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Systematic Review

Functional Outcome Difference in Adult Patients With Distal Radius Fractures Treated with External Fixation Versus Closed Reduction and Casting: A Systematic Review

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Abstract
Introduction: *Distal radius fracture is one of the most common fractures treated by orthopedic surgeons. There are multiple alternatives for treating these fractures, such as operative fixation, and casting. Each treatment option has its own advantages and disadvantages, but the main goal is to help patients return to their preinjury level of function. The objective of this study was to review the literature to determine which treatment modality provides the best functional outcome for patients with distal radius fractures.*
Search methods: *Investigators searched COCHRANE, PUBMED, and EMBASE for randomized, and quasi-randomized control trials comparing closed reduction and external fixation, with closed reduction and casting. They evaluated patient-reported functional outcomes. Studies in languages other than English, prospective studies without randomization, and studies lacking assessment of patient-reported functional outcome measures were excluded*
Results- *Seven randomized control trials involving 869 patients with both intra-articular and extra-articular distal radius fractures were included. Patients' age ranged from 16 to 80 years. The studies showed considerable variations in the type of injury, treatment protocol, and outcome measurement tools. Three studies showed that operative treatment of distal radius fractures was beneficial, while two trials suggested that the choice between the two modalities should be made on an individual basis based on the benefits and potential complications. One study concluded that operative treatment of distal radius fractures is harmful to patients' function. The studies had some methodological weaknesses.*
Conclusion *–Based on the results of this study, there is no enough strong evidence in the literature to determine a difference in patient-reported functional outcomes among adult patients with distal radius fractures treated with external fixation versus closed reduction and casting. It is challenging to make recommendations on which treatment modality leads to better functional outcomes.*

Keywords- *distal radius, functional outcomes, external fixation, closed reduction casting*
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Introduction

Distal radius fractures are common fractures treated by orthopedic surgeons worldwide, accounting for 16% of all fractures. They have a bimodal distribution caused by high-energy injuries in the young and falls in the elderly population, which is increasing due to a rise in life expectancy of active elderly population with osteoporosis (1,2). Distal radius fractures include those within 3cm of the wrist joint. In adults older than 50 years old, they are the second most common fracture patterns next to hip fragility fractures (3). Additional risk factors include female sex, decreased bone density, and smoking (4). Despite their high prevalence, there is a lack of clear diagnostic and treatment protocol, resulting in frequently missed injuries, longstanding wrist pain, and disability (5).

The most common fracture pattern in the elderly is Colle's fracture which is a metaphyseal bone injury over the cortico-cancelous bone junction. It is characterized by dorsal angulation, radial tilt, radial translation, and metaphyseal impaction. Intra-articular fractures mostly occur in young adults with

high energy injuries with reticular displacement, and impaction (6). Patients sustain a spectrum of soft tissue injuries with a reported incidence of more than 30% in those recovering from distal radius fractures or surgery which causes persistent disability (7).

In the literatures, there are twenty classification systems for adult distal radial fractures with different inter-, and intra-observer reliability. The complexity of choosing the appropriate classification systems also stems from different definitions of acceptable reduction with various treatment modalities. In addition to this, there is no consensus on the most favorable treatment option for different varieties of distal radius fractures in adults (8). Variations exist due to various bone quality, differences in age of the patient, degree of soft tissue injury, and patient expectations for the future use of their hands (9,10). Treatment modalities vary from closed reduction with casting to surgical fixation methods including k-wire fixation, external fixations, various types of plate fixations, and intra-medullary rods (11). The current working agreement is to treat extra-articular distal radial fractures with closed reduction and casting, as it is less invasive and cheaper with a subsequent displacement ranging from 43-60% worse for older patients (12, 13). However, there is no evidence suggesting less invasive treatments will give patients acceptable functional outcomes with fewer complications (14). Orthopedic surgeons aim to achieve less than 5 degrees of radial inclination, restore radial height within 2-3mm of normal, neutral volar tilt, and less than 1 mm of articular surface step-off (15).

Outcomes after treatment were historically measured using physician-reported measures, including the degree of motion in the joints and imaging parameters, which were determined to be less important in understanding the overall patient satisfaction with the treatment and the overall functional status of the patients. Patient-reported outcomes are the standard for any follow-up of a certain treatment modality. Studies suggest that during the early post-treatment phase, patients focus on getting proper pain control, and in the long term focus on returning to work and the ability to do daily life activities (16).

