ORIGINAL ARTICLE

Outcomes of transvers pinning versus antegrade intramedullary elastic nail in surgical fixation of 5th metacarpal neck fractures

MOHAMED ADEL. A. IBRAHIM, BAHAA A. KORNAH, MOHAMED N AKL, MOHAMED G ABDELKADER, MOHAMED I. ABULSOUD, LOTFY MOHAMED SHWITTER, MOHAMED A.I. ISMAIL, MOSTAFA M. ELGAHEL

Orthopaedic department, Faculty of medicine, Al-Azhar university, Cairo, Egypt

ABSTRACT

Background: The most prevalent hand fracture is a fifth metacarpal neck fracture. Due to hand impairments caused by improper therapy for fifth metacarpal neck fractures, there is a negative economic impact due to disabilities in workers', athletes', and housewives' hands. Additionally, there are aesthetic side effects and deficits in metacarpophalangeal extension.

Objective: Our study aimed to evaluate and juxtapose clinical and radiological outcomes following the use of percutaneous transverse k-wire versus antegrade intramedullary elastic nail for the treatment of fifth metacarpal neck fractures.

Patients and Methods: A prospective comparative study involving 40 patients presenting with 5th metacarpal neck fractures, who were treated surgically participated. Two patient groups were formed: Group 1 (20 patients) received fixation by single ante-grade intramedullary elastic nail. Group 2 (20 patients) were treated with fixation by percutaneous transverse k-wire. Both groups followed up for a full year.

Results: All patients recovered to their pre-injury activity level at the last follow-up, had excellent functional and acceptable results, and had achieved bony union. There were no significant postoperative or intraoperative complications noted, and there was no statistically significant difference between the two groups in terms of complications, pain, hand grip strength, or time of union. The total active motion (TAM) score demonstrated significant improvement in both groups with slight increase in significance in the intramedullary elastic nail group.

Received: 27 August 2025 | Accepted: 21 October 2025

Correspondence: Mohamed Adel. A. Ibrahim, MD / Lecturer of Orthopaedic surgery Orthopaedic department, Faculty of medicine, Al-Azhar university-Cairo, Egypt Al mokhayyam Al Dayem Street, Nasr City, 11675, Cairo, Egypt / E-mail: Mohamedadel@azhar.edu.eg
ORCID: 0000-0002-1796-4549

Conclusion: Based on the outcomes, high patient satisfaction and low complication rates both methods are considered valid options for safe, reliable and effective surgical management for 5th metacarpal neck fractures. (www.actabiomedica.it)

Key words: 5th metacarpal neck fractures, elastic nail, intramedullary, pinning, transverse.

Introduction

The human hand is valuable to everyone since it performs countless activities ranging from simple grasping to complicated skills (1). As the weakest point in the metacarpals, neck fractures are most common and account for approximately 10% of hand fractures. Cosmetic and functional deficiencies can develop from inappropriate reduction and fixation, which has a negative economic impact due to disabilities in workers', athletes', and housewives' hands (2). Fifth metacarpal bone neck fractures are mostly caused by punching or falling; hence, the moniker "boxer's fracture". This problem occurs when the hand is fist-clenched, and an axial force of compression is applied to the knuckles. The trauma severity determines how much the metacarpal head flexes; also, damage to the volar cortex and the pulling force of the intrinsic muscles cause the head to heal poorly (3-5). Surgical intervention is generally indicated when there is a clinical abnormality, such as rotation of the 5th digit in flexion or shortening greater than 3 mm, or when the volar angulation of the metacarpal head is considered significant. However, the degree of allowable volar angulation varies greatly (6). Fifth metacarpal unstable neck fractures can be treated surgically using a variety of methods, including transverse K-wire pinning, external fixation, ante-grade intramedullary nailing, ante-grade and retro-grade intramedullary K-wiring, and retro-grade cross pinning with K-wiring. Antegrade intramedullary nailing has grown in popularity among surgeons during the past 10 years (7,8). Kirschner wires were established for metacarpal fracture fixation many decades ago and are still regarded as one of the best procedures for treating metacarpal fractures (9). Stable elastic intramedullary nailing has recently been used to treat metacarpal fractures. Faster fracture healing, better cosmetic and functional results, a reliable and safe surgical method, and a lower severe complication rate are all advantages of ESIN (10,11). Berkman and Miles (12) defined the transverse pinning method, which involves passing wires transversely between the 5th and 4th metacarpal bones. According to a recent literature review, there is a still debate about the most effective ways to treat the 5th metacarpal neck fractures (13,14). So, the purpose of this study was to evaluate and juxtapose the clinical and radiological results of surgical fixation of 5th metacarpal neck fractures to those of antegrade intramedullary single elastic nail or transverse k-wire pinning.

