



Comparison of intramedullary nailing and plate fixation in the surgical treatment of isolated fractures of the distal two-thirds of ulna diaphysis

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Wrist and distal forearm are vulnerable to major injuries which may result in lifelong dysfunction as well as psychological, economic, and social consequences.^[1] Isolated fractures of the distal third of the ulna diaphysis (are extremely uncommon injuries; and there is a high possibility of complications, primarily delayed healing.^[2] Current treatments remain a matter of debate, but conservative treatment is at the forefront for non-displaced fractures.^[3,4] Surgery is recommended to prevent rotation restriction, if there is >50% displacement and >10° angulation.^[5,6]

In the surgical treatment of isolated fractures of the distal third of the ulna diaphysis, various fixation methods have been described, including Kirschner wires (K-wire), tension bands,

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ABSTRACT

Objectives: This study aims to compare the clinical and radiological results of intramedullary nailing and plating, which are both techniques utilized frequently in the surgical treatment of isolated fractures of the distal third of the ulna diaphysis.

Patients and methods: Between January 2010 and December 2016, a total of 54 patients (34 males, 20 females; mean age: 37.8±7.4 years; range, 22 to 56 years) with isolated fractures of the distal third of the ulna diaphysis were retrospectively analyzed. The patients were divided into those treated with locking plates (Plating group, n=25) and those treated with intramedullary nailing (IMN group, n=29). The operating time and clinical and radiological results were compared between the groups.

Results: The median follow-up time was 93 (range, 84.5 to 99.5) months in the Pg and 86 (range, 80 to 97) months in the IMNg (p=0.179). No significant difference was observed between the groups in respect of age, sex, trauma mechanism, fracture classification, smoking status, and time from trauma to surgery. The median operating time was 46 min in the Pg and 33 min in the IMNg (p<0.001). No significant difference was found in the postoperative length of stay in hospital, reduction quality, infection rates, clinical results, radiological results, and the Quick Disabilities of the Arm, Shoulder, and Hand (Quick DASH) score between the groups. Implant removal was only needed in the locking plate group (p=0.007).

Conclusion: In the surgical treatment of isolated fractures of the distal third of the ulna diaphysis, locked IMN seems to be a good alternative to the plate method with a shorter operating time and less need for implant removal.

Keywords: Fracture healing, intramedullary nailing, plating, ulnar shaft fracture.

intraosseous cabling, and plate-screw fixation.^[7] Of these surgical treatments, plate-screw fixation is the primary option.^[5] Although new-generation locking intramedullary nailing (IMN) is widely used in the treatment of several long bone diaphyseal region fractures, the results have not been reported

for isolated fractures of the distal third of the ulna diaphysis.

In the present study, we aimed to compare the clinical and radiological outcomes of plate fixation and locking IMN in the treatment of isolated fractures of the distal third of the ulna diaphysis.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Ümraniye Training and Research Hospital, Department of Orthopedics and Traumatology between January 2010 and December 2016. A total of 117 patients who were operated for isolated ulna fractures were screened. Of the patients, 54 (34 males, 20 females; mean age: 37.8 ± 7.4 years; range, 22 to 56 years) who met the inclusion criteria were enrolled. Anteroposterior and lateral radiographs of the cases were evaluated before surgery. Wrist and elbow radiographs were also evaluated to determine whether there was damage to the radioulnar joint complex. The fractures included in the study were those in the distal two-thirds of the ulna according to the definition of Corea et al.^[8] The cases were classified according to the AO classification. No neurovascular symptoms were observed in any of the cases preoperatively.

Surgical technique

In our clinic, the decision for surgery in cases of isolated fractures of the distal third of the ulna diaphysis is made, if there is $>50\%$ displacement and $>10^\circ$ angulation. The treatment selected was at the discretion of the surgeon. Plate-screw fixation (Trumed 3.5 mm locking ulna plate, Istanbul, Türkiye) (Figure 1) or locking IMN (TST Union Medical Devices Istanbul, Türkiye) (Figure 2) was used in the treatment of these fractures.

