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A Dual Center Experience with a Locking Intramedullary Nail for Wrist Fusion

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Abstract

Background In aggregate, there is varied efficacy for total wrist fusion (TWF) with a locking intramedullary (IM) nail which indicates the need for further investigation. It remains unclear whether preparation of the third carpometacarpal joint (CMCJ) will reduce the risk of complications including distal screw loosening.

Purpose Our objectives were (a) to report clinical outcomes for wrist arthrodesis using a locking IM nail and (b) to determine whether maintenance of the native third CMCJ articulation would contribute to short-term complications.

Patients and Methods A chart review from 2010 to 2022 was performed at two institutions for cases of TWF fixed with the IMPLATE locking nail (Skeletal Dynamics, Miami, FL). Clinical and radiographic outcomes were collected.

Results Radiographic union was achieved in 93.8% of cases, including one case of delayed union. The mean patient-rated wrist evaluation score was 30.4, the mean visual analog scale score for pain at rest was 1.7, and the mean visual analog scale score during activities of daily living was 3.2. There were seven cases of distal screw loosening (21.8%), and three cases of revision surgery (9.4%) which included two implant removals. A long radial nail was used in 24 (75%) of cases and a short metacarpal nail was used in 3 (9%) cases.

Conclusion The current series demonstrated satisfactory function with low rates of revision surgery following IM nail TWF without inclusion of the third CMCJ into the fusion mass. Cases with distal screw loosening had variable clinical presentation and our current practice is to offer outpatient screw removal for cases which reach the threshold for intervention.

Level of Evidence IV retrospective series.

Keywords
- intramedullary nail
- radiocarpal fusion
- wrist arthritis
- wrist arthrodesis
- wrist fusion

Total wrist fusion (TWF)—radiocarpal fusion—is a common surgical treatment for end-stage wrist arthritis. The elimination of motion via fusion provides pain relief which is the primary goal of surgical treatment. Patients have indicated that pain may be more detrimental to function than loss of wrist motion.[1]

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Union rates in TWF are variable, in part due to the wide variety of techniques and devices.[2] However, the collective results have demonstrated consistency for pain relief. Cavaliere and Chung[3] performed a systematic review comparing TWF ($N = 860$) to total wrist arthroplasty (TWA; $N = 503$). The results showed higher rates of major complication and lower rates of patient satisfaction following arthroplasty compared with arthrodesis. These findings were concordant with the review by Zhu et al[4] who reported higher rates of complication in TWF compared with TWA in rheumatoid arthritis (RA) patients.

Common TWF fixation methods include Kirschner wires, dorsal plates, and intramedullary (IM) nails. Dorsal plates provide a stable construct but are in close proximity to the extensor tendons which increases the risk of tendon complication. IM nails offer a minimally invasive fixation option that do not carry the risk for extensor tendon irritation. Further, recovery may be expedited due to minimal soft tissue insult. Orbay et al[5] reported the initial series for the IMPLATE locking nail ($N = 7$), with 100% union and satisfactory pain relief. Walker et al[6] reported 100% union with this device ($N = 9$) but 33% had distal screw migration. Samade et al[7] compiled the largest series to date ($N = 19/38$ cases) reporting implant-related complications in 55% of cases with 13% requiring reoperation. In aggregate, there is varied efficacy for this locking IM nail which indicates the need for further investigation. Inconsistency in outcomes may be due to implant design factors, implant application factors, and individual case details.

There continues to be debate for appropriate management of the third carpometacarpal joint (CMCJ) in TWF. The series by Orbay et al[5] included the third CMCJ in the fusion mass in all cases which resulted in no reoperations. Onuma et al[8] reported that complications following IM nail TWF occurred in cases where third CMCJ had not united. The case report by Kachooei et al[9] postulated that motion at the third CMCJ may lead to distal screw migration in locking IM nail TWF. It remains unclear whether inclusion of the third CMCJ into the fusion mass will reduce the risk of complications including distal screw loosening.

Our objectives were (a) to report clinical outcomes for TWF using a locking IM nail and (b) to determine whether complications may be related to maintenance of the native third CMCJ.

