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Session: I

Session Title: Do all fractures need surgery? How do I decide?

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INSTRUCTORS WHO CONTRIBUTED TO THIS HANDOUT: as of 1/5/2024

Moderator(s):

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Title: **Do all fractures need surgery? How do I decide?**

AAOS Symposium- Tuesday Feb 13, 2024

1. Introduction 5 minutes Nirmal C Tejwani, MD

2. **Distal radius fracture in patients > 60 years of age.** Philip Wolinsky MD: 10 minutes

3. **Proximal Humerus fractures in patients > 60 years of age**: Nirmal Tejwani, MD: 10 min

Q&A: 10 min

Case Discussions. 20 min

4. **Ankle fractures: who needs surgery?** Paul Tornetta MD: 10 min

5. **Humerus Shaft fractures in young active patients**. Robert Ostrum, MD: 10 min

Q&A: 10 min

Case Discussions. 20 min

Do all fractures need surgery? How do I decide?

Proximal Humerus fractures in patients > 60 years of age

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AAOS Symposium- Tuesday Feb 13, 2024

Proximal humerus fractures range from the simple, non-displaced to complex fracture dislocations. Most of the simpler fracture patterns are treated non-operatively with early physical therapy.[1]

Controversy arises when discussing surgical indications, especially in older population.

As we all age, but remain more active than ever before, the definition of age is relative. Most people now use functional age as opposed to chronological age for purpose of indications for surgery.

Typically, displaced 2,3 and 4 part fractures are indicated for surgery, however, age and function play a big role in decision making. The difficulty is in defining outcomes of surgery and what is improved with fixation as opposed to just the radiographic appearance.[2] The risk of complications including failure of fixation, intra-articular penetration and need for revision surgery should not be underestimated with range from 10-40 %.

The PROFHER study muddied the waters with presentation of similar results of operative versus non operative treatment for displaced proximal humerus fractures. [3] [4] This study had 250 patients enrolled (out of 1200) where they showed no difference in outcomes in functional scores at two years between the two groups.

Further follow up study at 5 years found that function was maintained with no difference or secondary surgeries between the two groups.

This study had significant shortcomings in that over a 1000 patients were excluded from the study, for various reasons, including surgeon preference, thus potentially creating a selection bias. However, in the patients and fractures that were included, the results demonstrated no advantage to operative treatment even in displaced fractures. [3]

A meta-analysis of the evidence for operative treatment in 2015 found that there is high or moderate quality evidence that, compared with non-surgical treatment, surgery does not result in a better outcome at one and two years after injury for people with displaced proximal humeral fractures involving the humeral neck and is likely to result in a greater need for subsequent surgery.

However, it does not cover the treatment of two-part tuberosity fractures, fractures in young people, high energy trauma, nor the less common fractures such as fracture dislocations and head splitting fractures.[5, 6]

In my opinion, age range 60-85 active adults, the treatment algorithm is as follows:

2 part fractures (typically displaced GT> 1cm): surgical treatment in active adults

3-4 part valgus fractures: non operative

3-4 part varus fractures; ORIF vs Reverse TSA

Over 85-90, low demand, minimal function: non operative irrespective of displacement

Shoulder dislocations do surprisingly well in the elderly, even when missed with functional range of motion and little or no pain.

Bibliography:

1. Tejwani, N.C., et al., *Functional outcome following one-part proximal humeral fractures: a prospective study.* J Shoulder Elbow Surg, 2008. **17**(2): p. 216-9.
2. Min, W., R.I. Davidovitch, and N.C. Tejwani, *Three-and four-part proximal humerus fractures: evolution to operative care.* Bull NYU Hosp Jt Dis, 2012. **70**(1): p. 25-34.
3. Rangan, A., et al., *Surgical vs nonsurgical treatment of adults with displaced fractures of the proximal humerus: the PROFHER randomized clinical trial.* JAMA, 2015. **313**(10): p. 1037-47.
4. Handoll, H.H., et al., *Five-year follow-up results of the PROFHER trial comparing operative and non-operative treatment of adults with a displaced fracture of the proximal humerus.* Bone Joint J, 2017. **99-B**(3): p. 383-392.
5. Handoll, H.H. and S. Brorson, *Interventions for treating proximal humeral fractures in adults.* Cochrane Database Syst Rev, 2015(11): p. CD000434.
6. Goch, A.M., et al., *Operative repair of proximal humerus fractures in septuagenarians and octogenarians: Does chronologic age matter?* J Clin Orthop Trauma, 2017. **8**(1): p. 50-53.

Do all fractures need surgery? How do I decide?
Treatment of Distal Radius Fractures in the "Elderly"

Philip Wolinsky, MD
Dartmouth Medical Center

AAOS Symposium- Tuesday Feb 13, 2024

Outline

DR Fx's are a common injury
Increasing numbers
Increasing number of surgeries/ higher cost with surgery
Who should get surgery vs non-op rx?
    Literature: unclear

Introduction

Distal Radius Fractures:
    2nd most common fx'd bone in the elderly
    18% of all adult fx's
    #1 UE fx in women > 50 years old
    Various definitions of elderly in the literature from 50-75 years old
    Treatment is controversial

DR Fx Treatment Decision Making

Multifactorial including:
    Radiographic parameters
    Functional/medical status
    Activity level- ADL's

Treatment goals:

Improve pain
Restore function

CR/ Cast vs ORIF

Use of ORIF has increased over the years
ORIF costs 3x as non-op rx for Medicare patients
Use of ORIF varies demographically and geographically
Patients treated by fellowship trained hand surgeons are more likely to have surgery

Imaging/ Bone Position
    No consensus on what an "acceptable" x ray position is in the "elderly"
    In fact, no consensus on what "elderly" is
    Should probably be defined as a position that predicts good function in the majority of cases

For High functional demand patients that might be:

Joint: < 2mm gap or step off
Dorsal tilt < 10 degrees
< 2-3mm loss of radial length (ulnar variance)
Carpal alignment is restored

Is This an Urban Legend?
The "elderly" can tolerate more deformity since they don't have as high a demand on their UE for ADL's
Is that true for all "elderly"?
What about the "active" "fit" elderly?
How much deformity cab be tolerated?

