

ORIGINAL RESEARCH ARTICLE

Modified non-transarticular K-wire external fixation versus traditional transarticular pinning for bony mallet finger: a prospective comparative cohort study

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ABSTRACT

Background: Traditional transarticular distal interphalangeal joint (DIPJ) pinning for bony mallet fingers risks stiffness and iatrogenic cartilage injury. This study compared a modified non-transarticular K-wire external fixator with traditional transarticular pinning for surgically treated bony mallet finger.

Methods: This single-center prospective nonrandomized comparative cohort study included 120 adults with acute bony mallet finger. Sixty patients underwent traditional transarticular DIPJ pinning, and 60 underwent modified non-transarticular K-wire external fixation. The primary outcome was overall postoperative complications, including pin tract infection, joint stiffness, loss of reduction, nail deformity, or radiographic degenerative change assessed at 1 year. Secondary outcomes included operative time, hardware removal time, bone union time, DIPJ motion, Crawford grade, pain, QuickDASH score, and return-to-work time. Logistic regression was used to identify predictors of overall complications.

Results: Baseline demographic and injury characteristics were comparable between groups. Overall complications were significantly less frequent after modified fixation than after traditional fixation (15.0% vs 48.3%, $p < 0.001$). The modified technique markedly reduced joint stiffness and nail deformity. It was also associated with shorter operative time, earlier hardware removal, faster bone union, lower extension lag, greater maximum DIPJ flexion, better Crawford grade distribution, lower pain and QuickDASH scores, and earlier return to work. In multivariable analysis, traditional fixation remained independently associated with higher complication risk.

Conclusion: Modified non-transarticular K-wire external fixation was associated with fewer complications and better early functional recovery than traditional transarticular DIPJ pinning. This joint-sparing, low-cost technique may be a useful surgical option for selected patients with bony mallet finger.

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Introduction

Mallet finger is a common terminal extensor mechanism injury in which sudden forced flexion of the distal interphalangeal joint (DIPJ) causes tendon rupture or avulsion fracture at the dorsal base of the distal phalanx [1]. Recent reviews emphasize that tendinous and bony mallet injuries should be considered related but mechanically distinct entities, because the presence, size, displacement, and subluxation pattern of the osseous fragment can change treatment decisions and prognosis [2, 3]. Population data from primary care and contemporary hand-injury reviews confirm that these injuries remain frequent, clinically relevant, and often initially managed outside specialist units [4–6].

The optimal treatment for bony mallet finger remains debated. Splinting or orthotic management can be effective in selected stable fractures, but patient adherence, fragment size, joint subluxation, and loss of reduction are recurrent concerns [7, 8]. Conversely, surgery can restore articular congruity and joint alignment, but transarticular pinning immobilizes the DIPJ and may add iatrogenic cartilage injury, stiffness, pin-site morbidity, or late degenerative change [9, 10]. Recent comparative and technique-focused studies continue to evaluate extension-block pinning, direct fragment fixation, customized plates, hook plates, suture anchors, and other

modifications, but no single strategy has resolved the tension between stable fixation and preservation of joint biology [11–13].

Management must also be interpreted in an age-specific context. In children, open physes, smaller fragments, remodeling potential, and the need to avoid physal injury can influence fixation choices, whereas adults more often present with mature bone, variable bone quality, and greater concern about stiffness and posttraumatic degeneration. A long-term pediatric series of Ishiguro extension-block pinning reported predominantly good or excellent outcomes without epiphyseal damage or nail deformity, while delayed treatment and a greater flexion angle were associated with worse results [14]. A recent comparative review similarly concluded that pediatric and adult treatment principles overlap but should not be assumed to be interchangeable because the available evidence is heterogeneous and age-specific [15].

An additional difficulty is measurement. Small differences in fracture-line angle, subluxation, and articular involvement can alter the apparent severity of a mallet fracture, and recent work has highlighted the need for reproducible radiographic assessment [16–18]. Late posttraumatic osteoarthritis of the DIPJ is also clinically relevant after mallet fractures, especially when the joint surface has been injured or left incongruent [19]. Therefore, a fixation strategy

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that avoids transarticular penetration while maintaining reduction may be clinically attractive.