Methods

Identification

A chart review from 2010 to 2022 (IRB# 1-1588149-1) was performed at two institutions for cases of TWF fixed with the IMPLATE locking nail (Skeletal Dynamics, Miami, FL). The population, intervention, comparison, outcome characteristics were the following:

- P: patients older than 18 years treated with TWF for all indications;
- I: the IMPLATE locking nail with a minimum of 4-month follow-up;
- C: with previously reported homogenized data;
- O: appropriate clinical outcome metrices and radiographic evaluation.

Cases were identified using procedure codes, thereafter records were scanned to determine the cases which aligned with the inclusion criteria.

Data Collection

Case details and outcomes' variables collected were patient age, indication for TWF, follow-up term, reoperations including any subsequent implant-related procedure, the patient-rated wrist evaluation (PRWE) score, a visual analog scale score for pain at rest (VASr) and visual analog scale score during activities of daily living (VASa). Radiographs were evaluated for bony union and implant-related changes. The criterion for radiographic union was greater than 50% bridging trabeculae across the fusion site on posteroanterior and lateral view.

Surgical Technique

A dorsal incision is used to open the second, third, and fourth extensor compartments, then the extensor pollicis longus is retracted radially. Thereafter extensor retinaculum is opened, and an H-shaped capsulotomy is oriented with the proximal "goalpost" across the radiocarpal joint and the distal goalpost across the midpoint slope of the capitate. The transverse incision is centered, connecting the goalposts. The joints are prepared for fusion according to surgeon's preference. A proximal row carpectomy is performed to provide bone graft and improve the mechanics of the fusion construct. A provided device is used to confirm sufficient space between the radius and the capitate. The distal entry point for the nail is at the base of the dorsal slope on the capitate. This optimizes the trajectory of the nail into the metacarpal canal. Cannulated reamers over a guidewire are used to prepare the canal for the metacarpal nail. The surgeon creates a trough for the proximal expansion of the nail, being sure to not perforate the dorsal cortex of the capitate.

Following nail insertion, the dorsal surface of the metacarpal is visualized then the distal locking screw is drilled, measured, and inserted. The entry point for the radial nail is centered on the radius in the coronal plane and slightly dorsal in the sagittal plane. The radial canal is prepared in similar fashion to the distal nail. Provisional fixation of the nail with a wire allows confirmation of position, then the locking screws are drilled, measured, and inserted. All three screws must remain incompletely tightened at this point. The nail system provides 0/7.5/15/22.5-degree connectors which allows the surgeon to determine the degree of extension and ulnar deviation. The spines along the connector fit into the proximal and distal nail and allow precise placement of the hand in space. The connector is placed into the metacarpal nail then into the radial nail. It is essential that complete seating of the connector splines into both nails is confirmed. The connector is locked with set screws and bone graft may be applied. After confirming that the nail

Table 1 Case details and outcomes from published reports and current series for total wrist fusion using a locking intramedullary nail

Report	Sample	Age (y)[a]	Follow-up (m)[a]	Union	Revision surgery[a]	DSL[a]	VAS[a]	PRWE[a]
Orbay, 2016	7	49[b]	6	100%	14%	0%	–	–
Walker, 2021	9	50	6.75	88.9%	33%	33%	–	–
Kachooei, 2021	3	80	10.2	100%	33%	100%	–	–
Samade, 2021	19/38	48	^37.5	73.7%	13%	21%	1.3	37.8
Current series	32	47	44.2	93.8%	9.6%	22%	1.7	30.4

Abbreviations: DSL, distal screw loosening; PRWE, patient-rated wrist evaluation; VAS, visual analog scale for pain.
[a]Age in years, follow-up in months, revision surgery includes secondary bone grafting procedures.
[b]Median.

connection is properly coupled and secured, the joint is manually compressed, and the proximal screws are tightened.

Results

The chart review yielded 44 cases, of which 12 were excluded for incomplete outcomes' scores (×9) and lack of adequate radiography (×3). The final series of 32 cases had a mean follow-up of 44.2 months and included 18 (56%) males (►**Table 1**). The most common indication for TWF across the series was posttraumatic arthritis (44%; ►**Table 2**). A long radial nail was used in 24 (75%) cases and a short metacarpal nail was used in 3 (9%) cases.