AAOS Guidelines 2010
Treatment of distal radius fractures
Lichtman D, Bindra R, Boyer M , et al
JAAOS 2010;18:180-189

No **strong** recommendations
Moderate strength recommendation for surgical fixation of fractures that post reduction have:
Radial shortening > 3 mm
Dorsal tilt > 10 degrees
Intra-articular gap or step > 2mm

Unable to recommend for or against surgical treatment of patient > 55 years of age
Rec strength: inconclusive
Elderly defined by:
infirmity
low functional demand
poor bone quality
low energy injuries (GLF)

Meta- Analyses of Distal Radius Fractures

Interventions for distal radius fractures: a network meta-analysis of randomized trials
Vannabouathong C, Hussain N, Guerra-Farfan E, et al
JAAOS 2019;27:e596-605

Network meta-analysis of randomized trials of different treatments for DR Fx in adults (adult and elderly)
38 trials included (1988-2017)

Function at 3 months:
6 studies, 277 patients
IMN: no info

No statistical differences between all other treatments
Overall ranking (higher is better):
KW (k wires): 80%
PF (plate fixation): 63%
EF (external fixation): 45%
PC (plaster cast): 11%

Function at 6 months:
6 studies, 325 patients
IMN: no info
NO difference between all other treatments
Ranking:
PF: 87%
KW: 60%
EF: 42%
PC: 11%

Function at 12 months:
17 studies, 1,123 patients
One sig outcome diff between plaster cast and plate fixation
Ranking:
PF: 83%
IMN: 61%
KW: 55%
EF: 45%
PC: 7%

Fracture healing complications:
25 studies, 2,253 patients
Patients with ORIF had sig lower odds of a complication compared to Ex fix, K wires, cast, or IMN
KW and EF were both sig more favorable than cast for reducing the odds of a fx healing complication

Conclusions:
ORIF with plates may offer the best results for DR Fx in adults (not just the elderly) in terms of early and long-term function and avoidance of fracture complications
Surgical intervention is associated with risks so be mindful of this when patients are at higher risk for complications

<u>Comparison of treatment outcomes between nonsurgical and surgical treatment of distal radius fractures in elderly: a systematic review and meta-analysis</u>
Ju J, Jin G, Li G, et al
Langenbecks Arch Surg 400, 2015: 767-779

Meta-analysis of outcomes of OP and non op in patients <= 65 years old
Studies until 5/2015 included
8 studies/ 440 patients surgical vs 449 non-surgical
All operative rx was analyzed as one group: ORIF, ex fix, perc pinning
No analysis of different kinds of DR fx's

Outcomes:
- Subjective functional outcome: DASH
- VAS pain
- Objective functional outcomes: grip, wrist ROM
- Images

DASH: 6 studies, no difference
VAS pain: 3 studies, no difference
Grip: 6 studies, no difference
ROM:
- Wrist extension (4 studies), pro (5), sup (5), ulna deviation (?), no difference
- Wrist flexion (5 studies), radial deviation (5), greater in non-op group

Images:
- Radial inclination (7 studies): greater (better) in OP group
- Ulna variance (7): less (better) in OP group

Conclusions:
- NO difference in outcomes as far as DASH, VAS pain, grip
- There were differences in wrist flexion, radial deviation, radial inclination, and ulnar variance
- But- did not impact VAS or DASH and so did not affect quality of life

<u>Treatment of radius of ulna fractures in the elderly: a systematic review covering effectiveness, safety, economic aspects and current practice</u>
Navarro C, Brolund A, Heintz E, et al
PLOS ONE March 28, 2019 14(3) e0214362

Optimal rx for DR and ulna fx's is unknown
The evidence for ORIF is limited
Yet incidence of ORIF is increasing

Swedish registry analysis: 2005-2013
- Age > 50, with a DR Fx
- Incidence of DR fx's went down:
- Women: 77/10,000 people/years in 2005 vs 63/10,000 in 2013
- Men: 18/10,000 in 2005, 14/10,00 in 2013

Surgical treatment:

Increased 7% in women
Increased 4% in men
Ex fix was most common in 2003
ORIF was most common in 2007-2013

Costs in Sweden:

Cast: 137 US dollars
ORIF: 1698 US dollars

Metanalysis of outcomes at 1 year (moderate certainty):

Elderly defined: >= 60 years old
"Moderately" displaced fx's were included- never defined

Significant differences in outcome measures:

Minimal clinically important differences (MCID)
DASH 13 points
EQ-50: 0.074 points
Grip strength: 6.5 kg (19.5%)

Studies for outcomes:

31 RCT's
10 cohorts

Study:

Age 60 or above
Any rx with comparison groups
Validated functional outcomes, grip, QoL, complications, costs
Randomized controlled trial (RCT), non-randomized controlled trial (non-R), comparative registry studies

Functional outcomes:

DASH, PRWE

Quality of life:

EuroQol, SF-36, WHOQoL, 15-Dimensional (15-D), grip strength

Major complications definition:

Need for additional surgery, and/or a serious disability
All others were classified as minor

Comparison groups:

Perc fixation: K wires, nailing, ex fix were combined
Plating
Nonoperative rx

31 studies met the inclusion criteria
Functional outcomes @ 1 year:
- ORIF vs non-op: no differences
- ORIF vs percutaneous fixation: no difference

Complications:
- Minor: no differences
- Major: more common in ORIF group

Comparison of non-op vs op:
- 10 trials: 8 RCT's, 2 non-R
  - Plate vs cast:
    - 2 RCT's, 1 non-R
    - No clinically sig diff at 1-year functional outcomes
    - Moderate evidence
    - Not enough data for: QoL, grip, complications

Comparison of non-op vs op:
- Percutaneous fixation vs cast:
  - 4 RCT's 2 non-R
  - No sig diff for functional outcomes/ moderate evidence
  - Grip: 6 RCT's. 1 non-R, no sig diff/ moderate
  - QoL: 2 RCT: perc is better or equal/ LOW evidence
  - Minor complications: 6 RCT's: less comps in non-op group, LOW evidence

Treatment of concomitant distal ulna fractures:
- Zero studies

Comparison of surgical options:
- 9 RCT's, 5 non-R
  - Diff plating techniques: not enough data/ very LOW evidence
  - Diff perc techniques: not enough data/ very LOW evidence

- ORIF vs Perc:
  - 5 RCT's, 1 non-R
    - Clinical function or grip: No diff / Moderate evidence
    - Qol: no difference/ LOW evidence
    - Minor complications: no difference
    - Major complications: less in perc group/ moderate evidence

Addition of bone substitute:
- 7 RCT's
  - Plates w/w-out: not enough data
  - Perc or cast w/w-out: bone substitute led to Equal or better results/ LOW evidence

