Archives of Current Medical Research
Arch Curr Med Res 2025; 6(2): 135-142

Received: 17 December 2024
Revised: 02 March 2025
Accepted: 05 March 2025
DOI: 10.47482/acmr. 1608827

ORIGINAL ARTICLE

Tension Band Wiring of AO 34C Patella Fractures: Relationship Between Fracture Subtype and Early-Term Functional Results

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Abstract

Background: Patella fractures account for about 1% of skeletal injuries, leading to pain, limited knee motion, extensor weakness, and difficulty with weight-bearing. This study retrospectively assessed clinical and radiological outcomes of patients with OTA/AO Type 34-C patella fractures treated with tension band wiring, analyzing fracture type and treatment outcomes in relation to daily activities to identify potential correlations.

Methods: Between 2017 and 2024, 28 patients treated for OTA/AO Type 34-C fractures with tension band wiring and attending regular follow-ups were included. Data on age, gender, ASA score, AO fracture type, and fracture side were collected. At six months postoperatively, KOOS, VAS, and knee range of motion (ROM) were assessed.

Results: The 28 participants had an average age of 45 ± 19.65 years. No significant differences were found between males and females in ROM, KOOS scores, or VAS ($p > 0.05$). AO34-C3 fractures were the most common. AO Type C1 fractures had the highest KOOS scores and lowest VAS pain scores, while AO34-C3 fractures had the lowest KOOS scores and highest VAS scores. However, no significant differences were found in ROM, KOOS, or VAS scores across OTA/AO fracture subtypes (C1, C2, C3) or fracture side ($p > 0.05$).

Conclusion: This study highlights that while literature reports poor medium- and long-term outcomes for comminuted, displaced patella fractures, the early period differences in outcomes between subtypes, though not statistically significant, suggest other contributing factors. The prevalence of OTA/AO Type C3 fractures emphasizes the need for tailored treatment protocols for this subtype.

Keywords: Patella fracture, OTA/AO 34-C subtype, early functional results, pain, range of motion.

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INTRODUCTION

The patella plays a critical role in the extensor mechanism by enhancing the mechanical advantage of the quadriceps muscle, which is essential for effective knee extension during walking and other weight-bearing tasks. As a sesamoid bone, the patella links the proximal quadriceps tendon and the distal patellar ligament, contributing to knee joint stability and force transmission. Fractures of the patella can disrupt this mechanism, leading to extensor weakness, reduced knee range of motion (ROM), and long-term complications such as patellofemoral or tibiofemoral arthritis (1-3).

Patella fractures are relatively uncommon, accounting for approximately 1% of all skeletal injuries, and predominantly affect individuals aged 20-50 years, typically occuring due to direct blow or indirectly from forceful quadriceps contraction against a flexed knee. Surgical treatment is commonly indicated in cases of extensor mechanism failure, articular displacement >2 mm, or interfragmentary displacement >3 mm (4). The primary goals of surgical fixation include anatomical reduction, stable fixation capable of withstanding physiological forces during healing, and preservation of extensor mechanism integrity to allow early mobilization. Persistent knee stiffness, extensor lag, and patellofemoral osteoarthritis may arise, especially in cases of comminuted fractures (2).

The AO/OTA classification provides a standardized approach with type 34-C specifically referring to complete articular fractures with varying degrees of comminution. Despite the utility of this classification, limited data exist correlating early postoperative outcomes with specific fracture subtypes within the 34-C category. Our study aims to address this gap by evaluating short-term postoperative physical examination findings, functional outcomes, and pain levels in patients with AO/OTA 34-C patella fracture subtypes, thereby contributing to the existing literature on fracture management and recovery patterns