All cases were operated by the same surgeon, one or two days after the trauma. In patients for whom plate fixation was selected to ensure stability, screw fixation was performed in each main fragment with at least six cortices corresponding to three bicortical screws. First, non-locking screws were applied to both main fragments and compression was done, if necessary. Then, locking screws were used. No lag screw was applied. In all cases, the plate was placed on the dorsolateral aspect of the ulna.

The amount of displacement of the fracture had no bearing on the decision to utilize IMN. The diameter of the nail was measured using a fluoroscope. Nails with a diameter of 3.5 mm, 4 mm, 4.5 mm, 5 mm,



FIGURE 1. Plate-screw fixation in a distal ulna fracture.



FIGURE 2. Intramedullary nail fixation in a distal ulna fracture.

and 6 mm were used. Nail length was determined by measuring the ulna length of the opposite extremity. Nails with diameters of 220 mm, 240 mm, 260 mm, and 280 mm were used. Two locking screws were applied, one proximal and one distal. Open reduction or percutaneous reduction maneuvers were not performed in any of the patients who underwent locking IMN. All of the cases in this group were closed-reduced.

No postoperative immobilization with plaster or a splint was performed, and the follow-up was done by the operating surgeon. Wrist and elbow movements were allowed from the first postoperative day.

The patients were accordingly divided into a Plating group (n=25) and an IMN group (n=29). The criteria defined by Gaumé et al.^[9] were used to evaluate the adequacy of the fracture reduction on the first postoperative radiograph. Fracture classification was made according to the 2018 AO Foundation/Orthopaedic Trauma Association (AO/OTA) fracture classification summary.^[10,11] The operating times were compared between the groups.

Clinical and radiological assessment

Direct radiographs were taken on postoperative Day 1, at six weeks; at three, six, and 12 months; and at the final follow-up. The outpatient follow-up of the cases was performed by the operating surgeon. Fracture healing was evaluated as trabeculation and callus formation visualized in the fracture line on the anteroposterior and lateral radiographs, the absence of pain on palpation of the fracture line, and absence of pathological movement.^[12]

No visual fracture healing and no verification on computed tomography scans within the first three months was evaluated as delayed union, and union not occurring within six months, as non-union. At the final follow-up, functional results were evaluated according to the classification of Altner and Hartmann^[13] after one year. In comparison with the contralateral extremity, the following evaluations were made: excellent, at least 90% preservation of forearm rotation, and elbow and wrist function; good, 70 to 90% preservation of forearm rotation, and elbow and wrist function; poor, <70% preservation of forearm rotation, and elbow and wrist function. At the final follow-up, the Quick Disabilities of the Arm, Shoulder, and Hand (Quick DASH) questionnaire was used to compare clinical outcomes.^[14]

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Continuous variables were expressed in mean \pm standard deviation (SD) or median (25th-75th percentile), while categorical variables were expressed in number and frequency. Conformity of quantitative variables to normal distribution was assessed with the Kolmogorov-Smirnov test. Comparisons of independent groups of variables with normal distribution were made with the independent samples t-test, and variables not showing normal distribution were compared with the Mann-Whitney U test. Relationships between categorical variables were examined with the chi-square analysis. A *p* value of <0.05 was considered statistically significant.

RESULTS

Of a total of 54 patients, 25 were in the Plating group and 29 were in the IMN group. No significant difference was observed between the groups in respect of age, sex, follow-up time, affected side, trauma mechanism, fracture classification, smoking status, and time from trauma to surgery ($p=0.177$, $p=0.668$, $p=0.179$, $p=0.514$, $p=0.493$, $p=0.421$, $p=0.704$, and $p=0.554$, respectively) (Table I). According to the AO classification, in the Plating group, 19 cases were 2U2A (A1: 3, A2: 9, A3: 7), and six were 2U2B (B2: 4, B3: 2); the IMN group cases were classified as 18 of 2U2A (A1: 4, A2: 8, A3: 6) and 11 cases of 2U2B (B2: 7, B3: 4).