Conclusions:

- No difference in clinical outcomes for “moderately” displaced DR Fx’s in patients > 60 years old for OP vs nonop
- No difference for different surgical techniques
- Plating is more expensive than non-op rx
- Major complications are higher in the ORIF group

Espisito et al

- ORIF did better than perc
- RCT’s only were included
- Patients were younger than this study
- Found a DASH MD of 5.92- May not be a clinically relevant difference
- No diff in grip
- No diff in complications

Chen et al meta-analysis of elderly patients:

- No clinically sig diff in DASH between OP and non-op
- Better images after ORIF
- Shows that better images does not mean better functional outcomes

The authors point out:

- This study is only valid for “moderately” displaced fx’s NOT “very” displaced ones
- Never defined
- Did not evaluate shorter term function which may be important in the elderly

<u>Safety and efficacy of operative versus nonsurgical management of distal radius fractures in elderly patients: a systematic review and meta-analysis</u>
Chen Y, Chen X, Li Z, et al
J Hand Surg Am 2016;41(3): 404-413

Meta-analysis: op vs non-op
Patients >= 60 years old
2 RCT’s, 6 retrospective studies
No differences in:

- Pain
- Function
- Wrist ROM
- Grip: greater in the ORIF group

Major complications requiring surgery/ tendon injury: more common in ORIF group

Radiographic outcome: Better in ORIF group

Considerable heterogeneity was present in ALL studies

Conclusions:

- No better clinical outcomes in elderly patients with ORIF
- Better grip and images in ORIF group
- More major complications in ORIF group

Study inclusion criteria:
Patients >= 60 years
Defined "unstable" fractures based on re-displacement after an initial reduction
Displacement had to exceed acceptable parameters for closed rx:

- Distal tilt > 10 degrees
- Volar tilt > 15 degrees
- Radial inclination < 10 degrees
- Ulna + variance > 2 mm
- Intra-articular step > 2 mm

Minimum follow- up of 12 months

Clinical outcomes: Pain VAS, grip, wrist ROM,
Functional outcomes: PRWE, DASH
Complications:

- Minor: did not need an additional treatment/ investigations
- Major: deep infections, nerve or tendon injury, need for re-operation

Pain level: 4 studies, 426 patients: no difference
Grip strength: 5 studies: sig greater in ORIF group
DASH (7 studies), PRWE (4 studies): No sig differences
ROM: 4 articles, no differences
Complications:

- Minor: no differences
- Major: sig differences, higher in surgical groups
- Most common complications were nerve and tendon injuries
- No difference in nerve injuries (7 studies)
- Tendon injury: higher risk in OR group (6 studies)

Images: ORIF or ex fix resulted in sig differences in (was better)

- Volar tilt
- Radial inclination
- Ulna variance

Comments:

- DASH and PRWE have not been validated for different age groups
- Since" many" elderly patients get a satisfactory outcome despite non-anatomical images perhaps these scores may not be optimal for this population

Articles and Studies Specifically Addressing the Elderly

Distal radius fractures in the elderly
Levin L, Rozell J, Pulos N
JAAOS 2017;25:179-187

2nd most common fx'd bone in the elderly (18% of all fx's)
#1 UE fx in women > 50 years old
Define elderly as 50-75 years old
Treatment is controversial

Decision making:
- Radiographic parameters: displacement, angulation
- Functional status
- Activity level

Goals:
- Improve pain
- Restore function

Use of ORIF has increased
ORIF costs 3x as non-op for Medicare patients
Use of ORIF varies demographically and geographically
Patients treated by fellowship trained hand surgeons also more likely to have surgery
Secondary re-displacement of a reduced fracture may be as high as 89% in the elderly

Outcomes:
Lutz et al
- Most common surgical complication was infection (12%)
- Most common nonop complication was median neuropathy (11%)

Malunions (systematic review in the elderly):
- X-rays are worse after non-op rx
- Functional outcomes are the same
- Major complication rates are higher after surgery

Multiple studies:
- No difference in clinical outcomes between op and non-op
- Surgery= better grip strength
- No difference in activities of daily living

Arora et al JBJS 2011:
- Prospective randomized study volar ORIF vs cast > 65 years old
- Better results at 3 months for ORIF
- No difference at 6 and 12 months

Grip strength was always better in the ORIF group

Nelson et al JOT 2015

96 patients > 60 years old
No differences between patients with a well aligned fx and those with a malunion @ 1 year
DASH, visual analog scale function, strength, or wrist motion

Conclusions:

No consensus on treatment of DR fx in the elderly
Surgery does make a better-looking x-ray
However, x-ray alignment does not seem to correlate with better functional outcomes

<u>The impact of patient activity level on wrist disability after distal radius malunion in older adults</u>
Nelson N, Stepan J, Osei D, et al
J Ortho TR 29(4), 2015

250,000 DR fx's/ year in the US in adults >= 65 years old
2nd most common fracture in the Medicare population
Unclear what the optimal rx is
Prior studies grouped patients by age and not by functional activity level
Hypothesis: highly active adults would have a worse functional outcome with a malunion vs a well aligned fx

Effect of malunion on 96 high activity patients > 60 years at least one-year post surgery
Activity level was defined using the Physical Activity Scale of the Elderly
Malunions vs well-aligned fx's
Malunions defined by a difference of compared to the uninjured wrist:

<= 20 degrees lateral tilt
>= 15 degrees radial inclination
>= 4mm of ulnar variance
>= 4mm articular step off or gap

Outcomes:

QuickDASH : patient related disability
VAS pain/function
Strength and motion measurements

Findings: No differences in QuickDASH, VAS function, strength, and wrist motion
Neither the physical activity score or malunion predicted QuickDASH after controlling for age, sex, and treatment

Findings: Operative rx did NOT improve outcomes but did increase complications (26% vs 7%) and decrease grip strength. Also, no differences in the low activity patients
Conclusions:

- Even for highly active older adults malunion of the DR did not affect functional outcomes
- Their regression model found that only general health (SF-12) and wrist flexion-extension arc were predictive of QuickDASH scores
  - Cannot fix general health
  - Perhaps rx should therefore focus on whatever maximizes ROM

<u>Factors associated with the decision for operative versus conservative treatment of displaced distal radius fractures in the elderly</u>
Wu Y, Yang J, Zhang J, et al
ANZ J Surg 2019