Radiographic union was achieved in 93.8% of cases which included one case of delayed union. The mean PRWE was 30.4, the mean VASr was 1.7, and the mean VASa was 3.2. There were two cases of radiographic nonunion, one of which was asymptomatic, and the patient was satisfied with the result. The other case of nonunion was symptomatic with continued pain but the patient refused surgical treatment. One case of delayed union which united following revision surgery with bone grafting. There were two implant removals (6.3%). One implant was removed at 8 months postoperatively in a patient with RA. There was no evidence of infection, and there was radiographic evidence of radiocarpal union. The patient presented with pain and swelling of undetermined cause that may have been secondary to the underlying condition. Another implant was removed at 13 months postoperatively due to discomfort during golf activity in a patient with clinical evidence of hyperlaxity. The patient reported no pain at rest and during activities of daily living and radiocarpal fusion was noted radiographically. The patient requested implant removal in hopes of reducing symptoms during golf. There were seven cases (21.8%) with distal screw loosening, of which three patients reported minimal discomfort (►**Fig. 1**). Two of the seven patients reported discomfort with extended activity that did not localize within proximity of the distal screw. Thus, these patients did not reach the threshold for screw removal. One patient is the previously described implant removal case. One patient reported diffuse pain and was dissatisfied with the result. There was radiographic evidence of radiocarpal union and distal screw loosening. Screw removal was offered but the patient was lost to further follow-up.

Discussion

The current results demonstrate satisfactory rates of radiographic union and clinical outcome scores following TWF with a locking IM nail. The PRWE scores indicate that satisfactory function can be attained when the hand is placed in a functional position despite the absence of wrist motion. A majority of the cases with distal screw loosening did not report consistent corresponding discomfort. However, this finding warrants monitoring as the long-term impact is unknown.

Patient reports describe pain relief as the primary expectation when deciding on surgical treatment for end-stage wrist arthritis. When presented with the treatment option of arthrodesis, patients often express concern for the limitations which may arise from the loss of wrist motion. The literature has demonstrated that the functional impairment following wrist fusion may not be as impactful as expected preoperatively.[10,11] There is an expectation for functional advantage following arthroplasty compared with TWF, but the literature displays inconsistency of postoperative function across the generations of wrist prostheses.[12] The aggregated results for arthrodesis have been predictable for pain relief which is the primary goal of surgical management.

There continues to be debate over the appropriate distal fixation in TWF. Fixation to the metacarpal bones is strong

Table 2 Case details for the retrospective series on total wrist fusion using a locking intramedullary nail

	Indication					Patient details	
	PTA	OA	RA	Arthritis	Other	Active smokers	Male
Current series	44%	22%	16%	9%	9%	16%	56%

Abbreviations: Arthritis, nonspecific arthritic condition; OA, primary osteoarthritis; PTA, posttraumatic arthritis; RA, rheumatoid arthritis.