The operating time was significantly lower in the IMN group (range, 31 to 37 min) than the Plating group (range, 37 to 60.5 min) ($p<0.001$). No difference was found between the groups in respect of postoperative length of stay in hospital, reduction quality, infection rates, radiological results, clinical results, and the Quick DASH score ($p=0.324$, $p=0.513$, $p=0.093$, $p=0.210$, $p=0.546$, $p=0.229$, respectively). No postoperative vascular and nerve problems were observed in either group. Wound site infection

developed in three cases in the Plating group, all of which were successfully treated with antibiotics. No implant failure was seen in any case.

In six Plating group cases, the implant was removed, as it caused irritation; none of the IMN group implants were removed ($p=0.007$) (Table II). All the implant removals were performed after one postoperative year. No union problems or refractures were observed in any patient who underwent implant removal.

DISCUSSION

In this study, in which the clinical and radiological results were compared of the locking IMN and plate-screw techniques applied to isolated fractures of the distal third of the ulna diaphysis, locking IMN was determined to be more advantageous than plate-screw fixation as the operating time was shorter, there was less need for implant removal, and fewer complications. Few studies have compared these two techniques in all ulna shaft fractures.^[15] Our study can be considered of value, as there are no others that have compared the two techniques in isolated fractures of the distal third of the ulna diaphysis.^[16]

TABLE I
Comparison of variables between two groups

Variables	Plating group (n=25)					IMN group (n=29)					p
	n	%	Mean±SD	Median	Min-Max	n	%	Mean±SD	Median	Min-Max	
Age (year)			36.3±7.4			39.0±7.4					0.177
Sex											0.668
Male	17	68				17	58.6				
Female	8	32				12	41.4				
Follow-up time (month)				93	84.50-99.50				86	80-97	0.179
Side											0.514
Right	16	64				22	75.9				
Left	9	36				7	24.1				
Trauma mechanism											0.493
Fall	15	60				14	48.3				
Blow	5	20				5	17.2				
Motor vehicle accident	5	20				10	34.5				
AO classification											0.421
2U2A	19	76				18	62.1				
2U2B	6	24				11	37.9				
Smoker											0.704
Yes	9	36				13	44.8				
No	16	64				16	55.2				
Time from trauma to surgery (day)				2	2-3				2	1-3	0.554

SD: Standard deviation; IMN: Intramedullary nail.

TABLE II
Comparison of clinical and radiological results between groups

Variables	Plating group (n=25)				IMN group (n=29)				p
	n	%	Median	Min-Max	n	%	Median	Min-Max	
Surgery time (min)			46	37-60.50			33	31-37	<0.001
Reduction quality									0.513
Anatomical	15	60			14	48.3			
A near anatomical	7	28			13	44.8			
Non-anatomic	3	12			2	6.9			
Postoperative hospital stay (days)	1	1-1					1	1-1	0.324
Infection									0.093
Yes	3	12			0	0			
No	22	88			29	100			
Radiological									0.210
Fracture healing	23	92			29	100			
Delayed union	2	8			0	0			
Functional									0.546
Excellent	18	72			20	69			
Good	8	24			9	31			
Poor	1	4			0	0			
Quick DASH			10	4.50-13.05			4.50	2.30-11.40	0.229
No implant failure	25	100			29	100			-
Implant removal									0.007
Yes	6	24			0	0			
No	19	76			29	100			

IMN: Intramedullary nail; DASH: Quick Disabilities of the Arm, Shoulder, and Hand.

In the literature, a recent study compared locking IMN with plate-screw fixation in isolated fractures of the distal third of the ulna diaphysis and, according to the Grace-Eversmann score, similar and satisfactory results were obtained in both groups: excellent/good results in 76% of the IMN group and in 86% of the plate group.^[17] The time to union was reported to be a mean of 12 weeks in the IMN group and 13 weeks in the plate group. Although there was no statistically significant difference, the time to union was approximately one week shorter in the IMN group. In a study of forearm double fractures by Zhang et al.^[18] in 2016, hybrid fixation was applied with locking IMN to the ulna and a plate to the radius and, compared to other combinations, improved biomechanical stability was obtained. Additionally, together with a reduction in complications, better functional results were achieved using this hybrid fixation. Although non-union was not observed in any of the other combinations, in the hybrid plate group, non-union or delayed union was reported in three of 21 fractures. Gao et al.^[19] treated forearm diaphyseal fractures with locking IMN and reported