The overall goal of treating these fractures is restoring the patient's pre-injury level of performance. The success of treatment modality is assessed using different outcome measuring tools. There are two types of functional outcome measures: performance-based outcome measures and patient-reported outcome measures. The rationale for conducting this review is to understand the evidence in the literature on the difference in patient-reported outcomes following treatment of distal radius fractures with two of the treatment options: external fixation and closed reduction casting. After analyzing the data, the authors hope to gain knowledge and provide suggestions on which treatment modality provides better functional outcomes. Commonly used tools for evaluation include questionnaires such as the Disabilities of the Arm, Shoulder and Hand Questionnaire (DASH), short form health survey (SF-36), and patient-rated wrist evaluation (PRWE) (17,18).

The objective of this study was to assess which group of patient populations are better treated with external fixation compared to casting by comparing the functional outcomes and complication rates of patients with in the two groups.

Methods

2.1 Searching strategy

Randomized controlled trials and quasi-randomized trials comparing functional outcomes of adult patients with any type of distal radius fractures treated with operative fixation, including external fixation with closed reduction, and casting for distal radius fractures of various severity and causes of injury were reviewed in this study. The following eligibility criteria were used for inclusion of published articles. The study needs to be randomized control trial comparing two treatment modalities, written in the English language, the full document must be available for review without any specification to the year of study and number of study participant**s**, and the studies must have at least 6 months of follow-up.

Literature searches were made in the online databases such as COCHRANE, EMBASE, and MEDLINE. Reference lists of index articles were also searched for additional information in Research-Gate, Science-Direct, and Google Scholar. The search strategy employed the use of key MeSH (medical subject headings) for every database, and articles with titles that corresponded to the study criteria were collected using the ZOTERO application, with the Google Chrome ex tension, for a repeat view by the coauthors.

2.2. Selection of studies

The titles and abstracts of retrieved studies have been reviewed for relevance, and the full-text versions of potentially relevant articles were then analyzed according to the inclusion criteria. We looked for additional references in the reference lists of all included studies. This review included English-language literatures, Trials comparing external fixation alone or with additional pin augmentation, and non-operative treatments, with additional treatment arms such as open reduction internal fixation, were included. Studies without randomization, and studies lacking assessment of patient-reported functional outcome measures were excluded.
The quality of the studies was appraised through Cochrane risk-of-bias (RoB 2) tool. Digital object identifiers (DOIs) were commonly used to search for original articles, and those studies whose full manuscripts were not available were excluded from the review. The researchers did not attempt to contact au-

thors to obtain new information or confirm published data. This review does not have an assigned registration or protocol number. Conference proceedings, textbooks, and guidelines were excluded from this review.

The primary outcome of the study is patients who have painless wrist motion with acceptable patient-reported functional outcomes. Functional outcome measures studied include the Musculoskeletal Function Assessment (MFA) instrument, *Jebsen-Taylor* Hand *Function* Test (JTHFT), and Michigan Hand Score (MHS). Pain assessment scales, range of motion measurements with a goniometer, dynamometer measurement of grip strength, and a combination assessment of patient-reported and physician-assessed outcome scores like the Mayo Wrist Score were also included**.** Data was extracted to a Microsoft Excel sheet by the Authors.

Results

All the included studies were written in the English language and spanned 32 years, with the earliest study in 1990 (19) and the latest study done in 2021 (20)**.** The total number of patients included was 896**.** In those studies where sex distribution was described, there was a female predominance with the highest covering 90% of the participants (21). The youngest patient age stated is 16 years (23). Two reasons mentioned as causes for injury were accidental falls and high-energy road traffic injuries. There was no description of the cause of injury for patients in two of the studies (19,20). Five of the studies were exclusive for extra-articular distal radius fractures (20,21,22,23,24), and one study had both intra and extra-articular fractures (19). Only three had a clear description of the radiologic parameters of fracture displacement for inclusion in the study.

Two of the studies had multiple arm trials including open reduction internal fixation with external fixation and casting (24). Three different methods of operative fixation - open reduction internal fixation, closed reduction pinning, and closed reduction external fixation were compared with casting (20). The other studies only included closed reduction with cast and external fixation. Methods of fixation were uniform across studies with all studies involving spanning external fixators, but there was a significant disparity in the type of external fixation device they used. The AO, Hoffman, Orthofix, Ace Colles, and Roger-Andersson were mentioned to be used in the stated studies.