MATERIALS AND METHODS

After Ethical approval for this study was obtained from Local Ethics Committee of the Tertiary Hospital (28.06.2024,No:2024/351), database records were reviewed retrospectively to identify patients who underwent tension band wiring for OTA/AO Type 3C patella fractures between January 2017 and January 2024 and attended their postoperative six-month follow-up. Patients who had preexisting knee conditions visible on the initial radiographs, patients who had fixation with screws either alone or in combination with tension band wiring and patients with additional ipsilateral lower extremity fractures were excluded from the study. Of the 32 patients treated with tension band wiring, two were lost in follow-up, one patient required implant removal due to symptomatic hardware prominence and another patient underwent implant removal for infection before the completion of postoperative sixth month. Therefore, 28 patients were enrolled in the study. Informed consents had been routinely obtained from all patients before the surgery. Data included age, gender, ASA score, side and the subtype of the fracture were collected (Figure-1). Fracture classification was initially performed by an attending surgeon and subsequently reviewed and revised as needed by a senior orthopedic surgeon. Anteroposterior (Figure 2a) and lateral knee radiographs (Figure 2b) confirming fracture union, knee joint range of motion (ROM), Knee Injury and Osteoarthritis Outcome Score (KOOS) with related subscales and Visual Analogue Scale (VAS) scores at the six-month postoperative follow-up were documented from outpatient clinic records.

In this study, internal fixation had been achieved using a modified tension band technique, in which a metallic cerclage wire was tightened in a figure-of-eight fashion in 16 patient and in circular fashion in 12 patients around vertically placed Kirschner wires (K-wires) to convert tensile forces on the anterior surface into compressive forces at the joint surface as described in the literature (5) (Figure 3a and 3b). Operations were performed by three different surgeons. Reduction quality and fixation stability was assessed by intraoperative flouroscopic images and digital palpation of the patellofemoral articular surface by the attending surgeon. Patients were instructed to wear an adjustable knee brace with full extension for the postoperative first two weeks. After the second week, controlled range of motion exercises were initiated. From the sixth week onward, full weight-bearing and full range of motion exercises were introduced.

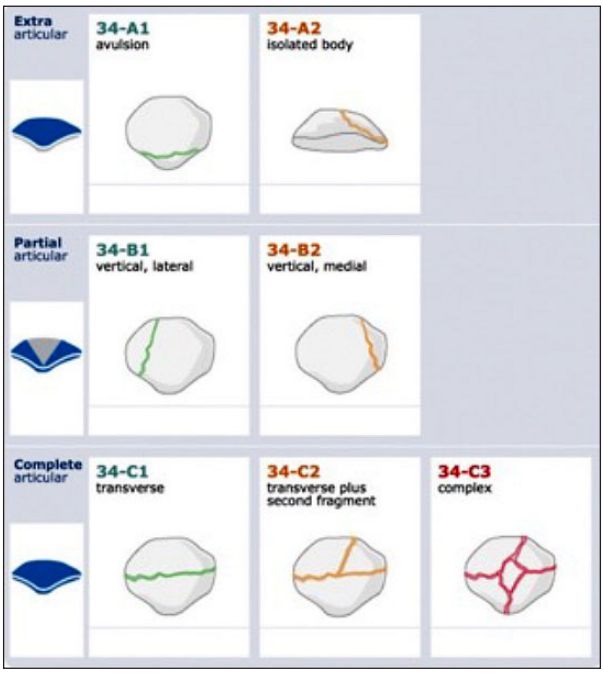

Figure 1: OTA/AO Classification for Patella Fractures: The OTA/AO classification categorizes patella fractures based on fracture morphology by indicating increased complexity. Type 34-A describes extra-articular fractures, Type 34-B includes partial articular fractures, and Type 34-C fractures represent complete articular fractures of the patella, involving disruption of the entire articular surface. They are further divided into: 34-C1: Simple, non-comminuted complete articular fractures. 34-C2: Complete articular fractures with partial comminution. 34-C3: Severely comminuted complete articular fractures with multiple fragments.