Elderly defined as: >= 55 years old
Only fx's treated within 14 days of injury were included
Displaced and unstable fx were defined as:

- Initial dorsal angulation > 20 degrees
- Initial shortening > 5 mm
- >50% dorsal comminution
- Intra-articular fx
- Ulna fracture

Goal- define factors associated with decision making for operative treatment
Authors reviewed rx of 318 consecutive patients treated from 2010-2017 at their clinic

Multivariate analysis- predictors of deciding on operative rx:

- Younger patients
- Associated orthopedic injuries
- Higher AO or Fernandez classification
- Radial shortening > 5 mm
- Volar tilt < -10 degrees
- Volar/dorsal comminution
- Ulna variance > 5 mm
- Intra-articular step /gap > 2 mm
- Associated DRUJ instability or RC dislocation
- Treatment by an upper extremity specialist

Conclusions: decision making was predominantly influenced by:

- Characteristics/ severity of the injury
- Patients age
- Specialty of the treating orthopedic surgeon

Early palmar plate fixation of distal radius fractures may benefit patients aged 50 years or older: a randomized trial comparing 2 different treatment protocols
Sirnio K, Leppilahti J, Ohtonen P, et al
Acta Ortho 90(2): 2019, 123-128

Prospective randomized trial
80 patients >= 50 years old
Displaced DR fx's defined as:
> 10 degrees dorsal, < 15 degrees radial inclination, >2 mm + ulna variance
AO type C3 excluded
Outcome: DASH at 24 months (clinically relevant difference defined as 15 points)
Randomized to volar ORIF (38) vs initial non-op (42) AFTER a good closed reduction
All patients had an acceptable reduction and then were randomized
16 in the non-op needed delayed surgery for loss of reduction

Findings:
All patients:
Mean DASH sig differed at 2 years: 7.2 vs 14.4 (p=0.005) NOT a 15 point (clinically sig diff)
Flexion and ulna deviation was sig better in the OP group
Grip: no difference
Images: all parameters better in the OP group
Delayed operations for loss of reduction did NOT result in comparable DASH scores to early ORIF
1/3 of all patients lost reduction after 2 weeks

DASH at 24 months for patients >= 65 years of age:
No difference between op and non-op

Review of prior studies:
ORIF makes a better x ray but may not be correlated with better functional outcome esp in the elderly
There are only a few randomized trials in the elderly:
Arora et al 2011, Bartl et al 2014: no benefit to ORIF
Martinez-Mendex et al 2018: better functional results for patients > 60 with volar ORIF vs cast

Intra-articular distal radius fractures in elderly patients: a randomized prospective study of casting versus volar plating
J Hand Surg (EUR) 2018;43(2): 142-147
Martinez-Mendez D, Lizaur-Utrilla A, de-Juan-Herrero J

All patients >= 60 years old
Included "displaced, complex, intra-articular" fractures

Cast (47) vs ORIF (50)
All had an acceptable closed reduction in the ED for inclusion/ randomization defined as:
    Radial height > 5mm, radial inclination > 15 degrees, volar tilt 15 degrees to neutral, ulnar variance < 2 mm, articular step off or gap < 2mm

2 years: patient rated wrist evaluation score (PRWE), DASH, pain, ROM, grip strength, images
25% of casts lost reduction
Functional outcomes and quality of life were better after volar ORIF
Key for good outcomes:
    Restoration of articular surface, radial inclination, ulnar variance
    Articular step-off was not related to outcome

All mean functional and quality of life scores were higher in the ORIF group
F/E arc same in both groups
Pro/Sup: better in the ORIF group
PREW multivariate analysis showed it was affected by:
    Treatment type
    NOT by: age, sex, fracture type
Images:
    All parameters except volar tilt were better in the ORIF group
    PRWE score was significantly associated with:
        Radial inclination
        Ulnar variance
        NO association with articular incongruity

<u>A comparative study of clinical and radiologic outcomes of unstable colles type distal radius fractures in patients older than 70 years: nonoperative treatment versus volar locking plating</u>
Arora R, Gabl M, Gschwentner M, et al
J Ortho Trauma 2009; 23:237-242

Retrospective study
130 patients > 70 years old
114 followed for >= 1 year
All were independent patients who could come back for follow up on their own
ORIF (53) vs CR/ cast (61)

Outcomes:
    ROM, grip strength, DASH, PRWE score, VAS pain, Green and O'Brien score
    Dorsal tilt, radial inclination, radial shortening, union, and arthritis

All initially reduced in ED with local anesthesia
Instability defined as lack of ability to hold the reduced position @ 1-2 weeks - advised to have surgery if/when:
    Dorsal tilt > 20 degrees

Shortening of >= 3 mm
Articular step of 2 mm

53 of those who lost reduction had surgery
61 declined surgery and were treated with a cast
NO randomization

Acceptable fx reduction:
Dorsal tilt < 10 degrees
Radial shortening < 2 mm
Articular step: < 1 mm
Carpal alignment was present

ROM, grip, DASH, PRWE, G+O score: No difference btwn groups
Pain: Sig less in cast group
Clinical deformity:
77% of cast group
0% ORIF group
No patients were dissatisfied with the clinical appearance or functional result of their wrist

Images: Malunion occurred in 89% of primarily reduced fractures
ORIF group: Dorsal tilt, radial inclination, radial shortening were sig better in the ORIF group
CR/Cast: 44% never got an acceptable reduction

Complications ORIF group:
1 delayed union
2 extensor tenosynovitis due to long screws
2 flexor tenosynovitis due to plate edge position
1 EPL rupture due to long screw
1 CTS @ 9 months
7 (13%) had a complication
6 (11%) additional surgeries were needed

Complications non-op group:
5 CRP type 1/ All resolved

There is poor correlation between images (shape as well as OA) and functional outcomes, in older people
Patients need to perform ADL's without pain to have good functional results:
Functional results were the same in both groups
There was less pain in the cast group

Radiographic post OA was higher in the cast group, but function did not differ

There were more complications in the surgical group
Therefore "less aggressive surgical treatment of DRF's in the elderly (> 70 years old) may be the preferred treatment option"

A prospective randomized trial comparing nonoperative treatment with volar locking plate fixation for displaced and unstable distal radius fractures in patients sixty-five years of age and older
Arora R, Lutz M, Deml C et al JBJA Am. 2011;93:2146-53