There is a significant variation in the outcome measuring tools used by the studies (23) used a baseline functional assessment for all patients past skeletal maturity immediately upon arrival after an acute trauma using score MFA score and SF-36 questionnaires. The MFA scale is a self-reported health instrument designed to evaluate the status of patients with musculoskeletal extremity disorders (26). The short form has a longer functional index with 34 sections, and the bother index with 12 questions regarding how the loss of function has bothered patients in a wide range of disabilities with four subscales including upper and lower extremity dysfunctions, problems with daily activities, and mental and emotional problems (27). The SF-36 is a multi-scale with 8 sections addressing issues of limitations in physical and social activities, body pain, and mental health (28).

In three trials, patients' ability to perform daily activities like opening door knobs, turning, and using keys, as well as carrying objects was used to evaluate the extent of functional recovery after treatment (19,21,25). Sarmiento's modification of Gratland and Werley's score was also mentioned as a measure of functional outcome. It is a combination of patient and clinician reported outcomes, including range of motion, residual deformity, grip strength, nerve injury, finger stiffness, severity of arthritis, and subjective evaluation of the patients (22). The MHS is one of the most common patient-reported outcome measurement tools for pain, satisfaction with hand function, motion, strength, and aesthetics with proven reliability and validity (20,30,31). Patients' subjective assessment of residual wrist deformity and wrist function at the end of the follow-up period was also used as an outcome measurement tool (24). Patient satisfaction with the function of their wrist after treatment was classified in to four groups: poor, fair, good, and excellent without detailing what each group represents.

There is a discrepancy in the clinical or radiologic criteria used to treat fractures, and different exclusion criteria were used. These trials are analyzed based on the quality of their study designs and the risk of bias. All of the studies had improper blinding of assessors towards the patients' treatment assignment. The lack of blinding could lead to detection (measurement) bias, where assessors may be biased while checking outcome measures such as joint range of motion and grip strength. However, the nature of treatments can make it difficult to blind assessors effectively. Patients may have visible implants, radiologic evidence of their treatment, and surgical incisions that reveal the type of treatment they received. Even if patients arrive with their surgical sites covered, assessors would need to remove the coverings for a proper evaluation.

Blinding of investigators towards allocation of patients to treatment groups is a vital part of conducting trials as prior knowledge can lead investigators to consider prognostic factors in the decision-making, potentially introducing selection bias. Two studies mentioned the importance of blinded sur-

geons and assessors during the initial allocation of patients, a factor not addressed in other studies (20,23). Another important factor that will help minimize selection bias is ensuring baseline characteristics of patients are similar. Factors such as age, gender, fracture patterns, and mode of injury are listed in the studies included as being similar across treatment groups in the included studies. Blinding patients is also vital in randomized trials as patients' knowledge of other treatment options may create decreased enthusiasm and performance which in turn might negatively affect the outcome. Blinding is mentioned in the methodology of only some of the trials (20,23).

Results with no statistical significance are equally mentioned with all the significant findings in all studies included, which minimizes reporting bias where researchers are inclined to report statistically significance results and omit those that did not have strong evidence. Avoiding a reporting bias enables the review to reach to proper conclusion backed by the evidence provided. Intention to treat analysis is the concept of analyzing patients in the group they are initially assigned to, irrespective of the fact that they might receive different treatment at the discretion of the treating surgeon. The purpose of this analysis is to minimize the bias in determining the effectiveness of a certain treatment modality. Intention-to-treat as a guide to analysis was used in the two of the trials (20,23).

In one of the studies 37 patients all above the age of 60 years were randomized (19). Radiographic comparison of the residual displacement between external fixation, and cast treatment groups were similar with no significant variation. In addition, the final functional outcomes after a total of fifteen months of follow up were similar. Accordingly due to the failure to achieve a significantly better result use of an external fixator was discouraged for patients above 60 years of age with distal radius fractures. Another study randomized 113 skeletally mature patients with distal radius fracture from 16 to 75 years of age, without specification for the cause of trauma (23). After following the patients for two years, they had similar pain and upper extremity function among patients treated with cast and external fixation. In the first year postop, the function was closer to the normal, or uninjured side. Grip, pinch strength, and range of motion also showed similar patterns up to 2 years post injury. Radiological assessment revealed that the external fixation group had better restoration of distal radius length, and palmar tilt but these results did not reach statistical significance. They concluded that anatomical reduction is possible to be achieved with either of the treatment modalities, and patients who are treated have better function in the end, which did not prove to be a statistically significant difference.