good or excellent results according to the Grace-Eversmann score in 16 of 18 patients, with a mean time to union of 10 weeks. In two cases with IMN applied to the ulna, the distal screws were removed due to screw loosening, but no union problems occurred in either case. Furthermore, the Altner and Hartmann^[13] classification was used to evaluate the functional results, and excellent/good results were obtained in 83% of the IMN group and in 90% of the plate group. Although there was no statistically significant difference in the radiological results, delayed union was seen in two (12%) cases in the Plating group. The results obtained in the current study are consistent with these previous findings in respect of fracture union. Similar and satisfactory clinical results were obtained both functionally and radiologically in both groups.

Plate fixation has significant advantages in forearm fractures, such as providing a stable fixation, preventing rotation, and improved reduction quality.^[20] The plate method is known to damage the soft tissue, disrupt the blood flow in the fracture

line, and increase the risk of infection.^[21] One of the important advantages of nailing is the use of closed reduction. In particular, in the distal ulnar region, the tendons and triangular structure of the ulna cause difficulties in plate-screw application techniques, irritation to the surrounding structures, and pain.^[22]

Bansal^[23] reported the results of 12 patients operated upon using locking IMN due to radius or ulna shaft fractures, and found that the IMN method was a good alternative to plate fixation due to the possibility for closed reduction, a smaller surgical scar, shorter time to union, and lower costs. In the study by Bansal,^[23] the nails were removed after bone consolidation in 25% of cases, but the reasons for removal of the implant were not specified. It is possible that the implants were removed due to the design of the locking screws and loosening. In another study by Gaumé et al.,^[9] plate and IMN techniques were compared in mid- and distal ulna fractures, and satisfactory clinical and radiological results were obtained in both groups. The K-wires were used as the intramedullary implant, and excellent results were reported in 19/27 (71%) of patients in the IMN group and in 22/27 (81%) of the plate group.^[9] The disadvantage of intramedullary fixation without locking is that it is difficult to obtain rotational stability. However, non-union or delayed union was not determined in any case. Another disadvantage of the use of K-wires is that it creates the need for a second operation in approximately 70% of cases. Of the cases where a plate was applied, the implant was removed in 43% of cases. Refracture was not observed in any case after implant removal. In the current study, nails with options for proximal and distal locking were compared with plate-screw osteosynthesis. The implant was removed after plate application due to symptomatic irritation of subcutaneous tissue in six patients, but there was no need for implant removal in any of the IMN cases.

An important study reporting the results of surgery using the same nail design was conducted by Kibar and Kurtulmuş.^[17] In their study, the mean follow-up time was 29.8±13.2 months in the plate group and 21.6±7.6 months in the IMN group. It was reported that implant removal was not performed due to irritation in any of the patients who underwent nailing during the follow-up period. In our study, the median follow-up period was 93 months in the nail group and 86 months in the plate group, making this study the longest follow-up period. Our study is particularly

important, as it was performed in distal two-part ulna fractures with less soft tissue coverage and reports long-term results. The fact that no implant removal was performed in any patient with long-term nailing is seen as an important advantage compared to plate-screw fixation.

Refracture after plate removal has been reported in the literature at a rate of approximately 4%, but there are also studies stating much higher rates.^[24,25] In the current study, no refracture was seen in any case after the plate was removed. In this context, the reduced need for implant removal with the use of IMN provides a greater advantage compared to the use of K-wire and plate. Although no rotation or union problems were seen in the study by Gaumé et al.,^[9] it can be speculated that more stable fixation is provided with locking nails. The low rate of second operations in the current study may reduce costs, but there was no cost analysis conducted between the groups in this study.