Our department developed a non-transarticular K-wire external fixator that maintains DIPJ extension without passing a longitudinal K-wire across the joint. Earlier internal experience suggested that this elastic construct might reduce stiffness and cartilage insult while retaining the low cost and technical familiarity of K-wires. The present prospective comparative cohort study evaluated whether this modified non-transarticular construct was associated with fewer overall complications and better functional recovery than traditional transarticular DIPJ pinning in 120 patients with bony mallet finger.

Methods

Study design and ethics

This was a single-center prospective nonrandomized comparative cohort study conducted at Zhejiang Rongjun Hospital between June 2024 and March 2025. The study was approved by the Ethics Committee of Zhejiang Rongjun Hospital, and written informed consent was obtained from all participants. The manuscript was prepared according to STROBE-oriented reporting principles for observational studies.

Participants

Eligible patients were adults with acute bony mallet finger confirmed by radiography and/or computed tomography, treated surgically with either traditional transarticular DIPJ pinning or the modified non-transarticular K-wire external fixator. The updated cohort included Wehbe-Schneider Type I, II, and III injuries and both closed blunt and open/cut mechanisms when the soft-tissue condition allowed definitive fixation. Exclusion criteria were congenital or pre-existing deformity of the affected digit, severe osteoporosis precluding stable K-wire fixation, prior surgery of the involved digit, chronic unreduced mallet injury not suitable for the index procedure, incomplete follow-up, or inability to complete functional assessment.

Preoperative clinical and radiographic assessment

Baseline variables included age, sex, injured side/dominant-hand involvement, occupation, body mass index, comorbidities, injured digit, injury mechanism, Wehbe-Schneider type and subtype, and time from injury to surgery. Standard anteroposterior and lateral radiographs were obtained in all patients, and computed tomography was used when fracture morphology or articular involvement required clarification. Fracture classification and subluxation assessment followed contemporary radiographic principles described in recent mallet-fracture literature [20, 21].

Traditional transarticular DIPJ pinning

Under digital nerve block and finger tourniquet control, a dorsal S-shaped incision was made over the DIPJ. The terminal extensor tendon insertion and avulsed fragment were exposed while preserving their continuity. Hematoma and interposed tissue were removed. After reduction, two 0.8-mm K-wires were inserted from dorsal-proximal to volar-distal through the fracture fragment and across the opposite cortex, with the dorsal ends shortened close to the fragment and the volar ends bent and cut. The distal phalanx and DIPJ were then held in approximately 5–10 degrees of extension, and a

1.0-mm K-wire was inserted longitudinally from the fingertip or obliquely from the side of the distal phalanx across the DIPJ into the middle phalanx. Fluoroscopy confirmed reduction and pin position before wound closure.

Modified non-transarticular K-wire external fixation

After exposure of the fracture site, a 1.0-mm K-wire was inserted longitudinally from the fingertip into the distal phalanx, with the proximal tip not advanced beyond the proximal-middle third of the distal phalanx. The fracture fragment was then reduced under direct vision. Two 0.8-mm K-wires were inserted from dorsal-proximal to volar-distal at an angle of 45–60°, passed through the opposite cortex, and brought out through the volar skin. The dorsal ends were shortened, and each wire was withdrawn with the drill until its dorsal tip remained 1–2 mm above the fragment; the volar ends were bent and cut. A 5-0 absorbable suture was placed between the soft tissue at the base of the distal phalanx and the terminal extensor tendon insertion. The wound was irrigated, hemostasis was secured, and the incision was closed.

A second 1.0-mm K-wire was inserted from dorsal to volar through the proximal part of the middle phalanx, engaging both cortices. With the DIPJ held in 5–10° of extension, the longitudinal fingertip K-wire was bent dorsally by approximately 30° at a point 3–5 mm from the fingertip, wrapped around the middle-phalanx K-wire, reflected distally through 180°, and cut. The middle-phalanx K-wire was then wrapped around the longitudinal wire, bent through 180°, and cut to complete the locked external frame. Final fluoroscopy confirmed articular reduction, wire position, and construct stability (Figure 1).