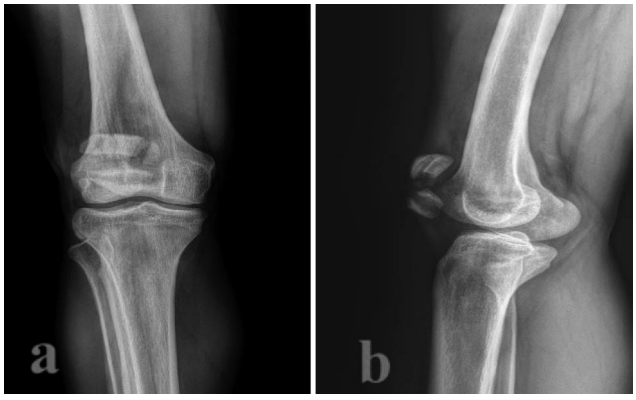

Figure 2a: Anteroposterior (AP) x-ray of OTA/AO Type 3C patella fracture, b. Lateral x-ray of OTA/AO Type 3C patella fracture demonstrating the multiple fracture lines and disrupted articular surface.

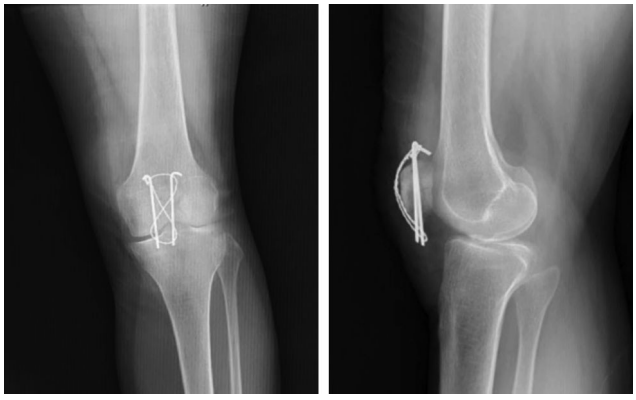

Figure 3a: Anteroposterior (AP) x-ray of tension band wiring b. Lateral x-ray of tension band wiring in figure-of-eight fashion around two vertically placed kirschner wires, performed after anatomical congruity of patellofemoral articular surface was achieved.

Statistical analyses were performed using IBM SPSS version 22.0 (IBM Corporation, Armonk, NY, USA), with a significance level set at $p<0.05$. Continuous variables were presented as mean ± standard deviation, and categorical data as frequencies and percentages. Normality of continuous variables was assessed using the Kolmogorov-Smirnov goodness-of-fit test. For data that did not follow a normal distribution, the Mann-Whitney U test was used. The Kruskal-Wallis test was employed for between-group comparisons of non-normally distributed values.

RESULTS

This study included 28 patients, with 71.4% (n=20) male and 28.6% (n=8) female. The mean age of the patients was 45 ± 19.65 years. The ASA scores were recorded as 28.6% (n=8) ASA 1, 57.1% (n=16) ASA 2, and 14.3% (n=4) ASA 3. The fractures were distributed as follows: 32.1% (n=9) AO 34-C1, 28.6% (n=8) AO 34-C2, and 39.3% (n=11) AO 34-C3. It was observed that 67.9% (n=19) of the fractures were on the right side (Table 1).

Table 1. Demographic data of patients

	n	%		n	%		n	%		n	%
Gender			ASA			Fracture subtype (OTA/AO Classification)			Laterality		
Male	20	71,4	1	8	28,6	34-C1	9	32,1	Dominant	19	67,9
Female	8	28,6	2	16	57,1	34-C2	8	28,6	Non-dominant	9	32,1
Age/year (mean±ss)	45 ± 19,65		3	4	14,3	34-C3	11	39,3			

In male patients, the mean ROM was 129 ± 8.97 degrees for flexion, 3.65 ± 1.30 degrees for extension, mean KOOS symptoms score was 74.05 ± 18.32, KOOS pain score was 84.80 ± 17, activities of daily living score was 82.90 ± 18.09, KOOS sports and recreation score was 61.50 ± 28.88, KOOS quality of life score was 58.50 ± 25.50, KOOS total score was 72.30 ± 19.45, and mean VAS score was 3 ± 3.06. In female patients, the mean ROM was 117.63 ± 18.66 degrees for flexion, 3.25 ± 1.03 degrees for extension, mean KOOS symptoms score was 72 ± 15.91, KOOS pain score was 76.38 ± 31.93, KOOS activities of daily living score was 74.13 ± 27.48, KOOS sports and recreation score was 50 ± 30.35, KOOS quality of life score was 36.13 ± 31.02, KOOS total score was 61.87 ± 23.14, and mean VAS score was 4.38 ± 2.38. No statistically significant difference was found between genders for any of these parameters (p-values: 0.153, 0.306, 0.444, 0.919, 0.541, 0.332, 0.059, 0.284, and 0.222, respectively) (Table-2).