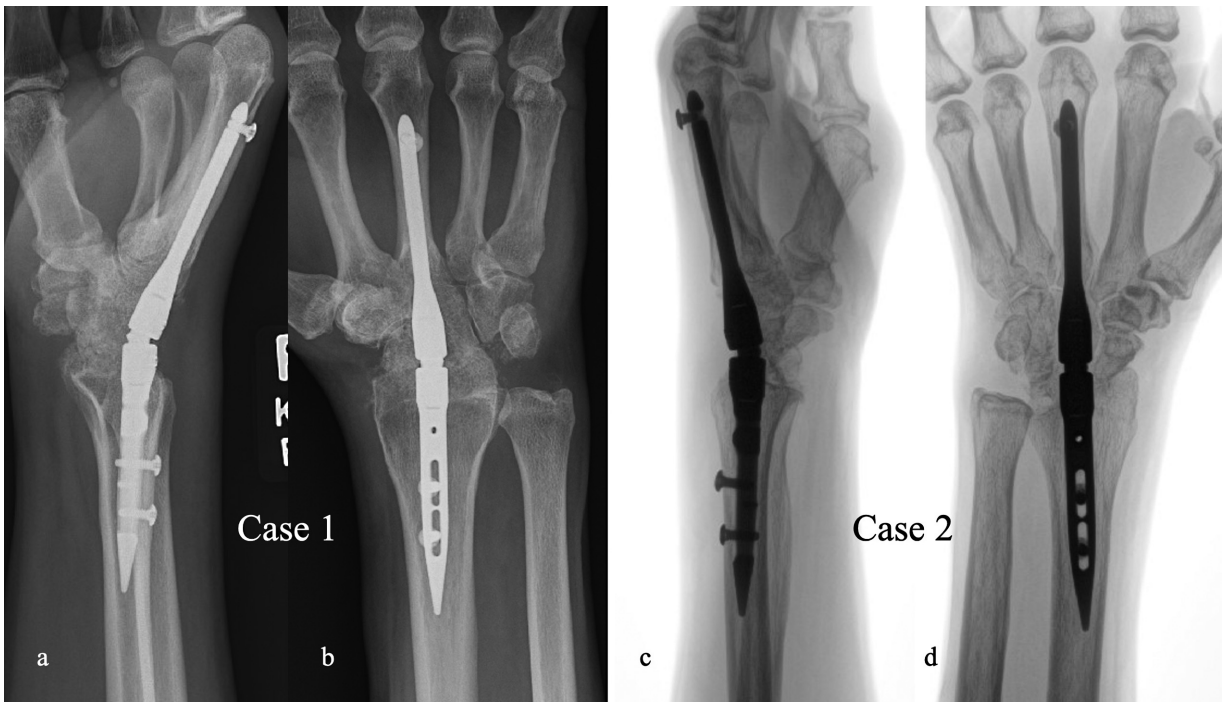

Fig. 1 Anteroposterior (**a, c**) and lateral (**b, d**) radiographs of total wrist fusion showing standard-length metacarpal nails and short-length radial nails. Of note, in case two, the distal screw has loosened from its fully seated position within the nail (**c, d**).

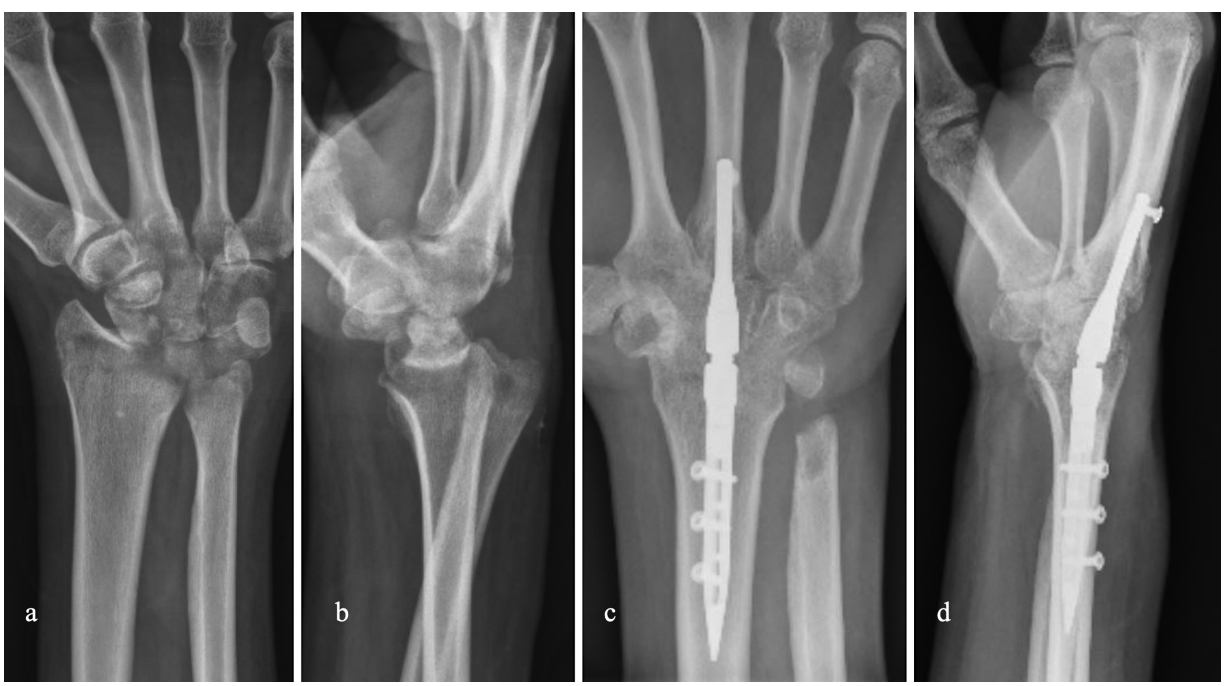

Fig. 2 Preoperative anteroposterior (**a**) and lateral (**b**) radiographs of infectious radiocarpal collapse and at 10 months postoperatively (**c, d**) following total wrist fusion with a short-length metacarpal nail and standard-length radial nail.