A third trial followed 90 patients, with an average age of 39 years, for four years; 70% of the causes of injury were road traffic injuries (24). A statistically significant difference in grip strength was observed among the cast immobilization groups. Patients in the external fixation group showed better radiologic restoration of dorsal tilt and radial height. Among the three arms the least articular step-off was in the open reduction and internal fixation group, followed by external fixation. The functional outcomes were better with external fixation compared to open reduction internal fixation and cast immobilization, though this difference was statistically insignificant. The authors concluded that operative treatment of distal radius fractures is better for maintaining the reduction and recovering the articular anatomy with the least risk of arthritis. Therefore, it is the preferred choice of treatment for displaced and comminuted intra-articular distal radius fractures.

A trial that enrolled 32 patients aged between 55 and 80 years with unstable intra-articular distal radius fractures, followed them for one year. The results showed significantly better radio-carpal angle and radial inclination in the external fixation group, and better finger grip in the cast treatment group, although this difference was not statistically significant (21). The mean range of wrist flexion was also better in the external fixation group. Both groups reported similar levels of pain, with residual radiocarpal pain present in both groups at one year. Other patient-reported functional outcomes showed no difference between the two groups throughout the one-year follow-up period. The authors concluded that the patient's activity level before the injury should be considered when deciding on the modality of treatment, as those patients with limited function may be satisfied with just cast immobilization.

A 2003 trial involving 125 patients ranging from 16 to 75 years of age with extra-articular distal radius fractures has the longest follow-up of seven years in this review (25). Anatomically, there was significantly better radial length and angulations in patients treated with external fixation. However, results at one year and at the 7^{th}-year follow-up showed similar wrist range of motion and grip strength compared to the opposite side, with an equal functional outcome. The authors concluded that there were better radiologic and anatomic outcomes in patients treated with an external fixator compared to closed reduction and casting which was not significant after 7 years.

The most common complications among patients treated with an external fixator were pin site infection, superficial nerve injuries, Dupuytren's contracture, and pin site pain reaching up to 20% in one

study (19). Cast treatment had complications including joint stiffness, tendon rupture, and carpal tunnel syndrome. The complication mentioned as the most significant determinant of long-term outcome was reflex sympathetic dystrophy (21,23). There was no correlation between the final anatomic reduction after treatment and the risk of developing reflex sympathetic dystrophy, nor was there a correlation between the risk of developing carpal tunnel compression and the initial or post-treatment degree of fracture displacement according to (22).

Discussion

There is a great diversity among the trials included in this review on demographic factors and mode of injury. The age of participants ranged from 16 to 80 years. High-energy injuries from road traffic accidents, which are likely to cause more severe fracture patterns and more severe associated soft tissue injuries were also studied with low-energy fractures secondary to accidental falls within the same trial. The study periods ranged from 1990-2021, which might impact treatment outcomes across decades due to advancement of surgical procedures, implants, and patient optimization in recent years which might cause diversity in the expected patient outcomes. The study areas have more diversity spanning three continents: Europe, North America, Asia, and New Zealand.

Most of the studies included both intra-articular and extra-articular fractures. Although only a fraction of the trials included future risk of wrist joint arthritis which is likely to be affected by the involvement of the joint surface, the functional outcomes of patients may be influenced by the severity of initial injury. There was lack of clear classifications for mode of injury, that resulted in poor understanding of the best treatment for patients with low-energy distal radius fractures from accidental falls. The patient groups included in the majority of the studies lacked exclusivity for age or severity of injury, which would directly affect the choice of treatment. Only one study analyzed the outcome of treatment for distal radius fractures in line with daily activities requiring proper hand functions including holding keys, opening taps, and carrying goods that are easier to replicate among wider population groups.

Conclusion

By conducting this review, the authors aimed to determine if there is a difference in functional outcomes among adult patients with distal radius fractures treated with external fixator and casting. Differences in functional outcomes should be studied to understand the effect of our treatment on the long-term functionality of patients. The evidence and suggestions at hand from different trials is not strong enough to conclude which treatment modality offers better short and long-term functional outcomes.