Saka et al.^[26] reported the median operating time to be 20 min in the application of locking IMN for ulna diaphyseal fractures. Kibar and Kurtulmuş^[17] compared locking IMN and plate fixation, and found a mean operating time of 30 min in the IMN group and 46 min in the plate group. Gaumé et al.^[9] reported a mean operating time of 18±6 min in ulna fractures treated with IMN and 29±5 min, when fixation was made with a plate and screws. In this study, the median operating time was calculated as 33 min for cases treated with IMN and 46 min for plate-screw fixation. The shorter operating time can be regarded as another reason for the selection of IMN in the treatment of ulna fractures.

Nonetheless, this study has some limitations. First, it has a single-center, retrospective design with a relatively small sample size. Second, there is a need for a significant amount of fluoroscopy in the IMN technique.^[27] However, due to the lack of data regarding fluoroscopy use in patients treated with IMN, no statistical analysis could be made. Finally, another limitation is the inability to compare the amount of bleeding between the two groups for similar reasons.

In conclusion, there continue to be difficulties in the treatment of isolated fractures of the distal third of the ulna diaphysis due to the different anatomy of the distal ulna and poor soft tissue coverage. With a shorter operating time and less need for implant removal, locking IMN seems to be a good alternative to the plate-screw method of fixation in these fractures.

Ethics Committee Approval: The study protocol was approved by the Ümraniye Training and Research Hospital Clinical Research Ethics Committee (date: 16.12.2021, no: 00154852323). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept and design, references and fundings, materials, writing the article: A.S., O.P.; Data collection and/or processing, literature review, critical review: A.S.; Analysis and/or interpretation and control/supervision: O.P.