Compare outcomes in a randomized prospective trial of ORIF (n=36) vs CR/casting (n=37) for unstable displaced FR fx's in patients >= 65 years old
Outcomes: DASH PRWE, grip, ROM, VAS pain, images, complications
Only independently living patients who were able to travel on their own to the clinic were included in the study
Inclusion:
- Unstable dorsally displaced distal radius fractures

Acceptive reduction:
- Dorsal tilt < 10 degrees
- Radial shortening <= 3 mm
- Intra-articular step <= 2mm

All fractures were reduced in the ED
Patients who had an initial acceptable reduction and lost it at one week were eligible for the study
Those randomized to cast were NOT re-reduced

Wrist ROM, pain VAS: No differences @ any time point
DASH, PRWE:
- ORIF group did better up to 12 weeks
- No difference @ 6 or 12 months

Grip: Better in ORIF group at all time points
Images: Better in the ORIF group ($p<0.05$)
Complications: Higher in the ORIF group (13 vs 5, $p<0.05$)

Clinical deformity:
- 78% of non-op group
- 0 of the OR group
- NO patients were dissatisfied with the clinical appearance or function of their wrist

Images:
- 100% of the non-op group had a malunion

>10 degrees dorsal tilt
>2 mm radial shortening
> 1mm step off

Union rate/ time: No differences

Arthritis: Present in 53% of patients
Sig higher in the intra-articular group
No patients with x-rays arthritis had pain
But patients were only followed for 1 year

Complications:
Sig more in the OR group (13 vs 5)
13 (36%) of the OR group had a complication
11 (31%) needed a second operation
0 patients in the non-op group needed an operation
5 extensor tenosynovitis due to prominent screws
4 flexor tenosynovitis due to edge of plate position
1 EPL rupture due to long screw
1 CTS release

Conclusions:
At 12 months:
NO difference in ROM, pain, PRWE or Dash
ORIF had better grip and better images
Therefore: better looking x-rays do not translate into better functional outcomes for ADL's

Complications of Treatment in the Elderly

Complications associated with operative versus nonsurgical treatment of distal radius fractures in patients aged 65 years and older
Lutz K, Yeoh K, MacDermid J, et al
J Hand Surg Am. 2014;39(7):1280-1286

Single institution study
DR fx's in patients >= 65 years old
Matched by: AO class, sex, age, energy of injury
Complications for operative (n=129) and non-operative (n=129) treatment
Operative rx was not standardized or randomized
Contained a lot of ex fix with pin tract infections
OR group had 13 open fractures vs 0 in the non-op group

Complications definition:

Minor: transient, requited no rx
Moderate: required non-surgical treatment or further studies
Severe: required an operation

Images:
Acceptable vs unacceptable
Unacceptable:
Dorsal tilt > 10 degrees
Radial inclination < 15 degrees
Ulna variance >= 3 mm

Functional outcome:
PRWE @ 1 year
Subset of patients only (140/ 218)

Mean age 74 (65-90)
F:M 92%: 8%
90% low energy GLF

Complications:
29% (37) OP vs 17% (22) non- op SIG p=.03

CTS was most common:
N= 22
8 (3 op, 3 non-op) were transient, did not need rx
6 (3 and 3) were moderate, EMG and splinting
8: (2 OP, 6 non-op) were severe, needed surgery

SSI:
2nd most common complication
N= 16 (6%), all op by definition
Pin sit infections 12/16 (75% of SSI)
Incision site needing oral abx, N= 3
1 recurring draining sinus that need operative I+D and ROH in a patient with glucose control issues, a post op MI, post op ischemic colitis who had a prolonged hospital stay

Greater number of “moderately severe” comps in the OP group mostly due to pin tract infections P<.001

Late complications (defined as after fracture healing):
No diff: 11 (9%) OP vs 7 (5%) non-op
CTR: 2 op and 6 non-op
Tendon transfers for EPL or long extensor rupture: 5 OR, 0 non op
Tenolysis for tendon adhesions: 5 OR, 0 non-op

Dupuytren release: 1 non-op
Ulna shortening and/or ulna hemi-resection: 2 OP, 1 non-op
Revision ORIF/ graft for non-union: 1 OP
I+D, ROH for infection: 1 OP

Volar plates ROH: 2/76 at 2-4 years

Complication rates by operative treatment type:
Volar plate: 22% (16/74)
Dorsal plate: 50% (2/4)
Ex fix: 42% (16/38)
Perc pin: 23% (3/13)

Malunions:
38% OP vs 69% non-op p<.001

1-year PRWE scores:
Available for 140/218 patients
Pain or disability: no difference

Conclusions:
Elderly patients who had OR had better x rays
But higher comp rates
Mostly pin tract infection in ex fix group
No difference in functional outcomes in the subset of patients who had scores

<u>A systematic review of outcomes and complications of treating unstable distal radius fractures in the elderly</u>
Diaz-Garcia R, Oda T, Shauver M, et al
J Hand Surg 2011;36A:824-835

There were stat sig differences in wrist ROM
Grip strength was sig different

Most common fx seen by physicians
Second most common fx in the elderly after hip fractures
10% of 65 yo white women will have a DR fx in their remaining lifetime
Works out to about 372,000/ year
Will increase as the baby boomers age
Optimal rx is unclear
>50% will lose reduction in a cast
Unclear if operative stabilization results in better functional outcomes

Systematic literature review of 5 methods of rx of DR fx's

Volar locking plate, non-bridging ex fix, bridging ex fix, per wire fixation, cast (CI)
For patients with a MEAN age of >= 60 years of age
Functional outcomes, images, complications
Minimum follow up of 12 months

21 studies were included:
- 8 RCT
- 3 prospective cohort
- 10 retrospective case reviews

Detected sig differences for ROM, grip, and DASH although" these differences may not be clinically meaningful" (2.5/100 DASH)
Volar tilt and ulna variance differed between the groups with CI having the worst image outcomes
Complications were sig different:
- CI had the lowest rate
- Volar locking had the highest rate that required additional operations

Despite worse images after casting, functional outcomes did not differ between the op and non-op groups
However, the plating group had a higher rate of major complications requiring another operation
ROM differed sig: CI was the best
Grip strength: did not differ
Weighted mean DASH: did differ
Image parameters: did differ
Complications: did differ

Complications:
Most common *minor*:
- Superficial pin tract infections in EF and PKF groups
- 77 major complications not requiring surgery:
- 63 were CRPS and nerve lesions

Most common *major* complication requiring surgery was rupture or adhesion of the FPL, EPL or both
- 4 patients needed CTR
- 8 volar plates were taken out