When analyzed based on OTA/AO fracture subtypes (C1, C2, C3), no statistically significant differences were observed for ROM, KOOS symptoms, KOOS pain, KOOS activities of daily living, KOOS sports and recreation, KOOS quality of life, KOOS total score, or VAS scores ($p > 0.05$ for all). However, a trend of lower KOOS scores and higher VAS pain levels was noted as the fracture complexity increased (C1 to C3). KOOS pain and KOOS quality of life scores were more affected in AO 34-C2 and C3 groups compared to the C1 group. VAS scores were also higher in the C2 and C3 subtypes, although not statistically significant.(p-values: 0.306, 0.814, 0.626, 0.191, 0.598, 0.817, 0.536, 0.689, and 0.880, respectively).

No statistically significant difference was found in knee joint ROM, KOOS symptoms, KOOS pain, KOOS activities of daily living, KOOS function sports and recreation, KOOS quality of life, KOOS total score, or VAS score based on whether the fracture was on the domi-

Table 2. Results at postoperative sixth month

	Gender		Fracture type (OTA / AO Classification)			Laterality	
	Male	Female	34-C1	34-C2	34-C3	Right	Left
	mean ±ss	mean±ss	mean±ss	mean±ss	mean±ss	mean±ss	mean±ss
Flexion	129 ±8,97	117,63±18,66	123,67±16,18	126,63±12,63	127,55±11,91	123,53±13,60	130,44±11,63
P	0,153*		0,306**			0,126*	
Extension	3,65 ±1,30	3,25±1,03	3,89±1,26	3,25±1,48	3,45±1,03	3,68±1,25	3,22±1,20
P	0,306*		0,814**			0,310*	
KOOS Functional Scores							
KOOS Symptoms	74,05±18,32	72±15,91	77±14,33	70,13±14,92	73±21,83	71,79±17,57	77±17,50
P	0,444*					0,375*	
KOOS Pain	84,80 ±17	76,38±31,93	90,67±8,78	76,50±26,98	79,91±25,22	82,53±22,85	82,11±21,31
P	0,919*					0,921*	
KOOS Activities of Daily Living	82,90±18,09	74,13±27,48	85,67±17,74	75,38±24,18	79,73±22,08	79,95±21,34	81,33±21,60
P	0,541*		0,598**			0,844*	
KOOS Sports and Recreation	61,50±28,88	50±30,35	62,78±30,32	56,88±24,48	55,45±33,50	55,79±27,65	63,33±33,44
P	0,332*		0,817**			0,570*	
KOOS Quality of Life	58,50±25,50	36,13±31,02	55,67±33,38	49,38±22,87	51,18±30,31	49,79±25,89	57±34,59
P	0,059*		0,536**			0,538*	
KOOS Score	72,30±19,45	61,87±23,14	74,44±16,80	65,50±20,45	67,91±24,50	67,95±19,98	72,22±23,08
P	0,284*		0,689**			0,506*	
VAS Score	3±3,06	4,38±2,38	2,22±2,6	4±3,02	3,82±3,02	2,95±2,89	4,22±2,94
p	0,222*		0,880**			0,315*	
	*Mann-Whitney U Test, ** Kruskal Wallis Test						

nant or non-dominant side (p-values: 0.126, 0.310, 0.375, 0.921, 0.844, 0.570, 0.538, 0.506, and 0.315, respectively).