and reliable due to their cortical thickness but requires bridging a variably mobile third CMCJ. This motion may compromise the distal fixation over time. Fixation into the carpal bones obviates problems with the CMCJ but is less reliable due to the spongy nature of these bones and the shortened working length of the implant. Currently, there is no consensus for superiority of outcomes with or without fusion of the third CMCJ following TWF with an IM locking nail. In 2016, Orbay et al[5] reported 100% radiocarpal union across seven cases of IM nail TWA with the third CMCJ

incorporated into the fusion mass. In the studies by Walker et al[6] and Samade et al,[7] it was not clear whether the third CMCJ was included in the fusion mass. Walker et al[6] did report a symptomatic nonunion of the third CMCJ. This debate is also ongoing regarding plate fixation in TWF. In 2002, Nagy and Büchler [13] compared outcomes for dorsal plate TWF with ($N = 47$) and without ($N = 34$) preparation of the third CMCJ for fusion. Cases without third CMCJ fusion were temporarily bridged with the plate and demonstrated higher rates of pain relief compared with cases with third CMCJ fusion. In 2019, Hernekamp et al[14] reported similar clinical outcomes at more than 1-year follow-up for plate fixation that did and did not cross the third CMCJ. In 2022, Briotti et al[15] reported TWF union of 100% ($N = 23$) and a mean visual analog scale for pain of 1.3 using a novel CMCJ sparing plate. This design has an increased number of carpal fixation points compared with plates that span the third CMCJ. The authors surmised that exclusion of the third CMCJ from the construct may preserve grip strength and function.

The third CMCJ was not included in the fusion mass across the current series. Although our conclusions regarding the third CMCJ are limited due to lack of a control group, our experience is noteworthy. We agree with the postulate by Kachooie et al[9] that micromotion at the third CMCJ may contribute to distal screw loosening. Motion at the third CMCJ creates multiplanar forces which have the highest impact on the distal fixation given its distance from the motion site. This finding may be mitigated by a short metacarpal nail which was used infrequently in the current series (►**Fig. 2**). The reduced working length of nail minimizes the magnitude of motion at the distal screw. Although all cases of distal screw loosening occurred with long metacarpal nails, we were unable to derive meaningful inferences due to an inadequate sample of cases with short nails (9% of the series). The function of the distal screw is to facilitate compression at the radiocarpal fusion site. Thus, distal screw fixation is integral during the early postoperative period. Our current practice is to offer outpatient removal of the distal screw if there is radiographic evidence of loosening with corresponding symptomology. Sufficient evidence of radiocarpal union indicates that screw removal may be performed without risk of subsequent detriment. Our series demonstrated a variable clinical presentation of cases with distal screw loosening, with some cases not reaching the threshold for removal.

Limitations of this work included those that are inherent to retrospective reports including selection bias and recall bias. There was no accompanying preoperative data to determine the improvement that may be attributed to the procedure and the device. It is feasible that dissatisfied patients sought care elsewhere; thus, artificially improving the aggregate results. Although relatively small, the current sample size is one of the largest series to date and is reflective of the overall procedure volume. The use of a short metacarpal nail may reduce the incidence of distal screw loosening. However, due to an inadequate sample of this subset, statistical evaluation and reporting was not feasible. Our derived conclusion would be strengthened by comparison with a third CMCJ fusion control group.

Conclusion

The current series demonstrated satisfactory function with low rates of revision surgery following IM nail TWF without inclusion of the third CMCJ into the fusion mass. Cases with distal screw loosening had variable clinical presentation and our current practice is to offer outpatient screw removal for cases which reach the threshold for intervention.

Institutional Review Board

IRB# 1-1588149-1.

Note

This study and associated work was carried out at Miami Hand and Upper Extremity Institute and Center for Bone and Joint Disease.

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Conflict of Interest

F.R. discloses a consultant and speaker's bureau relationship with Skeletal Dynamics. J.J.H., R.J.R., O.G., and G.S.K. have nothing to disclose.

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