Complications:
- Sig differences in rates and types for all treatments
- BrEF: highest proportion of major and minor complications not requiring surgery
- VLPS: highest rate of major complications requiring surgery
- Cast: lowest complication rate

Conclusions:
ROM: Differed, However, all groups had ROM sufficient for ADL's
DASH: Sig different, but no clinically sig difference (2.5/100)
Images: Sig diff for ulna variance and volar tilt

Expert Opinion

Defining displacement thresholds for surgical intervention for distal radius fractures- a Delphi study
Johnson N, Leighton P, Delphi Study Group, et al
PLOS ONE Jan 8, 2019

3 panels of expert opinion from 43 national/ international "expert" surgeons
Assumption: evidence which fractures benefit from intervention is varied and of poor quality
There is no objective data
What patient factors affect the decision to intervene?
Based on outcomes at 3 months
3 aims:

- Which x-ray paraments are clinically important
- Quantify the thresholds at which interventions should happen
- What patient factors affect the decision to intervene

Extra-articular fractures:

- Ulnar variance was most important
- Then dorsal tilt
- Then radial inclination
- Then radial height

Intra-articular:

- Step was the most important
- Then gap

Surgical thresholds for ages 38 and 58

- Surgeons would intervene for:
  - +2mm ulnar variance
  - 10 degrees dorsal tilt
  - 2 mm step
  - 3 mm gap
- Age 75:
  - Ulnar variance: no consensus
    - 50%: intervene at +4mm
    - 42%: would accept >+5mm
  - 20 degrees dorsal tilt
  - 3 mm step

4 mm gap

Most important factors for intervention decision making:
- All related to pre-injury function:
  - Mental capacity
  - Pre-injury functional level
  - Medical co-morbidities

Rank order patient factors:
1) mental capacity
2) Function
3) Medical co-morbidities
4) Age
5) Compliance with rehab
6) Occupation
7) Fragility

<u>International survey: factors associated with operative treatment of distal radius fractures and implications for the AAOS appropriate use criteria</u>
Kyriakedes J, Crijns T, Teunis T, et al
J Ortho TR 33(10)Oct 2019

Intra-articular DR Fx's
Expert opinion study of 28 cases/ survey of 224 surgeons
Image based
Age based (50 years old vs 70 years old)

2013 AAOS released Appropriate use Criteria (AUC) based in 2009 Clinical practice Guidelines (CPG) for DR Fx's
Factors in the AUC include:
- OTA/AO fx type
- MOI
- Patient activity level
- ASA status (patient health)
- Other injuries

The online tool gives recs for rx options:
- Appropriate
- May be appropriate
- Rarely appropriate

Patient age, image based fx displacement are NOT included in the AUC
Found to be "critical" clinical factors in decision making in studies

Fractures were classified as:

Not clinically sig displaced
    Expected to be treated non-op
Potentially clinically significantly displaced:
    >2mm intra-articular step
    Dorsal angulation > 20 degrees
    Dorsal comminution (>= 3 fragments)
    Radial shortening
    Associated ulna fracture

Based on studies that showed these are factors that adversely affect functional outcome

Patient factors independently associated with deciding for surgery:
Younger age, OR 6.7
Clinically sig fx displacement, OR type B 122, Type C 59
Normal activity level, OR 5
High energy MOI, OR 1.3

Surgeon factors associated with deciding for surgery:
Practicing in Europe vs the US, OR 2.6, other countries OR 4.8
Hand trained vs trauma trained OR 2.3
Hand trained vs "other" ortho surgeons, OR 2.2

Age: No differences between patients aged 50 vs 70

No effect on decision making:
Patient gender
Surgeons gender, age, years in practice, number of fx's rx's/year, teaching trainees

Most survey surgeons more frequently treated non-displaced intra-articular fx's non-op than displaced intra-articular fx's
May represent a paradigm shift
Jupiter's paper introduced a "gold standard" of obtaining < 2mm of intra-articular step off
However:
    Image based dx or arthrosis does NOT correlate with poor functional outcomes
    The cartilage injury itself may lead to arthrosis
    Intra-articular malunions and image arthrosis are not associated with worse outcomes in 2 studies with 15 and 38 year follow up

Survey surgeons more frequently treated intra-articular fx's non-op in older active patients vs. younger active patients
Several studies have shown that image mal-unions do not correlate with functional outcomes in patients > 55 years old 6-12 months post injury
Even in highly active patients

Non-op rx in the elderly is associated with fewer complications, less pain, and similar clinical outcomes
Non-op rx in the elderly may lead to a cosmetic deformity that patients tolerate but need to be warned about

AUC rec:
- Non-op rx of most intra-articular fx's is "rarely appropriate"
  - Only 60% of survey results agreed
  - 37% were in disagreement
  - Survey surgeons decision for rx of a clinically insignificant intra-articular displacement was "rarely appropriate" 84% of the time
  - Due to lack of inclusion of fx displacement in the AUC algorithm
  - And AUC recommends surgery for nearly all low energy intra- articular fx's for ASAS 1,2,3

Older patient decision making:
- 48% disagreement with AUC
- AUC uses patient activity, and ASA status
- But not age
- May prevent the identification of healthy, active, older patients

Study showed that surgeons take patient age and fx displacement into account when making decisions
Evidence that surgery does not improve outcomes in the elderly
Non-op management is a viable option for this population

Imaging and Instability and/or Outcomes

Do radiological and functional outcomes correlate for fractures of the distal radius?
Plant C, Parsons N, Costa M JBJS 2017;99-B:376-82

Do radiological measurements correlate with patient reported functional outcomes, health related QOL, and physical measures of function?
50 patients
Mean age 57 (26-85) ("predominantly elderly") and able to have surgery
Surgical fixation (volar plate or perc pinning) of an acute dorsally displaced DR fx

X-ray measurements correlated poorly with patient reported outcomes and physical measures of function:
- Post op palmar tilt (weak) and ulnar variance (weak @ 12 months only):
  - At 6 weeks and 12 months correlated with patient rated wrist evaluation (PRWE), DASH
  - At 3,6 and 12 months with EuroQol scores, grip strength, pinch strength, and ROM

Outcome was age related:

All patients < 50 had better DASH and PRWE at all time points

All patients < 50 had greater grip and pinch strength at all timers

Historically x ray deformity was thought to correspond with poor functional outcome:

McQueen: 17 patients

Dorsal angulation > 10 degrees and radial shortening > 2 mm had worse outcome

Now controversial

Prior studies on x-rays and clinical outcomes:

Villar et all (900 patients): correlated post op images and grip strength (no other study has found this)

McQueen (15 patients): dorsal > 10 and radial shortening > 2 mm associated with poor grip strength and ROM at 5 years

Only one study (n=78) detected a weak correlation btwn dorsal angulation and DASH

Kumar et al and other studies on "older" patients: association in dorsal and DASH in patients < 60 years old only, no association when > 60

Synn et al: "older" no association between PRWE and images at 6 months

Karzernis et al: weak correlation of PRWE and radial shortening at 12 months

<u>What are the radiological predictors of functional outcome following fractures of the distal radius?</u>

Ng C, McQueen M JBJS(Br) 2011;93-B:145-50

No consensus on what "acceptable" x ray position is

Should be defined as a position that predicts good function in the majority of cases

High functional demand patients:

Joint: < 2mm gap or step off

< 2mm loss of radial length

Carpal alignment is restored

Articular incongruity:

Relationship to degenerative change is unclear

1) Jupiter et al:

40 pts mean of 6.7 years FU

Step of >= 2mm = 100% xrays DJD

93% were symptomatic but

Only 1 pt with bilateral fx's stopped working

61% had a good or excellent result

2) Catalano et al

21 patients, young, mean 7.1 years FU
76% xray DJD
NO poor clinical outcomes

3) Forward et al
108 patients at 38 years
65% malunion rate
No reported limitation of activity, no salvage procedures
Intra-articular injury was predictive of xray changes and reduced wrist flexion

Radial height:

Radial shortening in cadaveric experiments had the greatest effect on DRUJ kinematics and distortion of the DRUJ
Compared to loss of radial inclination and palmar tilt

Clinical studies:

Prospective and retrospective found that shortening had the greatest effect on results
Should be the primary goal of surgery
>4 mm of shortening was associated with pain at 23 months

Ulna variance:

Greater variance correlates with ulna sided wrist pain
McQueen et al:
120 patients
Pro/ randomized trial
> 3mm of increased variance resulted in decreased grip strength

Radial inclination:

Loss is due to axial compression
Correlates with decreased grip strength
Loss > 10 degrees corelated with a worse DASH in one study

Dorsal/ palmar tilt:

Conflicting evidence on impact on clinical functional outcomes
Cadaveric studies:
Increasing dorsal tilt leads to worse incongruity of the RUJ, tightness of the interosseous membrane and limited rotation
Pressure distribution changes

Conclusions:

Unclear what acceptable x ray measurements are
Wide spectrum of injuries
Different study methodologies
Different parameters studied

Emphasized that these be used for active patients likely to use their wrists for ADL's where some strength is required
NOT for frail older patients

Grewel et al:
216 patients
Extra-articular fx's assessed at 1 yeart
Unacceptable: dorsal tilt > 10, radial inclination < 15, > 3mm ulna variance
Mal- alignment was associated with a higher risk of a poor outcome
But the impact diminished with age

Emphasized that the best data is associated with loss of radial length/ ulna variance:
Recommend restoring to within 2 mm of normal length
Effect of step off is less clear:
Leads to x-ray changes but does not necessarily affect function
2mm would be a sweet spot for those with high functional demands
Residual palmar/dorsal tilt:
Less clear
May be associated with loss of motion and strength

<u>Is it really necessary to restore radial anatomic parameters after distal radius fractures?</u>
Perugia D, Guzzini M, Civitenga C, et al
Injury 45S (2014) S21-26

Retrospective review
51 patients, volar plate, "articular unstable" DR Fx
Mean age: 53 years
Radial height
Radial inclination
Volar tilt
Ulnar variance
Avg FU:40.5 months

Unstable fx:
Dorsal tilt > 20 degrees
Initial displacement > 1 cm
Intra-articular "disruption"
Excluded:
Partial articular injuries AO B2

Outcomes: ROM, grip strength, DASH

84% recovered "completely" ROM compared to the other side:
F/E, sup/pro

8 patients did not:
Post op ulnar variance (0.7-1.5 mm) or volar tilt (7-15 degrees) was out of range
Had a stat difference in ROM and a worse DASH

All patients:
Had stat diff in grip strength: avg of 87% of the other side
Mean DASH: 12.2

Conclusions:
Restoring ulnar variance and volar tilt seem to be the key for restoring good functional outcomes
Small variations do not seem to affect outcome
Not over 17 degrees of volar tilt
27.5 degrees of radial inclination
17.3 mm of radial height
4 mm of ulnar variance

Predictors of unstable distal radius fractures: a systematic review and meta-analysis
Walenkamp M, Aydin S, Mulders M, et al J Hand Surg (EUR) 2016;41E(5):501-515

Systematic review to identify predictors of secondary displacement of DR Fx's
27 studies included: only included fractures treated non-op
Likely excluded the most unstable fx's from this analysis

Pooled results showed an increased risk for:
Dorsal comminution
Women
Age > 60

Pooled data shows NO increased risk for:
Associated ulna fracture
Intra-articular involvement

Defined un-acceptable parameters are:
>10 degrees dorsal angulation
>3mm radial shortening
Intra-articular step off

Quote a re- displacement rate of 64%

Lafontaine et al 1989 defined 5 factors predictive of instability:
>20 degrees dorsal angulation at presentation
Dorsal comminution
Intra-articular extension
Age > 60

Potentially unstable if >=3 if these are present
Studies have confirmed and refuted this

Pooled data defined predictors:
Female gender
Age > 6—65 years
Dorsal comminution

Pooled data defined NOT a predictor:
Associated ulna styloid fx
Intra-articular component
Noted that this could be due to the fact that patients with this might get operative treatment so there would be less severe fx's in the studies
Dorsal angulation > 15 degrees or > 20 degrees from neutral
Same might be true where these fractures are preferentially operated on

<u>Influence of cortical comminution and intra-articular involvement in distal radius fracture on clinical outcome: a prospective multicenter study</u>
Wadsten M, Buttazzoni G, Sjoden G, et al J Wrist Surg 2017;6:285-293

Dorsal comminution defined as:
Free floating piece of cortex
Fragments <= 3mm were not included

Acceptable alignment:
Volar tilt< 20 degrees
Dorsal titl < 10 degrees
Radial tilt > 10 degrees
+ ulna variance < 2mm
Joint step < 2mm