Our study found that AO 34-C3 fractures were more frequently encountered. There was no significant difference between AO C1-C2-C3 fracture types and KOOS and VAS scores. KOOS scores were highest in AO Type C1 fractures and lower in C2 and C3 fractures. VAS pain scores were higher in AO Type C2 and C3 fractures, with the lowest scores observed in AO Type C1 fractures. No significant difference was observed between fracture types and joint range of motion.

DISCUSSION

The subcutaneous position of the patella and the limited soft tissue coverage over it increase its risk of fracture from impacts. Given the high contact stress experienced by the patellofemoral joint due to its location and function, it is crucial to achieve an optimal distribution of stress by reconstructing the articular surface accurately post-fracture (10).The tension band method is commonly preferred in non-displaced or two-part patellar fractures without fragmentation, etiher alone or combined with cannulated screw fixation, which offers biomechanical advantages. In fractures with significant fragmentation, other methods like mini fragment screws and angular plates are utilized in addition to the conventional tension band technique (11).

Post-fracture complications of patellar fractures include extension weakness, gait disturbances, pain, degenerative changes in the patellofemoral joint surface, and the development of osteoarthritis. Thus, many studies have evaluated the functional outcomes of surgical treatment for patellar fractures over mid and long terms using various radiological and clinical parameters (12-17). While good functional outcomes are reported for non-displaced or minimally displaced patellar fractures treated conservatively, there is a lack of recent studies to support these results (18, 19). However, outcomes for displaced patellar fractures requiring surgical treatment differ. LeBrun and colleagues evaluated the mid-term functional outcomes of 241 patients who underwent tension band or partial patellectomy for displaced patellar fractures, using SF36 and KOOS scoring, and reported poor functional outcomes in the mid-term (10). Vedel and colleagues assessed long-term functional outcomes of surgically treated patellar fracture patients with KOOS, muscle strength measurements, and gait analysis, observing significant reductions in knee extension strength and accelerated osteoarthritis progression in both the patellofemoral and tibiofemoral joints, with a notable decline in health-related quality of life (20). Özdemir and colleagues evaluated mid-term outcomes of patients with operated patellar fractures and reported that nearly half of the patients had moderate or unsatisfactory results (21).

According to the AO classification, patellar fractures are categorized alphanumerically as AO 34, with three main types: Type A (extra-articular fractures), Type B (fractures partially involving the joint surface), and Type C (complete articular fractures). Type C is further subdivided into three subgroups: Type C1 indicates a transverse fracture line, Type C2 includes an additional fracture line in one of the major fragments, and Type C3 represents multifragmentary fractures (22).

In our study group, the most common fracture subtype was OTA/AO C3, a finding consistent with Larsen and colleagues' recent large-scale epidemiological study on patellar fractures, which also identified OTA/AO C3 as the most frequent subtype (23). We found no significant differences were observed between fracture subtypes (C1, C2, C3) in terms of knee joint ROM, KOOS scores, or VAS scores. However, a trend toward lower KOOS scores and higher VAS pain scores was evident in more complex fractures (C2 and C3), despite the absence of statistical significance. These findings align with previous studies highlighting the correlation between increased fracture complexity and poorer functional outcomes (10).

Notably, the KOOS pain and quality of life subscales were lower in the C2 and C3 groups, while the KOOS activities of daily living and KOOS sports and recreation scores were less impacted. Our results suggest that more complex fractures may have a greater impact on pain perception and quality of life rather than functional domains such as activities of daily living or sports participation in the early postoperative period. The lack of statistical significance may be related to the limited sample size, but the clinical relevance of these patterns warrants consideration. Our results suggest that clinicians should be aware that increasing fracture complexity might be associated with reduced pain relief and functional capacity, even in the early postoperative period, emphasizing the need for individualized surgical and rehabilitation strategies for complex fractures. Although poor mid- and long-term outcomes for patellar fractures are attributed to accelerated patellofemoral joint arthrosis due to articular involvement, inadequate reduction, and fixation; our findings indicate that poorer results may also be observed in the early term, even in the absence of arthrosis. This may be explained by the possibility that the degree of fragmentation could affect outcomes and this effect does not necessarily have to be mediated through patellofemoral osteoarthritis. Moreover, demonstrating the impact of fragmentation degree on early outcomes could lead to the adoption of different surgical strategies among complete articular fracture subtypes of patella.