Materials and methods

A prospective randomized comparative study using a case series of 40 patients (20 patients in each group) who complained of 5th metacarpal neck fractures, was conducted between May 2022 and April 2024 in the hospitals of Al-Azhar University in Egypt. Patients were randomly assigned to two equal groups using the closed envelope method. Twenty patients were managed by antegrade single intramedullary elastic nail (Group 1). The other 20 patients were managed with percutaneous transverse k-wires pinning (Group 2). Rationale for sample size: Considering the primary outcome (TAM score), eighteen participants per group were needed, assuming a clinically significant between-group difference of 15 points, SD of 15 points, $\alpha = 0.05$, and 80% power. Each group included 20 individuals to allow for possible dropouts. The following were the inclusion criteria: isolated closed fractures, moderate to severe angulation (less than 30°),

clinical malrotation deformity, unstable or irreducible fractures and failed nonsurgical treatment. Among the exclusion criteria are all patients aged > 65 and < 15 years, had open, comminuted, or intra-articular fractures, were in poor general health, were uncooperative or had neglected cases.

Preoperative evaluation

Each patient underwent a thorough medical history and general checkup upon recruitment. Clinical examinations were performed to assess alignment, ROM, and a neurovascular examination. The authors assessed patient symptoms, activity, hand function, and post-operative patient satisfaction using total active motion (TAM) score (15) of the little finger, the disabilities of the arm, shoulder, and hand (DASH) score (16,17) and the strength of the hand grip compared to the normal side. The pain visual Analog scale (18) (PVAS) evaluates postoperative pain. Radiological evaluation including X-ray radiographs of the injured hand in the antero-posterior and oblique views was done for all patients. All patients underwent the standard laboratory, cardiac, chest, and anesthetic evaluations before surgery to determine their surgical suitability and obtain their consent.

Operative technique

All of the patients were positioned in supine posture, with their hands resting on the fluoroscopic device. Among the patients in Group 1, 18 patients had general anesthesia, and two patients had regional anesthesia. In Group 2, one patient had regional anesthesia, and 19 patients had general anesthesia. Antibiotics were administered intravenously as prophylaxis to all patients. Surgical procedures were performed under complete aseptic conditions.

Group 1: Antegrade intramedullary elastic nail technique

The entry point was chosen at the base of the ulnar dorsal border of the fifth metacarpal. Then, a skin incision was made, and subcutaneous tissue was bluntly dissected to protect the cutaneous dorsal branch of the ulnar nerve and expose the base of the 5th metacarpal bone. A 2.5 mm drill bit was used to create a tiny hole in the cortex and medulla. The distal tip of the elastic nail of an appropriate diameter was introduced via an antegrade approach into the hole with the T handle. The fractured part was reduced, and the nail passed across the fractured part to the metacarpal head. The bent distal end of the elastic nail was subsequently rotated 180 degrees to maintain reduction and correct angulation. The elastic nail was cut off and hidden behind the skin. The skin incision was closed (Figure 1).

Group 2: The percutaneous transverse pinning technique

Three K-wires of suitable diameter were prepared. Traction was applied to reduce the displaced fracture of the 5th metacarpal neck. The 1st K-wire was introduced into the fifth metacarpal bone's medial cortex and passed from the 5th to the 4th metacarpal shaft,

Figure 1. Preoperative and postoperative X-ray radiograph of the hand antero-posterior and oblique views of 5th metacarpal neck fracture fixed by a single ante-grade intramedullary elastic nail.

up to ten mm proximally to the fracture. Then, 2nd and 3rd k-wires were inserted through the medial cortex of the 5th metacarpal, which passed from the 5th to the 4th metacarpal heads parallel to the first one, avoiding the articular surface. Finally, the K-wires were curved, cut and removed to increase the ease of removal (Figure 2).