Fx's with acceptable alignment were placed into a SAC
Fx's without were reduced
Checked again at 10-14 days
If they displaced patients were offered surgery

Analysis showed that operative vs conservative rx did not affect: QuickDASH, EQ-5D, or grip

What is the predictive value of cortical comminution and intra- articular involvement on functional outcomes @ 1 year
406 patients from skeletal maturity to 74 years old
Initial unacceptable position correlated with:
Worse QuickDASH, EQ-5D, lower grip, and less ROM
Dorsal comminution was associated with:

Worse QuickDASH, reduced flexion and pro/sip
Volar comminution was associated with: Less extension

Intra-articular involvement was associated with: Less f/e, worse EQ-5D
Comminuted vs non-comminuted fx's:Sig effect on ROM
Older age and female gender (women in the study were older): Lower QuickDASH

Concluded the following affected clinical outcomes:
Initial fx position
Type of comminution
Intra-articular involvement

Initial fx position has the greatest effect on clinical outcome
Type of comminution and intra-articular involvement also affected outcome

Other studies showed these factors affect outcome:
Displacement at union, ligamentous injuries, fx comminution, age, patient education level, socioeconomic status, injury compensation

<u>Prediction of distal radius fracture displacement: a validation study</u>
Walenkamp M, Mulders M, van Hilst J, et al
J Ortho TR 2018;32:e92-96

Evaluate the Edinburgh Wrist Calculator at predicting re-displacement of DR Fx's
Included fx's with:
Initial dorsal angulation > 10 degrees
And/or ulna variance of > 3mm
Treated with CR/ cast between 2009-2014
EWC was not a good predictor

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ANZ J Surg 2019,

Do all fractures need surgery? How do I decide?

Ankle Fractures Indications for Surgery

Paul Tornetta III , MD

AAOS Symposium- Tuesday Feb 13, 2024

A. Principles

1. Congruence
2. Stability
3. Outcome
    a. Mortise at union
    b. Joint reaction forces

B. Isolated Malleolar Fractures

1 Medial Malleolus
    a. Weight bearing vs. not
    b. Pattern
        i. Supracollicular
        ii. Intracollicular
        iii. Anterior colliculus
    c. Displacement
        i. Periosteum interposed or not
        ii. Union needed or not

2. Lateral Malleolus
    a. Height
        i. Weber classification
        ii. LH classification
    b. Stability
        i. Deltoid in or out
        ii. Syndesmosis in or out

C. Bi- and Tri- Mallolar Fractures

1. Patient factors
    a. Age
    b. Activity level
    c. Neuropathy
    d. Potential compliance
2. Fracture considerations
    a. Displacement
    b. Position in cast

Do All Fractures Need Surgery? How Do I Decide?

Humerus shaft fractures in the young.

Robert F. Ostrum, M.D.
University or North Carolina – Chapel Hill
AAOS Symposium- Tuesday Feb 13, 2024

Humeral Shaft Fractures

Radial nerve injury 10-12%
- Operative management showed no improved recovery (Liu)
- Recovery not influenced by management,
- Should not wait for recovery > 6 mos (Shao)
- Early exploration _ GSW, assoc vascular injury, open fractures, penetrating wound
- Holstein Lewis - ? entrapment, can treat non-op

Floating elbow – high complication rate, suboptimal results

Non-op management – Fracture brace
- Indication - Closed, isolated fx
- Accept 15-20° angulation, < 30° rotational malalignment, up to 5 cm shortening
- Relative indications – Type A fxs, proximal 1/3, segmental, open fx, polytrauma
- Sarmiento – 620 fxs – open 25%, segmental 1%, radial nerve palsy 11%
    - 6% open, 1.5% closed fxs to nonunion
    - healing 9.5 weeks closed, 14 weeks open
    - 87% of 565 - <16° varus
    - 81% of 546 - <16° anterior angulation
    - 89% lost <10° shoulder motion, 92° lost <10 ° of elbow motion, ? loss of shoulder ER but better with PT
- Higher nonunion rate – proximal 1/3, type A, increase gap (Papasoulis)
- Lack of bridging callus at 6 weeks (Papasoulis, Oliver, Neuhaus)
- Return to function for SF-36 and return to work (62%) at 24 weeks – Cannada

Operative Treatment
- Indications – unsatisfactory closed treatment, polytrauma, floating elbow, intra-articular extension, vascular injury, progressive nerve injury, neurologic injury after penetrating trauma, pathologic fx
- Plate fixation
    - Approaches
    - Anterolateral approach for proximal and midshaft fxs
    - Brachialis split – radial and musculocutaneous innervation
    - Posterior approach for middle, distal third or radial nerve exploration
    - Split, paratricipital

- Radial nerve pierces lateral IM septum at 10 cms from lateral epicondyle
- 4.5 narrow DCP, 6-8 cortices on each side of fracture
- 96 fxs treated with 3.5 plate, 3 plate failures, 97.5% union at 17 weeks (Idoine)
- pre-bend for transverse fracture, long bridging plate for comminution
- bicortical locking screws for osteoporotic bone
- early ROM, WB on arm safe with 94% of 83 fxs healing with WB depending on other injuries not fracture pattern (Tingstad, Wolinsky)
- Plating union rate >95% with contemporary fixation
- Complications – radial nerve palsy (2-5%) usually neurapraxia, infection (closed fx 1-2%, open fx 2-5%)

- **<u>Intramedullary Nailing</u>**
  - Antegrade around greater tuberosity,
  - Antegrade nails, distal interlocking anterior to posterior
  - Antegrade nails can cause significant rotator cuff injury
  - 5-33 % chronic shoulder pain
  - Retrograde from supracondylar region – locking, flexible options
  - Flexible nails with complications – backing out, loss of axial stability
  - 91% union rate but intra-op complications, 2% poor elbow function

-Comparing plating vs non-op

Author	Number	Nonunion	Malunion	Radial Nerve Palsy	DASH 3 mos 6 mos	Time to union months
Denard 2010 Non-op	34	24% *	12.7% *	9.5%		4.76
Plating	82	8.7% *	1.3% *	2.7%		4.87
Cannada 2018 Non-op	57	11%		14%	35 20	
Plating	45	2%		13% + 13%	28.8 18.3	
Mahdi 2019 Non-op	30	2			26.7	19 weeks *

Plating	30	0			29.1	14 weeks *

- No evidence available in literature
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- Clement ND, Systematic Review 2015

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