There is currently no strong evidence to support which surgical treatment modality for distal radius fractures offers the best outcome. There is no clear definition of age group and radiologic parameters that physicians can use to choose between treatment with external fixation and casting as treatment options. Patients with varying expectations, different use of their hands, and different activity levels should be approached differently and with an understanding of advantages and disadvantages of each treatment alternative. There is lack of protocols in the literature on how to properly follow and rehabilitate patients with distal radius fractures after treatment. Therefore, the authors suggest that there is a need for a high-quality randomized controlled trials that encompass various treatment modalities for distal radius fractures, taking into account variables such as modes of injury, age, and degree of displacement.

Limitation of the review

There is a potential for missing trials, both published and unpublished. We only have two studies with long-term follow-up, spanning 4, and 7 years (24,25). Only two studies had strong evidence backed by adequate blinding, and randomization resulting in less bias (20,23).

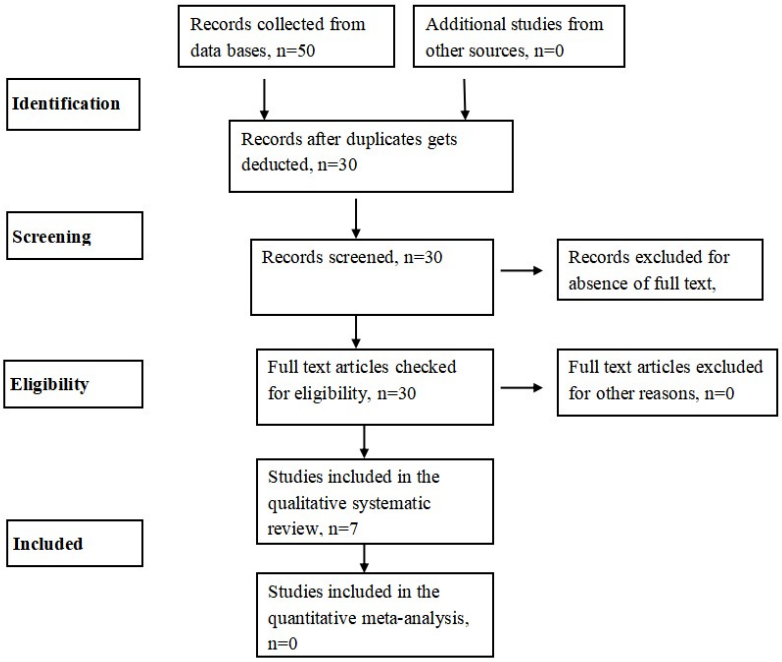

Fig-1-Preferred Reporting Items for Systemic Reviews and Meta-analysis (PRISMA) flow diagram describing the method of selecting trials

Table 1- Descriptions of basic demographic characters of studies included

Study ID	**Year of publication**	**Study area**	**Number of patients**	**Age of patients**	**Length of follow up (in months)**
Horne et al	1990	New Zeeland	37	Above 60	15
Kreder et al	2006	Canada	113	16-75	24
Kapoor et al	2000	India	90	average age 39	48
Hegeman et al	2004	Netherlands	32	55-80	12
Young et al	2003	United kingdom	125	16-75	84
Roumen et al	1991	Netherlands	101	Above 55	6 and half
Yoon et al	2021	US, Canada, Singapore	296	Above 60	12