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REFERENCES

- Wang F, Zhang R, Liu S, Ruan H, Xu J, Kang Q. Severe spaghetti wrist injury: Should we expand the terminology from wrist to proximal forearm? *Jt Dis Relat Surg* 2022;33:273-84. doi: 10.52312/jdrs.2022.652.
- Pollock FH, Pankovich AM, Prieto JJ, Lorenz M. The isolated fracture of the ulnar shaft. Treatment without immobilization. *J Bone Joint Surg [Am]* 1983;65:339-42.
- Atkin DM, Bohay DR, Slabaugh P, Smith BW. Treatment of ulnar shaft fractures: A prospective, randomized study. *Orthopedics* 1995;18:543-7. doi: 10.3928/0147-7447-19950601-06.
- Coulibaly MO, Jones CB, Sietsema DL, Schildhauer TA. Results of 70 consecutive ulnar nightstick fractures. *Injury* 2015;46:1359-66. doi: 10.1016/j.injury.2015.02.012.
- Mackay D, Wood L, Rangan A. The treatment of isolated ulnar fractures in adults: A systematic review. *Injury* 2000;31:565-70. doi: 10.1016/s0020-1383(00)00051-6.
- Pearce PK, Der Tavetain A, Handoll HH. Interventions for isolated diaphyseal fractures of the ulna in adults. *Cochrane Database Syst Rev* 2000;(2):CD000523. doi: 10.1002/14651858.CD000523.
- Dennison DG. Open reduction and internal locked fixation of unstable distal ulna fractures with concomitant distal radius fracture. *J Hand Surg Am* 2007;32:801-5. doi: 10.1016/j.jhsa.2007.03.010.
- Corea JR, Brakenbury PH, Blakemore ME. The treatment of isolated fractures of the ulnar shaft in adults. *Injury* 1981;12:365-70. doi: 10.1016/0020-1383(81)90004-8.
- Gaumé M, Descamps J, Donadio J, Rousseau MA, Boyer P. A comparative study of fixation methods in adults with two-thirds distal isolated ulnar shaft fractures with a minimum of 2 year follow-up. *Injury* 2020;51:964-70. doi: 10.1016/j.injury.2020.02.085.
- Marsh JL, Slongo TF, Agel J, Broderick JS, Creevey W, DeCoster TA, et al. Fracture and dislocation classification compendium - 2007: Orthopaedic Trauma Association classification, database and outcomes committee. *J Orthop Trauma* 2007;21(10 Suppl):S1-133. doi: 10.1097/00005131-200711101-00001.
- Meinberg EG, Agel J, Roberts CS, Karam MD, Kellam JF. Fracture and dislocation classification compendium - 2018. *J Orthop Trauma* 2018;32 Suppl 1:S1-170. doi: 10.1097/BOT.0000000000001063.
- Grace TG, Eversmann WW Jr. Forearm fractures: Treatment by rigid fixation with early motion. *J Bone Joint Surg [Am]* 1980;62:433-8.
- Altner PC, Hartmann JT. Isolated fractures of the ulnar shaft in the adult. *Surg Clin North Am* 1972;52:155-70. doi: 10.1016/s0039-6109(16)39640-2.
- Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: The DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). *Am J Ind Med* 1996;29:602-8. doi: 10.1002/(SICI)1097-0274(199606)29:6<602::AID-AJIM4>3.0.CO;2-L.
- Boussouga M, Bousselmame N, Lazrek K, Taobane H. Surgical management of isolated fractures of the ulnar shaft. *Acta Orthop Belg* 2002;68:343-7. French.
- Atik OŞ. Which articles do the editors prefer to publish? *Jt Dis Relat Surg* 2022;33:1-2. doi: 10.52312/jdrs.2022.57903.
- Kibar B, Kurtulmuş T. Treatment of adult isolated ulnar diaphyseal fractures: A comparison of new-generation locked intramedullary nail and plate fixation. *Eklem Hastalik Cerrahisi* 2019;30:246-51. doi: 10.5606/ehc.2019.66344.
- Zhang XF, Huang JW, Mao HX, Chen WB, Luo Y. Adult diaphyseal both-bone forearm fractures: A clinical and biomechanical comparison of four different fixations. *Orthop Traumatol Surg Res* 2016;102:319-25. doi: 10.1016/j.otsr.2015.11.019.
- Gao H, Luo CF, Zhang CQ, Shi HP, Fan CY, Zen BF. Internal fixation of diaphyseal fractures of the forearm by interlocking intramedullary nail: Short-term results in eighteen patients. *J Orthop Trauma* 2005;19:384-91. doi: 10.1097/01.bot.0000157911.76433.db.
- Schulte LM, Meals CG, Neviasser RJ. Management of adult diaphyseal both-bone forearm fractures. *J Am Acad Orthop Surg* 2014;22:437-46. doi: 10.5435/JAAOS-22-07-437.
- Rodriguez-Merchan EC, Gomez-Castresana F. Internal fixation of nonunions. *Clin Orthop Relat Res* 2004;(419):13-20. doi: 10.1097/00003086-200402000-00004.
- Shaerf DA, Chae WJ, Sharif-Razavian R, Vardakastani V, Kedgley AE, Horwitz MD. Do "anatomic" distal ulna plating systems fit the distal ulna without causing soft tissue impingement? *Hand (N Y)* 2022;17:506-11. doi: 10.1177/1558944720930302.
- Bansal H. Intramedullary fixation of forearm fractures with new locked nail. *Indian J Orthop* 2011;45:410-6. doi: 10.4103/0019-5413.83760.
- Hidaka S, Gustilo RB. Refracture of bones of the forearm after plate removal. *J Bone Joint Surg [Am]* 1984;66:1241-3.
- Deluca PA, Lindsey RW, Ruwe PA. Refracture of bones of the forearm after the removal of compression plates. *J Bone Joint Surg [Am]* 1988;70:1372-6.
- Saka G, Sağlam N, Kurtulmuş T, Özer C, Uğurlar M, Akpınar F. Interlocking intramedullary ulna nails in isolated ulna diaphyseal fractures: A retrospective study. *Acta Orthop Traumatol Turc* 2013;47:236-43. doi: 10.3944/aott.2013.3021.
- Azboy I, Demirtaş A, Alemdar C, Gem M, Uzel K, Arslan H. A newly designed intramedullary nail for the treatment of diaphyseal forearm fractures in adults. *Indian J Orthop* 2017;51:697-703. doi: 10.4103/ortho.IJOrtho_79_16.