Postoperative rehabilitation and hardware management

Dressings were changed every 2–3 days, pin tracks were disinfected twice daily with alcohol, and sutures were removed at approximately 2 weeks. Hardware was removed when clinical and radiographic healing permitted. Rehabilitation followed a progressive protocol combining active and passive DIPJ motion after removal of the DIPJ-fixation construct. Return to work was individualized according to occupation, pain, wound condition, and radiographic union. The role of rehabilitation access and adherence was considered when interpreting patient-reported outcomes, given contemporary evidence that hand-injury recovery is influenced by barriers to rehabilitation [22].

Primary and secondary outcome measures

The primary outcome was overall postoperative complication, defined as the occurrence of at least one of the following: pin tract infection, joint stiffness, loss of reduction, nail deformity, or radiographic degenerative change assessed at the 1-year visit. The radiographic component was retained as part of the originally reported composite endpoint but was interpreted as an exploratory 1-year finding rather than established long-term osteoarthritis. Secondary outcomes included operative time, number of fluoroscopy shots, cost, hardware removal time, DIPJ extension lag, maximum DIPJ flexion, bone union time, Crawford grade, visual analogue scale (VAS) pain scores at rest and during activity, QuickDASH score, and return-to-work time. QuickDASH was used as a patient-reported upper-extremity functional measure, with interpretation informed by recent evidence on DASH and QuickDASH clinically important differences [23].