Postoperative follow up

A plaster splint (ulnar gutter) was placed postoperatively for two weeks with the wrist in a functioning position in both groups. Active movement of the whole hand is recommended after a splint is removed. All patients were advised to avoid heavy work 2 months after surgery. The elastic nail was buried under the skin. Transverse K-wires were removed after 6 weeks (Figure 3). Clinical and radiological follow up was carried out on a regular basis, with the DASH, TAM scores and the PVAS. Radiological assessment was performed with serial X-ray radiographs at 2,4,6 weeks, and three months for sign of healing at the fracture site and every 3 months for a duration of one year for follow-up. Comparisons between the two groups were performed for ROM, hand grip strength, pain, complication and time of union (Figure 4).

Statistical analysis

SPSS version 23 (Chicago, Illinois, USA) was utilized for statistical analysis. The mean ± SD is used to describe continuous variables, which are quantitative, while percentages are used to represent categorical variables. They also utilized chi-square tests ($\chi 2$ tests) to compare categorical variables and paired t tests to compare continuous variables. 95% confidence intervals (CIs) were calculated for all key outcomes. For continuous variables, 95% CIs for group means were computed using the t-distribution and for between-group, mean differences using the standard error of the difference. For proportions, 95% CIs were calculated using the Wilson method.

Results

Forty patients presented with a fracture of the 5th metacarpal neck and were divided into two equal groups. The 1st group (n=20), group 1, was treated with antegrade single intramedullary elastic nail. Percutaneous transverse K-wire pinning was applied to the 2nd group (n=20) designated as group 2. According to the demographic data, there are no statistically significant differences in the distribution of ages or sexes. The mean age for group 1, was 34.72 years, while for group 2, it was 34.85 years, Additionally, the sex distribution was similar across both groups, with males comprising 95% of group 1, and 100% of group 2. Most of the patients in both groups were manual workers (Table 1). The mean follow-up was 9 months (6-12 months) in both groups. Punching was the most common mode of trauma in the two groups, followed by falling to the ground. All the injured hands were the dominant hands, and most of the patients were right-handed. The time of injury to surgery ranged from 1-14 days, without

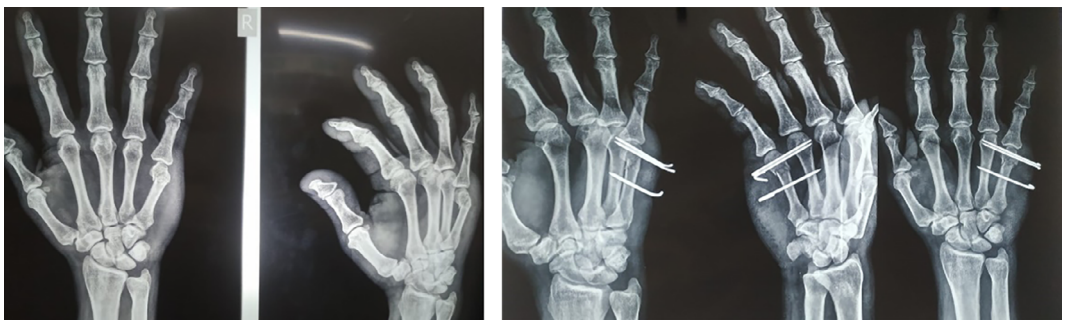

Figure 2. Preoperative and postoperative X-ray radiograph of the hand antero-posterior and oblique views of 5th metacarpal neck fracture fixed by percutaneous transverse K-wires.

Figure 3. X-ray radiograph of the hand antero-posterior and oblique views show removal of transverse k-wires after 6 weeks.