Table 2– Summary of important characteristics of the studies included

Study ID	Fracture patterns included	Mode of injury	Exclusion criteria	Outcome measure used	Complication	Conclusion
Horne et al	displacement decided by the physician	not stated	None stated	wrist range of motion, grip strength, pain, limitation of mobility	radial nerve irritation, and pin site problems	no difference in anatomic end results, and functional outcomes
Kreder et al	Displaced fracture with metaphyseal comminution	29% high energy injuries	comminution, dorsal tilt >10 degrees, joint gap, prior trauma, congenital anomaly, delay more than a week, mental incompetence, open fractures	SF-36, MFA questioners, Jebsen Taylor test, grip strength, lateral pinch strength, and a sensory-motor exam	Pin site infection, reflex sympathetic dystrophy	Trend towards better function with fixation, evidence not statistically significant
Kapoor et al	intra articular distal radius fractures	70% road traffic injuries	None stated	wrist range of motion, Grip strength	carpal tunnel syndrome, finger stiffness, pin track infection, reflex sympathetic dystrophy	operative treatment has better functional outcome for intra articular fractures, external fixation is preferred for comminuted fracture types
Hegeman et al	Unstable distal radius intra-articular fractures	Accidental fall	Previous fracture, unable to perform functional evaluation	wrist range of motion, grip strength, Gartland, and Werley score, Goris criteria	reflex sympathetic dystrophy, dupuytren contracture	Functional outcome is good in the studied age regardless of modality
Young et al	dorsally angulated with more than 10-degree angule, and 2mm radial shortening	89% accidental fall, 11% road traffic injuries	bilateral fractures, ipsilateral limb injuries, unable to comprehend	wrist range of motion, grip strength,Gartland, and Werley score	reflex sympathetic dystrophy, pin site scar, wrist pain, extensor policies longus tendon rupture	radiographic results of treatment with external fixator are significantly better but long term follow up did not show any difference
Roumen et al	Displaced colles' fractures	Accidental fall	None stated	grip strength	reflex sympathetic dystrophy, carpal tunnel syndrome, stenosing synovitis, wrist pain, extensor policis longus rupture	external fixation has no indication for elderly patients with redisplased distal radius fractures, severity of soft tissue injury determines the outcome
Yoon et al	extra articular distal radius fractures	not stated	bilateral fractures, open fractures, previous fractures	pain, grip strength, Michigan hand assessment, wrist range of motion, esthetics	pin site, and surgical site infections	Regardless of treatment options patients have similar outcome in the long run, choice depend on the recovery process

Table 3- Summary of analysis of quality of studies

	Allocation concealment	**Blinding assessors**	**Blinding patients**	**Intension to treat analysis**	**Baseline character similarity**	**Inclusion/ Exclusion criteria**	**Loss to Follow up**
Horne et al	none stated	none	none	none stated	no mention	not clearly stated	22%
kreder et al	used Computer generated, envelopes	Final assessors were not blinded	Blinded to their group	All results analyzed accordingly	similar in age, gender, and cause of injury	Excluded for severity of injury, language barrier, and inability to participate	25%
kapoor et al	none stated	none stated	none stated	none stated	age, sex, and initial deformity	none	Full follow up
hegeman et al	not stated	not stated	not stated	not mentioned	cause of fall ,age, sex, pre-injury status, fracture pattern	prior fractures ,inability to perform functional evaluation	not stated
young et al	envelope allocation	not stated	not stated	not mentioned	not clearly stated	additional injury, bilateral fracture, inability to comprehend	32%
roumen et al	not mentioned	not mentioned	not mentioned	not mentioned	mode of injury and age distribution	not mentioned	20%
yoon et al	computerized	surgeons and assessors were not completey blinded	partially blind and were informed of other options sometimes	mentioned as primary method of analysis	similar except volar tilt, and age.	open fracture, bilateral fracture, prior same wrist surgery	4%

Table 4. summary of conclusion drawn from studies

Study ID	Horne et al	Kreder et al	Kapoor et al	Hegeman et al	Young et al	Roumen et al	Yoon et al
Clear inclusion, and exclusion	none stated	yes	Not stated	yes	yes	Not clearly stated	yes
Clearly defined outcome measures	Both anatomic, and functional outcomes stated	Clearly stated primary, and secondary outcomes	yes	yes	yes	yes	yes
Conclusion	External fixation for distal radius treatment is likely to be harmful	External fixator for distal radius fractures is likely to be beneficial	Operative treatment of displaced comminuted intra articular fracture is beneficial for functional outcome	Choosing between treatment options is a tradeoff between harm and benefit	External fixator has neutral long term functional outcome	External fixation is unlikely to be beneficial to elderly patients with redisplacement	Operative treatment is likely to be beneficial to patients who require quicker recovery

Table 5: Patient rehabilitation Protocols

Study ID	Rehabilitation protocol described
Horne et al	mobilization after 5 weeks, physical therapy if there is wrist, or hand stiffness
Kreder et al	mobilization after 6-8 weeks
Kapoor et al	writing, and eating allowed immediately , mobilization after 6-7weeks, active hand, elbow, and shoulder motion, and strength training after
Hegeman et al	Mobilization after 6 weeks, and sent to physical therapy afterwards
Young et al	external fixation group start wrist range of motion at 3 weeks, full mobilization at 6 weeks for both groups
Roumen et al	mobilization after 5 weeks
Yoon et al	used institution based rehabilitation protocol

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