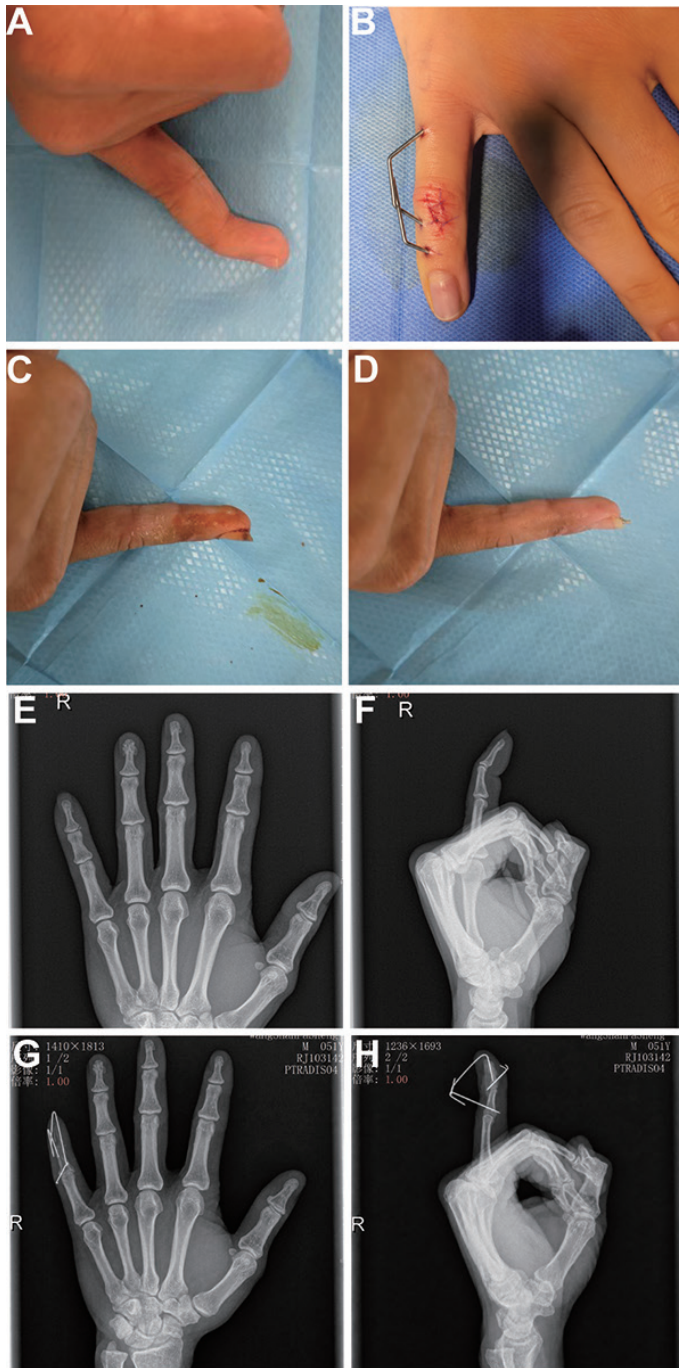


Figure 1. Clinical and radiographic course of a representative adult with a right little-finger bony mallet fracture treated using modified non-transarticular K-wire external fixation. (A) Preoperative clinical appearance of the mallet deformity. (B) Immediate postoperative dorsal view showing the completed external fixation construct. (C) Clinical appearance immediately after hardware removal. (D) Three-month clinical view demonstrating active extension. (E, F) Preoperative anteroposterior and lateral radiographs. (G, H) Immediate postoperative anteroposterior and lateral radiographs showing fracture reduction and the locked external construct. DIPJ, distal interphalangeal joint.

Statistical analysis and regression modeling

Continuous variables were summarized as mean $\pm$ standard deviation and compared between groups with independent-samples *t* tests when appropriate. Categorical variables were summarized as *n* (%) and compared with chi-square or Fisher's exact tests.

Ordinal Crawford grades were compared as categorical/ordinal outcomes according to distribution. Univariate logistic regression evaluated candidate predictors of overall complications, and clinically relevant factors were entered into multivariable logistic regression. Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). Prespecified exploratory subgroup analyses estimated the treatment effect for overall complications by age (< 45 vs ≥ 45 years), Wehbe type (I/II vs III), and occupation (non-manual vs manual). Two-sided $p < 0.05$ was considered statistically significant.

Results

Patient demographics and baseline injury characteristics

The study included 120 adult patients aged 27–68 years, with 60 treated using traditional transarticular fixation and 60 treated using the modified non-transarticular external fixator. Baseline demographic and injury characteristics were well balanced between groups. Mean age was 44.8 ± 9.0 years overall, 46.2 ± 8.0 years in the traditional group, and 43.3 ± 9.7 years in the modified group ($p = 0.073$). Thus, the traditional group was numerically older, but the between-group age difference did not reach statistical significance. Sex distribution, dominant-hand involvement, occupation, body mass index, comorbidities, injured digit, injury mechanism, Wehbe-Schneider type, and subtype did not differ significantly between groups (Table 1).

Comparison of perioperative metrics and functional recovery

Compared with traditional fixation, the modified technique was associated with shorter operative time (33.4 ± 4.8 vs 38.6 ± 5.0 minutes; $p < 0.001$), similar fluoroscopy exposure, and similar cost. Hardware was removed earlier in the modified group (5.2 ± 0.6 vs 6.1 ± 0.6 weeks; $p < 0.001$), and bone union occurred earlier (6.3 ± 0.6 vs 7.2 ± 0.7 weeks; $p < 0.001$). Functional outcomes also favored the modified group, including lower DIPJ extension lag, greater maximum DIPJ flexion, better Crawford grade distribution, lower VAS pain at rest and during activity, lower QuickDASH score, and earlier return to work (Table 2).

Incidence and types of postoperative complications

Overall complications occurred in 29 of 60 patients (48.3%) after traditional fixation and 9 of 60 patients (15.0%) after modified fixation ($p < 0.001$). Joint stiffness was markedly less frequent after modified fixation (5.0% vs 41.7%; $p < 0.001$), and exploratory radiographic degenerative change at 1 year was recorded in 16 patients (26.7%) after traditional fixation and 1 patient (1.7%) after modified fixation ($p < 0.001$). Because follow-up was limited to 1 year, this radiographic finding should not be interpreted as established post-traumatic osteoarthritis or as evidence of a long-term degenerative trajectory. Nail deformity occurred in 6 patients (10.0%) in the traditional group and in no patient in the modified group ($p = 0.027$). Pin tract infection and loss of reduction were numerically lower after modified fixation but did not reach statistical significance (Table 3).

Univariate and multivariable predictors of overall complications

In univariate logistic regression, traditional fixation was associated with higher odds of overall complications than modified fixation

Table 1. Baseline demographic and clinical characteristics of patients with bony mallet finger stratified by fixation technique.