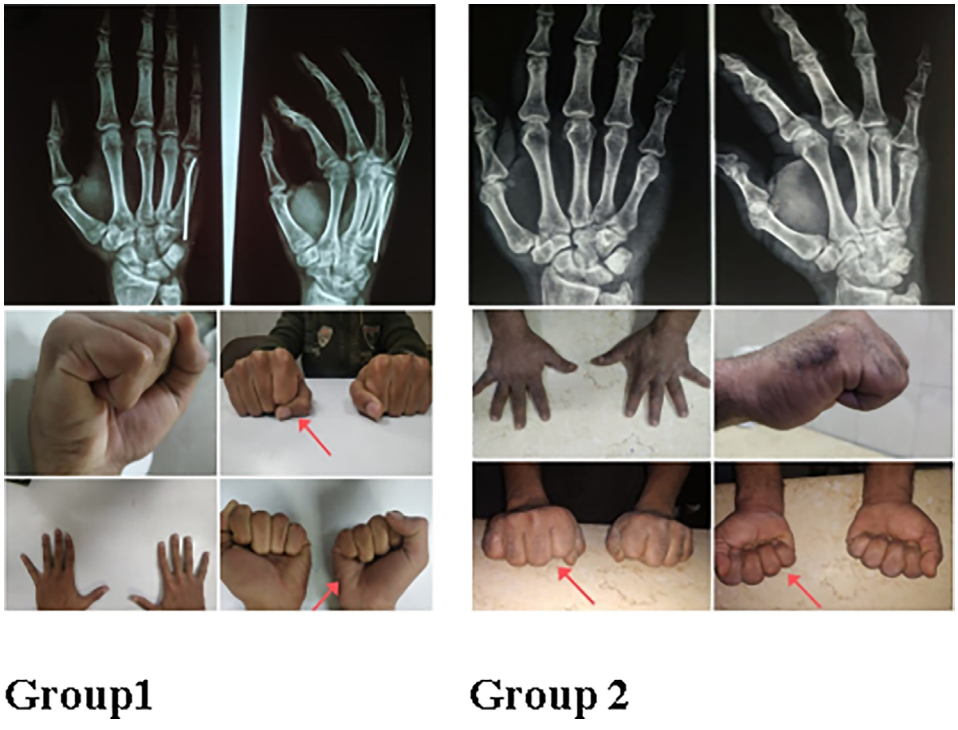

Figure 4. Six months clinical and radiological follow up of both groups.

Table 1. Comparison of demographic data of the studied population.

		Group I	95% CI	Group II	95% CI	Independent student T-test/chi-square test	
		N=20		N=20		t/X2	p-value
Age/years	Range	17-61		20-58		0.033	0.974
	Median	34 (24.5-45)		34 (23-42)			
	Mean ± SD	34.72 ± 12.83	28.87–40.57	34.85 ± 11.86	29.49–40.21		
Sex	Male	19 (95%)	76.4–99.1%	20 (100%)	83.9–100%	1.026	0.311
	Female	1 (5%)	0.9–23.6%	0 (0%)			
Occupation	Manual worker	11 (55%)	34.2–74.2%	9 (45%)	26.2–65.6%	1.629	0.653
	Office	2 (10%)	2.8–30.1%	5 (25%)	11.2–46.9%		
	Not work	3 (15%)	5.2–36.0%	3 (15%)	5.2–36.0%		
	Student	4 (20%)	8.1–41.6%	3 (15%)	5.2–36.0%		

Values are mean ± SD or n (%); 95% confidence intervals (CI) for means use t-distribution; proportions use Wilson method.

a statistically significant difference between the groups (Table 2). Regarding clinical and radiological results, the TAM score was slightly greater in group 1 (245.75± 12.70), than in group 2, (230.25± 22.16) (p value=0.009). The mean hand grip strength showed no significant difference between the two groups. (P value=0.284). Also, the DASH score was excellent in 80% of patients in group 1, and in 70 % of patients in group 2. Furthermore, the VAS score at the final follow-up showed no discernible difference between the two groups. The time of union ranged from 6-14 weeks, with no discernible difference between both studied groups (P value was 0.670) (Table 3). Concerning the complication rate, in group 1, one patient had hypoesthesia at the dorsum of the little finger recovered after receiving neurotronic drugs and vitamin B12 supplementation for 6 months. In group 2, three patients had a pin tract infection, improved by local antibiotics and pin tract care, and one had stiffness at the 5th MCP joint which improved by physiotherapy (Table 3).