The frequent observation of OTA/AO Type C3 fractures among patellar fractures underscores the need to develop an evidence-based treatment protocol specific to this fracture subtype (23). Several studies suggests locked plates are biomechanically superior and might be more suitable especially for complex fractures (24, 25, 26). However, Bickel et al report that one-year functional outcome does not differ significantly between cerclage wiring and locked plate groups, while the locked plate group is associated with less complications and revision surgeries (27). Poh et al report similar functional outcomes with tension band wiring compared with cannulated screw constructs at postoperative fifth year in their multi-center study, although the latter is associated with less implant-related complications (28). On the other hand, the meta-analysis by Zhang et al conclude that the alternative types of surgery might yield better functional results and pain scores with less complications than tension band wiring (3). Considering the literature and our results in early postoperative period, it could be more appropriate to evaluate alternative surgical techniques as fracture complexity increases, rather than adopting a one-size-fits-all approach.

The primary limitations of this study include its retrospective design, the fact that surgeries were performed by multiple surgeons with varying experience, and the small sample size. The inclusion of only 28 patients may have reduced the statistical power of the analyses, potentially limiting the detection of significant differences between groups. Furthermore, the small sample size could restrict the generalizability of the findings to broader patient populations. Our findings should be confirmed by studies with larger sample sizes and methods that can assess the quality of articular surface reconstruction. In our study, we aimed to investigate the impact of fracture subtypes on functional outcomes in patients operated on with the same surgical technique in the early postoperative period, before the development of patellofemoral osteoarthritis, which is a significant cause of poor functionality and pain after patellar fractures. Therefore, we established the sixth postoperative month as the evaluation point. A noteworthy limitation is the lack of long-term data to determine whether the early outcomes observed at this time point correlate with long-term results. Future studies should aim for larger cohorts and longer follow-up durations to better establish the relationship between fracture complexity and functional recovery.

As conclusion, in patients treated with tension band wiring for AO Type 34-C patella fractures, no significant difference was found in functional outcomes or pain levels at the sixth month based on gender, fracture subtype, or fracture side. AO Type C3 fractures were the most common, but functional outcomes were similar across fracture subtypes, with a slight improvement tendency observed in AO Type C1 fractures, although this was not statistically significant. Compared to non-displaced simple patellar fractures, multifragmentary patellar fractures are generally associated with poorer mid- to long-term outcomes, which are often linked to accelerated development of patellofemoral joint osteoarthritis. Our findings suggest that early functional outcomes may be influenced by factors other the development of osteoarthritis.

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Abbreviations list

ROM: range of motion
VAS: visual analogue scale
K-wires: kirschner wires
KOOS: knee ınjury and osteoarthritis outcome score
AP: anteroposterior

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Gülhane Faculty of Medicine (Decision No: 2024/351). Written informed consent was obtained from all participants prior to surgery.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request. No restrictions apply to data availability.

Competing interests

All authors of the study titled "Tension Band Attachment of AO 34C Patella Fractures: Relationship Between Fracture Subtype and Early Functional Outcomes" declare that they have no conflict of interest.

Funding

No specific funding was received for this study. All procedures and data collection were carried out independently by the authors without external financial support.

Authors' contributions

Idea/Concept: MA, Desıgn: BAK, AMB, Control/Supervısıon: MA, DÇ, Data Collectıon And/Or Processıng: ÖLK, AA, EK, Analysıs And/Or Interpretatıon: MA, BAK, AMB, Lıterature Revıew: ÖLK, AA, EK, Wrıtıng The Artıcle: MA, Crıtıcal Revıew: MA, DÇ, References And Fundıngs: BAK, AA, Materıals: MA, AA, EK, Other: ÖLK, AA, EK.

Acknowledgements

No acknowledgments are made to any individual for this study.