Characteristic	Total (n = 120)	Traditional (n = 60)	Modified (n = 60)	Statistic	p
Age, years	44.8 ± 9.0	46.2 ± 8.0	43.3 ± 9.7	t = 1.81	0.073
Sex					
Female	51 (42.5%)	26 (43.3%)	25 (41.7%)	$\chi^2 = 0.03$	0.853
Male	69 (57.5%)	34 (56.7%)	35 (58.3%)		
Dominant hand injured					
No	53 (44.2%)	27 (45.0%)	26 (43.3%)	$\chi^2 = 0.03$	0.854
Yes	67 (55.8%)	33 (55.0%)	34 (56.7%)		
Occupation					
Non-manual	65 (54.2%)	32 (53.3%)	33 (55.0%)	$\chi^2 = 0.03$	0.855
Manual	55 (45.8%)	28 (46.7%)	27 (45.0%)		
BMI, kg/m ²	23.5 ± 2.6	23.7 ± 2.8	23.4 ± 2.3	t = 0.63	0.532
Comorbidities					
No	97 (80.8%)	48 (80.0%)	49 (81.7%)	$\chi^2 = 0.05$	0.817
Yes	23 (19.2%)	12 (20.0%)	11 (18.3%)		
Injured digit					
Index	21 (17.5%)	10 (16.7%)	11 (18.3%)	Fisher exact test	1.000
Middle	35 (29.2%)	18 (30.0%)	17 (28.3%)		
Ring	34 (28.3%)	17 (28.3%)	17 (28.3%)		
Little	24 (20.0%)	12 (20.0%)	12 (20.0%)		
Thumb	6 (5.0%)	3 (5.0%)	3 (5.0%)		
Mechanism					
Open/cut injury	19 (15.8%)	10 (16.7%)	9 (15.0%)	$\chi^2 = 0.06$	0.803
Closed blunt injury	101 (84.2%)	50 (83.3%)	51 (85.0%)		
Wehbe-Schneider type					
Type I (<1/3)	36 (30.0%)	18 (30.0%)	18 (30.0%)	$\chi^2 = 0.00$	1.000
Type II (1/3–2/3)	60 (50.0%)	30 (50.0%)	30 (50.0%)		
Type III (>2/3)	24 (20.0%)	12 (20.0%)	12 (20.0%)		
Wehbe-Schneider subtype					
A	67 (55.8%)	33 (55.0%)	34 (56.7%)	$\chi^2 = 2.49$	0.289
B	36 (30.0%)	21 (35.0%)	15 (25.0%)		
C	17 (14.2%)	6 (10.0%)	11 (18.3%)		

Note: Values are mean ± SD or n (%). BMI: body mass index. Wehbe-Schneider type/subtype classified bony mallet fracture morphology. P values compare traditional transarticular fixation with modified non-transarticular fixation.

(OR 5.30, 95% CI 2.22–12.66; $p < 0.001$). Age was also associated with complications in univariate analysis (OR 1.07 per year, 95% CI 1.02–1.12; $p = 0.005$), as was Wehbe Type III injury compared with Type I injury (OR 3.50, 95% CI 1.14–10.74; $p = 0.029$). In the multivariable model, traditional fixation remained independently associated with complications (OR 6.20, 95% CI 2.32–16.60; $p < 0.001$). Age retained a modest but significant independent association (OR 1.09 per year, 95% CI 1.03–1.16; $p = 0.002$), while Wehbe Type III injury (OR 5.77, 95% CI 1.54–21.59; $p = 0.009$) and longer time to surgery (OR 1.28 per day, 95% CI 1.01–1.64; $p = 0.045$) were also independent risk factors. Wehbe Type II injury was not independently associated with overall complications (Table 4).

Exploratory subgroup analysis of treatment effects

The direction of the treatment effect was consistent across exploratory subgroups, although the magnitude varied. Traditional fixation was associated with higher odds of overall complications in patients aged <45 years (OR 12.40, 95% CI 2.46–62.59; $p < 0.001$), while the association in patients aged ≥45 years was borderline according to the reported p -value (OR 3.04, 95% CI 1.01–9.11; $p = 0.064$). The association remained evident in Wehbe Type I/II injuries (OR 3.84, 95% CI 1.43–10.31; $p = 0.011$) and was numerically strongest in Wehbe Type III injuries (OR 25.00, 95% CI 2.92–213.99; $p = 0.003$). By occupation, the treatment effect was observed in non-manual

Table 2. Comparison of perioperative variables, pain scores, and functional outcomes between traditional and modified fixation groups.