Discussion

Most 5th metacarpal neck fractures are isolated, straightforward, closed, stable and managed conservatively. Inappropriate reduction and stabilization lead to cosmetic and functional loss (5,6).

Indications for surgical intervention include malrotation, longitudinal shortening, and severe head angulation. Additionally, metacarpus shortening of more than three mm, as well as any rotation deformity, is poorly tolerated and must be corrected. However, it is still unclear how much angulation can be endured without resulting in hand pain or functional loss (7). Several procedures have been reported, and they all share a common goal: restoration of anatomy with no residual abnormalities and reliable fixation, allowing for quick recovery of joint motion and function (19). We reported forty patients who were presented with 5th metacarpal neck fractures; and were treated by two different methods, Group 1 was treated with a single ante-grade intramedullary elastic nail, and group 2 was treated with percutaneous transverse k-wire. The clinical and radiological results of both methods were excellent regarding the TAM, grip strength, time of union and complication rate. Yuanshi She and Youjia Xu (20) reported that ante-grade single elastic intramedullary nailing was an effective treatment for fifth metacarpal fractures as it had a result of rapid functional recovery of the hand while avoiding complications. It is also recommended by Langqing Zeng and Lulu Zeng (21) because the distal ends of the nails have a slight curve and are more flexible than K-wires; additionally, they are easier to control throughout the procedure and do not require bending. Another study by Potenza et al

Table 2: Comparison of fracture characteristics of the studied population.

		Group I		Group II		Independent T/ chi-square test	
		N=20	95% CI	N=20	95% CI	t/X2	p-value
Mechanism	Punch	15 (75%)	53.3–88.9%	13 (65%)	43.3–82.7%	0.587	0.746
	Fall	4 (20%)	8.1–41.6%	5 (25%)	11.2–46.9%		
	RTA	1 (5%)	0.9–23.6%	2 (10%)	2.8–30.1%		
Side of fracture	Right	19 (95%)	76.4–99.1%	18 (90%)	69.9–97.2%	0.360	0.549
	Left	1 (5%)	0.9–23.6%	2 (10%)	2.8–30.1%		
Associated injury	No	17 (85%)	64.0–95.0%	18 (90%)		0.229	0.632
	Yes	3 (15%)	5.2–36.0%	2 (10%)	2.8–30.1%		
Time of injury (d)	Range	1-14		1-14		0.608	0.547
	Median	12 (10.25-12)		7 (3.75-11.25)			
	Mean ± SD	8.30 ± 4.11	6.36–10.24	7.50 ± 4.21	5.51–9.49		

Values are mean ± SD or n (%); 95% CIs for means use t-distribution; proportions use Wilson method.

(22) reported that percutaneous transverse K-wire pinning is simple to perform for all boxer fractures, and clinical outcomes are usually acceptable. Additionally, excellent clinical and radiological results were reported by Galanakis et al (23) in a group of patients with unstable metacarpal fractures who underwent percutaneous transverse pinning using K-wires. Our findings are matched to those of Kai Wang et al (24) who employed a similar methodology with fixation of patients with unstable metacarpal fractures either by percutaneous transverse pinning using K-wires or by elastic stable intramedullary nail and all patients demonstrated excellent clinical and radiological results. Like we did with our patients, Winter et al (25) also employed the TAM score to assess the fingers active range of motion of their patients after surgery, and it was 279 in the intramedullary group and 261 in the transverse group after 12 months in their study, while, the mean of TAM score was 245 in our intramedullary group and 230 in transverse pinning group. Additionally, Yuanshi She and Youjia Xu (20) reported that the mean TAM diameter was 270°, in twenty-seven patients treated with antegrade single intramedullary nail. Regarding, the time of injury to surgical intervention in our study, it had a mean of 8.30 days in group 1 and 7.50 days in group 2. Yuanshi She and Youjia Xu (20) also reported that the mean time between injury and surgery was 6.7 days, with a range of 2-13 days. Concerning the time of union, the mean value was 9.25 weeks for group 1 and 8.95 weeks for group 2 ranged from 6-14 weeks for both groups. These results match those of Wong et al (26) who reported that the mean time to union in the transverse and intramedullary groups was 10 weeks, ranging from 1-16 weeks. Khan et al (27) also reported that the average time to union was 5.4 weeks in 30 patients with 5th metacarpal neck fractures managed by K-wires applied percutaneously. In our study, we reported low complications rate, only one patient (5%) in group 1, developed hypoesthesia at the little finger's dorsum due to injury to the dorsal cutaneous branch of the ulnar nerve which supply the dorsal portion of the little finger, the dorso-ulnar side of the ring finger, and the dorso-ulnar side of the hand, recovered after receiving neurotronic drugs and vitamin B12 supplementation for 6 months This also matched with Yuanshi She and Youjia Xu (20) study who described one patient had hypoesthesia on the little finger's dorsum. In group 2, Three patients (15%) developed superficial pin tract infections that are resolved after local antibiotics and daily pin tract care, only one patient (5%) experienced improvement in MCP joint stiffness following physiotherapy. Wong et al (26) reported that

