percent of unions were reported to have excellent or good performance.[42]

Sun et al. have made recommendations for the treatment of comminuted patellar fractures using MCW.[27] The transverse incision was favored over the longitudinal one because it allowed for easier wire needle insertion and a more secure locking wire buckle during surgery. The steel wire should be tightened evenly without excessive force. Care should be taken when suturing to prevent further dislocation of the fracture block and wire penetration of the block at the site of the patella fracture. To ensure satisfactory reduction, C-arm X-ray machine fluoroscopy should be performed many times during the operation. After locking and embedding the steel wire in the lateral patellar soft tissue, the tail end should be trimmed and smoothed to prevent irritation of the surrounding soft tissue.

We accept that our analysis has limitations, such as the minimal number of included studies and the small sample size of the enrolled population. Moreover, we could not perform a head-to-head comparison due to the scarcity of studies that compared both techniques. The high heterogeneity in some analyses is another limitation; however, we have employed sensitivity analysis, when applicable, to solve this heterogeneity. We could not perform a subgroup analysis as the available data were inadequate.

### *4.1. Conclusion*

Recent research indicates that LPP surgery is safe and effective for boosting the clinical performance of patients with a reported patellar fracture, with favourable results, improved quality of life, and a low complication rate. MCW was successful in producing outstanding performance in the majority of treated patients without problems; however, more researches are necessary to validate this finding.

## Disclosure

The authors have no financial interest to declare in relation to the content of this article.

## Authorship

All authors have a substantial contribution to the article.

### Conflicts of interest

The authors declared that there were no conflicts of Interest.

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