Characteristic	Total (n = 120)	Traditional (n = 60)	Modified (n = 60)	Statistic	p
Operative time, min	36.0 ± 5.5	38.6 ± 5.0	33.4 ± 4.8	t = 5.80	< 0.001
Fluoroscopy shots, n	9 ± 2	9 ± 2	9 ± 2	t = -1.06	0.291
Cost, RMB	8930 ± 1738	9062 ± 823	8798 ± 2319	t = 0.83	0.408
Hardware removal time, weeks	5.6 ± 0.8	6.1 ± 0.6	5.2 ± 0.6	t = 7.71	< 0.001
DIPJ extension lag, degrees	6.6 ± 2.1	7.2 ± 2.2	6.0 ± 1.9	t = 3.23	0.002
DIPJ maximum flexion, degrees	56.5 ± 9.4	54.4 ± 6.2	58.6 ± 11.4	t = -2.54	0.013
Bone union time, weeks	6.7 ± 0.8	7.2 ± 0.7	6.3 ± 0.6	t = 7.39	< 0.001
Crawford grade					
Excellent	49 (40.8%)	18 (30.0%)	31 (51.7%)	Fisher exact test	0.019
Good	46 (38.3%)	25 (41.7%)	21 (35.0%)		
Fair	20 (16.7%)	12 (20.0%)	8 (13.3%)		
Poor	5 (4.2%)	5 (8.3%)	0 (0.0%)		
VAS at rest	1.2 ± 0.8	1.6 ± 0.7	0.7 ± 0.6	t = 7.12	< 0.001
VAS during activity	2.5 ± 1.0	3.0 ± 0.8	2.0 ± 0.9	t = 6.21	< 0.001
QuickDASH score	21.7 ± 6.1	23.4 ± 6.0	20.1 ± 5.6	t = 3.09	0.003
Return to work, weeks	8.0 ± 1.4	8.7 ± 1.2	7.4 ± 1.4	t = 5.21	< 0.001

Note: Values are mean ± SD or n (%). RMB: renminbi (Chinese currency); DIPJ: distal interphalangeal joint; VAS: visual analogue scale; QuickDASH: shortened Disabilities of the Arm, Shoulder and Hand questionnaire. P values compare treatment groups.

Table 3. Incidence of specific and overall postoperative complications at 1-year follow-up.

Characteristic	Total (n = 120)	Traditional (n = 60)	Modified (n = 60)	Statistic	p
Pin tract infection	15 (12.5%)	10 (16.7%)	5 (8.3%)	$\chi^2 = 1.90$	0.168
Joint stiffness	28 (23.3%)	25 (41.7%)	3 (5.0%)	$\chi^2 = 22.55$	< 0.001
Loss of reduction	9 (7.5%)	7 (11.7%)	2 (3.3%)	Fisher exact test	0.163
Nail deformity	6 (5.0%)	6 (10.0%)	0 (0.0%)	Fisher exact test	0.027
Radiographic degenerative change at 1 year	17 (14.2%)	16 (26.7%)	1 (1.7%)	$\chi^2 = 15.42$	< 0.001
Overall complication	38 (31.7%)	29 (48.3%)	9 (15.0%)	$\chi^2 = 15.40$	< 0.001

Note: Values are n (%). The 1-year radiographic finding is reported as an exploratory degenerative change and does not establish long-term osteoarthritis. Overall complication indicates at least one listed postoperative complication.

Table 4. Univariate and multivariable logistic regression analyses identifying risk factors for overall postoperative complications.