Table 3: Clinical and radiological outcomes of the studied population.

		GROUP1	95% CI	GROUP2	95% CI	Mean Difference (95% CI)	Independent T/ chi-square test	
		n=20		n=20			t/X2	p-value
TAM score	Range	220-260		170-260			2.66158.	.005667
	Mean ± SD	245.75 ± 12.70	239.81–251.69	230.25 ± 22.16	219.88–240.62	15.50 (4.31–26.69)		
Grip strength	Range	80-100		70-100			1.08566	.142234
	Mean ± SD	92 ± 6.96	88.74–95.26	89.5 ± 7.59	85.95–93.05	2.50 (–2.01–7.01)		
DASH	Good	4 (20%)		6 (30%)			-0.87449	.193673
	Excellent	16 (80%)	59.3–92.0%	14 (70%)	48.0–85.5%			
Time of union (W)	Range	6-14		6-14			0.44501	.32942
	Mean ± SD	9.25 ± 2.33	8.16–10.34	8.95 ± 1.90	8.06–9.84	0.30 (–1.02–1.62)		
Complications	Hypoesthesia at the dorsum of little finger	1 (5%)		0%				
	Stiffness	0%		1 (5%)				
	Pin Tract Infection	0%		3 (15%)				

Values are mean ± SD or n (%); 95% confidence intervals for means calculated using t-distribution (df = 19). Proportion CIs calculated using Wilson method. Between-group mean differences expressed with 95% CIs.

ACTA BIOMED 2026; VOL. 97, N. 1: 17812 DOI: 10.23750/ABM.2026.17812

stiffness in the affected finger was present in one patient in the percutaneous group. While Kasman et al (28) reported that two patients had Superficial pin site infection in the group with intramedullary fixation, one patient only had Superficial pin site infection in transverse K-wires group, and the treatment was completed with antibiotic therapy in both groups. Psychological concern is a significant factor influencing more patient satisfaction with intramedullary elastic nail due to better cosmetics, functional results and less medical complication rate especially, pin tract infection, but the necessity for another surgery to remove the nail and the greater cost of this surgery in comparison to K-wires may restrict the use of ante-grade intramedullary elastic nails. Finally, our study limitation is the lack of control group and the brief number of participants, which necessitates further investigation into a larger patient's cohort. Therefore, future studies, preferably multicenter studies, are recommended to validate our results.

Conclusion

Based on the outcomes, high patient satisfaction and low complication rates both methods are considered valid options for safe, reliable and effective surgical management for 5th metacarpal neck fractures.

Ethical approval: Our study adhered to the principles of the Helsinki Declaration, and the Institutional Review Board at Al-Azhar Ethics Council of Al-Azhar University Hospitals, approved this research project. The registration number: Pat.3Med-Research-000003 was issued on 1/5/2022.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interests, patent/licensing, arrangement etc-) that might pose a conflict of interest in connection with the submitted article.

Author contributions: MAAI, BK, MA, MG: participated in data collecting and analysis, supervised the project, and contributed the basic idea, and study design. MAAI, MA, MG, MNA, LS, and MI: Responsible for manuscript writing. MAAI, MG, MI, ME and LS: Data analysis and collection. LS, MNA, ME and MI: Participated in statistical analysis. The contents and similarity index of the paper are the responsibility of all authors, who have critically examined and approved the final draft.