Variable	Univariate OR	Univariate 95% CI	Univariate p-value	Multivariate OR	Multivariate 95% CI	Multivariate p-value
Traditional vs Modified	5.30	2.22–12.66	< 0.001	6.20	2.32–16.60	< 0.001
Age, per year	1.07	1.02–1.12	0.005	1.09	1.03–1.16	0.002
Wehbe Type I	Reference	Reference		Reference	Reference	
Wehbe Type II vs Type I	1.50	0.57–3.92	0.408	1.22	0.40–3.69	0.730
Wehbe Type III vs Type I	3.50	1.14–10.74	0.029	5.77	1.54–21.59	0.009
Time to surgery, per day	1.13	0.92–1.37	0.236	1.28	1.01–1.64	0.045

Note: OR: odds ratio; CI: confidence interval. The dependent variable was overall postoperative complication. Traditional fixation was compared with modified non-transarticular fixation.

workers (OR 3.83, 95% CI 1.17–12.53; $p = 0.028$) and manual workers (OR 7.67, 95% CI 2.09–28.11; $p = 0.002$) (Figure 2).

Discussion

In this prospective comparative cohort of 120 patients with bony mallet finger, a non-transarticular K-wire external fixator was associated with a substantially lower overall complication rate than traditional transarticular DIPJ pinning. The modified construct also showed advantages in operative time, hardware removal time, union time, DIPJ motion, pain, QuickDASH score, Crawford grade, and return to work. These findings extend the rationale from earlier clinical experience: preserving the DIPJ articular surface while maintaining extension may improve the balance between fixation stability and early biological recovery.

The main clinical signal was the lower overall complication burden, particularly joint stiffness, together with better early function. Traditional transarticular pinning creates a rigid bridge across the DIPJ, immobilizes the joint, and requires a wire to pass

through a small articular surface [24]. Even when this is technically successful, the joint is exposed to cartilage penetration, intra-articular hematoma, and prolonged immobilization. Recent literature continues to support K-wire techniques as efficient and widely accessible, especially extension-block constructs [10, 25], but the complications of pinning and the technical sensitivity of closed reduction remain real concerns [26, 27]. The 1-year radiographic comparison was retained because it formed part of the originally reported composite endpoint; however, it should be regarded as an exploratory degenerative-change signal rather than evidence that the modified technique prevents long-term osteoarthritis.

The improvement in early function is also clinically coherent. The modified external frame behaves as an elastic extension-maintaining construct rather than a rigid transarticular pin [28]. This may permit minor physiological micro-motion, reduce tendon adhesion, and allow earlier removal of immobilizing hardware once fracture stability is adequate. The observed differences in extension lag, maximum flexion, VAS pain, and QuickDASH are therefore not isolated endpoints; they point in the same direction as earlier return to work.

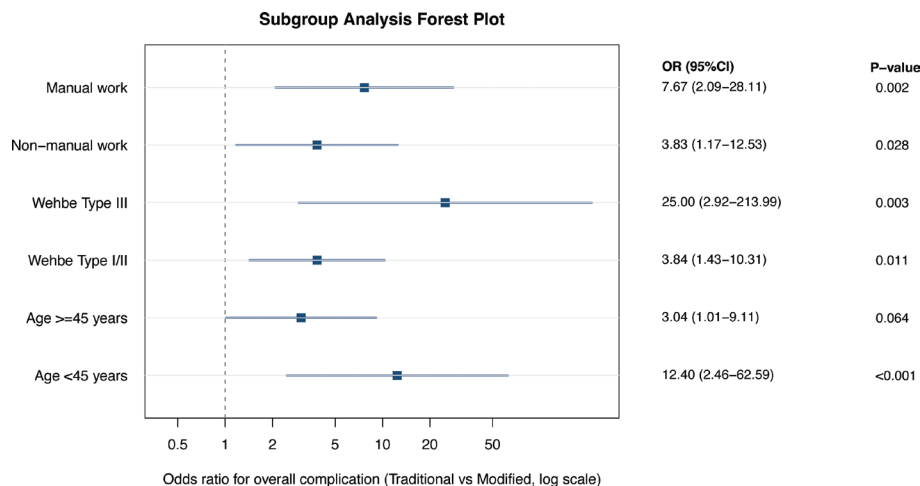


Figure 2. Subgroup analysis of overall postoperative complications after traditional transarticular fixation versus modified non-transarticular K-wire external fixation. The forest plot displays odds ratios (ORs) with 95% confidence intervals (CIs) for overall postoperative complications in prespecified exploratory subgroups. ORs compare the traditional transarticular fixation group with the modified non-transarticular fixation group; therefore, ORs greater than 1 indicate higher complication odds with traditional fixation and favor the modified technique.

The subgroup findings should be considered exploratory, but the stronger point estimate in manual workers is clinically understandable because stiffness, pain, and small losses of DIPJ motion may become more consequential when patients return to repetitive gripping, lifting, or fingertip-loading tasks [29]. This patient-centered interpretation is important because even small residual DIPJ pain or stiffness can be meaningful for manual workers, athletes, musicians, and patients whose daily tasks depend on fingertip precision [22, 23].

The multivariable model provides a second message: technique matters, but it is not the only determinant of outcome. In the multivariable analysis, the association between traditional fixation and overall complications remained substantial after adjustment for age, fracture classification, and time to surgery. Age also remained an independent risk factor, but the effect size was modest, with each additional year associated with a 9% increase in the odds of overall complications. This calibrated estimate is clinically plausible: older patients may have less forgiving periarticular soft tissue, slower recovery, or more vulnerability to stiffness, but age alone did not explain the complication difference between techniques [22, 30, 31]. Type III injuries likely represent more complex articular and metaphyseal damage, which can challenge reduction and healing. Delayed surgery may allow hematoma organization, fragment contracture, and early soft-tissue stiffness, making reduction less reliable and potentially increasing the risk of residual deformity or malunion [32, 33]. These findings are consistent with recent studies emphasizing fracture geometry, subluxation assessment, malunion management, and the quality of reduction as determinants of mallet-fracture outcome [31, 34].

The results should also be interpreted against the broader controversy between nonoperative and operative care. Recent systematic and cohort evidence shows that orthotic treatment can be appropriate for selected stable injuries, but failure rates, adherence, and delayed deformity remain concerns [26, 27]. Our study does not argue that all bony mallet fingers require surgery. Rather, for patients selected for operative fixation, it suggests that the method used to maintain DIPJ extension may influence recovery. A joint-sparing K-wire construct may be particularly useful when the surgeon wants the economy and availability of K-wires but wishes to avoid transarticular cartilage injury [35].

The present cohort comprised adults aged 27–68 years. Its findings therefore cannot be extrapolated directly to children, in whom physeal status, fragment size, remodeling potential, and treatment tolerance may alter both procedural choice and prognosis. The favorable long-term pediatric results reported for Ishiguro extension-block pinning and the age-specific distinctions summarized in the comparative review support individualized pediatric decision-making rather than direct application of the present adult estimates [14, 15].

Alternative fixation strategies, including suture anchors, custom plates, hook plates, pull-out sutures, and other fragment-specific methods, can be effective in selected cases [13, 28]. However, these techniques may add implant cost, require specialized hardware, or demand secondary removal. In contrast, the modified technique uses familiar K-wires, avoids extra implant expense, and keeps the external wire frame away from the dorsal incision, which facilitates dressing changes and suture removal. The absence of nail deformity in the modified group is clinically encouraging, although this finding should be confirmed in larger cohorts.

This study has limitations. Treatment allocation was nonrandomized, and selection bias cannot be excluded despite balanced baseline characteristics. The study was single-center, and all operations reflected local experience with both techniques. Rehabilitation was not fully standardized, and differences in adherence or access to therapy may have influenced QuickDASH, pain, stiffness, and return-to-work

outcomes. Radiographic change was assessed only at 1 year; this interval cannot establish posttraumatic osteoarthritis or define the long-term degenerative trajectory of the DIPJ. The available image archive did not include additional stepwise intraoperative photographs, radiographs after hardware removal, or final flexion photographs. Finally, the subgroup analysis was exploratory and should be interpreted as hypothesis-generating rather than definitive.

In conclusion, non-transarticular K-wire external fixation for bony mallet finger was associated with fewer overall complications and better early clinical recovery than traditional transarticular DIPJ pinning. By avoiding articular penetration while preserving stable extension, the modified construct may reduce stiffness without increasing cost or fluoroscopy exposure. Randomized multicenter studies with longer follow-up are warranted to determine whether these early advantages persist.

Declarations

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Competing interests

The authors have no relevant financial or non-financial interests to disclose.

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