Declaration on the use of AI: The authors certify that neither the manuscript nor the photos were written or edited using AI technology.

Patients' consent to use their data and images: The authors certify that they obtained all required patient consent forms.

References

1. Cha SM, Shin HD. Antegrade Intramedullary Pinning in Subacute Fifth Metacarpal Neck Fracture After Failed Conservative Treatment: A Prospective Comparative Study with Acute Fracture. Ann Plast Surg. 2018;80(4):347-52. doi: 10.1097/SAP.0000000000001265.
2. Cotterell IH, Richard MJ. Metacarpal and phalangeal fractures in athletes. Clin Sports Med. 2015;34(1):69-98. doi: 10.1016/j.csm.2014.09.009.
3. Sletten NI, Nordsletten L, Husby T, Odegaard RA, Hellund JC, Kvernmo HD. Isolated extra-articular neck and shaft fractures of the 4th and 5th metacarpals: a comparison of transverse and bouquet (intra- medullary) pinning in 67 patients. J Hand Surg Eur. 2012;37(5):387-95. doi: 10.1177/1753193411431048.
4. Soong M, Got C, Katarincic J. Ring and little finger metacarpal fractures: mechanisms, locations, and radiographic parameters. J Hand Surg Am. 2010;35(8):1256-9. doi: 10.1016/j.jhsa.2010.05.013.
5. Cepni SK, Aykut S, Bekmezci T, Kilic A. A minimally invasive fixation technique for selected patients with fifth metacarpal neck fracture. Injury. 2016;47(6):1270–5. doi: 10.1016/j.injury.2016.01.034.
6. Yammine K, Harvey A. Antegrade intramedullary nailing for fifth metacarpal neck fractures: a systematic review and meta-analysis. Eur J Orthop Surg Traumatol. 2014;24(3):273–8. doi: 10.1007/s00590-013-1344-5.
7. Kim JK, Kim DJ. Antegrade intramedullary pinning versus retrograde intramedullary pinning for displaced fifth metacarpal neck fractures. Clin Orthop Relat Res. 2015;473(5):1747–54. doi: 10.1007/s11999-014-4079-7.
8. Pogliacomi F, Mijno E, Pedrazzini A, et al. Fifth metacarpal neck fractures: fixation with antegrade locked flexible intramedullary nailing. Acta Biomed. 2017 Apr 28;88(1):57-64. doi: 10.23750/abm.v88i1.6195.
9. Franssen BB, Schuurman AH, Mink Molen A, Kon M. One century of Kirschner wires insertion techniques: a historical review. Acta Orthop Belg 2010;76(1):1-6. PMID: 20306956.
10. Lieber J, Härter B, Schmid E, Kirschner HJ, Schmittenbecher PP. Elastic stable intramedullary nailing (ESIN) of pediatric

metacarpal fractures: experiences with 66 cases. Eur J Pediatr Surg. 2012;22(4):305–10. doi: 10.1055/s-0032-1313339.
11. Shen K, Cai H, Wang Z, Xu Y. Elastic stable intramedullary nailing for severely displaced distal tibial fractures in children. Medicine (Baltimore). 2016;95(39):e4980. doi: 10.1097/MD.0000000000004980.
12. Berkman EF, Miles GH. Internal fixation of metacarpal fractures exclusive of the thumb. J Bone Joint Surg. 1943;25(4):816–821, October 1943.
13. Toemen A, Midgley R. Hand therapy management of metacarpal fractures: an evidence-based patient pathway. Hand Therapy. 2010;15(4):87-93. doi: 10.1258/ht.2010.010018
14. Zong SL, Zhao G, Su LX, et al. Treatments for the Fifth Metacarpal Neck Fractures: A Network Meta-analysis of Randomized Controlled Trials. Medicine (Baltimore). 2016 Mar;95(11): e3059. doi: 10.1097/MD.0000000000003059.
15. Carole Johnson, Loren H. Engrav, David M. Heimbach, Janet A. Marvin, evaluating functional hand results after deep dermal bums with total active motion measurements. The Journal of Burn Care & Rehabilitation. 1980;2(1):19–21. doi:10.1097/00004630-198011000-00004
16. Jester A, Harth A, Wind G, Germann G, Sauerbier M. Disabilities of the arm, shoulder and hand (DASH) questionnaire: determining functional activity profiles in patients with upper extremity disorders. J Hand Surg Eur 2005;30B:23–8. doi: 10.1016/j.jhsb.2004.08.008.
17. Alotaibi NM. Cross-cultural adaptation process and pilot testing of the Arabic version of the Disability of the Arm, Shoulder and Hand (DASH-Arabic). J Hand Ther 2010;15:80–6. doi:10.1258/ht.2010.010021
18. Delgado DA, Lambert BS, Boutris N, et al. Validation of Digital Visual Analog Scale Pain Scoring with a Traditional Paper-based Visual Analog Scale in Adults. J Am Acad Orthop Surg Glob Res Rev. 2018;2(3):e088. doi: 10.5435/JAAOSGlobal-D-17-00088.
19. Freeland A, Geissler W, Weiss A. Surgical treatment of common displaced and unstable fractures of the hand. Instr Course Lect.2002; 51:185–201. PMID: 12064103.
20. Yuanshi She and Youjia Xu. Treatment of fifth metacarpal neck fractures with antegrade single elastic intramedullary nailing. BMC Musculoskeletal Disorders.2017;18(1):238. doi: 10.1186/s12891-017-1592-3.
21. Langqing Z, Lulu Z, Xiaogang M, Yunfeng C, Weiguo L, Yuwen J. Single versus dual elastic nails for closed reduction and antegrade intramedullary nailing of displaced fifth metacarpal neck fractures. Sci Rep 2021;11(1):1778. doi: 10.1038/s41598-021-81242-3.
22. Potenza V, Caterini R, De Maio F, Bisicchia S, Farsetti P. Fractures of the neck of the fifth metacarpal bone. Medium-term results in 28 cases treated by percutaneous transverse pinning. Injury.2012;34(2):242-5. doi: 10.1016/j.injury.2011.10.036.
23. Galanakis I, Aligizakis A, Katonis P, Papadokostakis G, Stergiopoulos K, Hadjipavlou A. Treatment of closed unstable metacarpal fractures using percutaneous transverse fixation with Kirschner wires. Journal of Trauma. 2003 Sep;55(3): 509–513. doi: 10.1097/01.TA.0000029368.40479.A2. PMID: 14501895.
24. Wang K, Du W, Deng C, Hu N, Zhuang W. Treatment of fifth metacarpal neck fracture in adolescents with minimally invasive surgery: percutaneous Kirschner wire fixation versus elastic stable intramedullary nailing. Journal of International Medical Research. 2023;51(5). 3000605231174981. doi: 10.1177/03000605231174981.
25. Winter M, Balaguer T, Bessie' re C, Carles M, Lebreton E. Surgical treatment of the boxer's fracture: transverse pinning Versus intramedullary pinning. J Hand Surg Eur.2007;32(6): 709–13. doi: 10.1016/J.JHSE.2007.07.011.
26. Wong TC, Ip FK, Yeung SH. Comparison between percutaneous transverse fixation and intramedullary K-wires in treating closed fractures of the metacarpal neck of the little finger. J Hand Surg Br 2006; 31(1): 61-5. doi: 10.1016/j.jhsb.2005.06.022.
27. Khan J, Shrestha SK, Pradhan NM, Acharya BK, Khanal P. Percutaneous K wire fixation of fifth metacarpal neck fracture-new and simple technique. J Nepal Health Res Counc. 2012;10(1):61-5. PMID: 22929640.
28. Kasman UO, Turemis C, Surucu S, Korkmaz Ö. Alternative Surgical Treatment Method for 5th Metacarpal Neck Fractures: Comparison of Clinical Outcomes of Intramedullary and Transverse K-Wire Fixations with Additional Antirotational K-Wire. Acta Chir Orthop Traumatol Cech. 2024;91(4):229-233. doi: 10.55095/ACHOT2024/030.