Acute Clavicle Fractures: Why are we fixing them and how?

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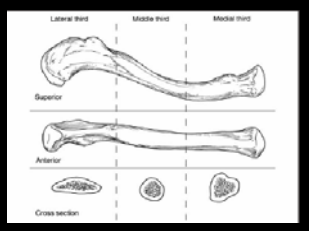
Clavicle Fractures

- Account for 2.6% to 5% of all fractures
  - ***Mid-shaft clavicle fractures account for 69% to 82% of all clavicular fractures***
- Incidence is 71 per 100,000 in men and 30 per 100,000 in women

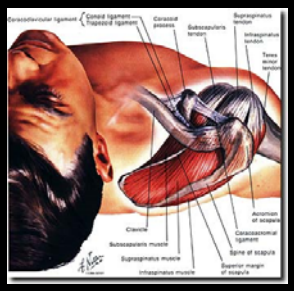
Clavicle Anatomy

- Clavicle is S-shaped and double curved
- Flat laterally to Triangular medially
- Convex on its medial side and concave laterally



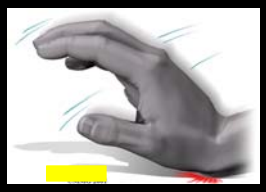
Clavicle Anatomy

- ***Junction of outer and middle thirds is the thinnest part of the bone (A → P)***
  - Area not protected by or reinforced with muscle and ligamentous attachments
  - ***Prone to fracture***



Mechanism of Injury

- ***Direct fall or blow*** to the shoulder accounts for 85 to ***94% of injuries***
- Forces transmitted through the arm during a fall on an outstretched arm
  - Not delivered directly to clavicle
  - Only accounts for 2 to 5% of all mid-shaft fractures



Neer CS, 1960

- Non-union in 3 of 2235 midshaft clavicle fractures treated non-operatively
- Overall non-union rate reported as <1%

!

This figure dominated clavicle fracture management for years

- "They all heal."
- "Surgery causes non-unions."
- "The functional results are great."
- "Join the painless non-union society."
- "You are just trading a bump for a scar."

Is a 1960 patient the same as a 21st century patient?




21st Century


21st Century

- People are much more athletic
- Expectations are higher
- Modern biologic fixation techniques and implants
- We have validated outcome measures

UNION IS NOT THE ONLY VARIABLE

What are the results of treatments?

Conservative Treatment

- Andersen et al (1987) compared figure of eight bandage vs. a simple sling
- *Figure of eight bandage*
  - *Increased complications such as pain, edema, paresthesias, DVT of the UE*
- Simple sling
  - Less discomfort and fewer complications

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Conservative Treatment

- Andersen et al (1987)
  - Patients in sling group more satisfied with treatment
  - ***No difference***
    - *Functional result*
    - *Cosmesis*
    - *Alignment*

Conservative Treatment

Hill et al. (1997)
52 pts: avg f/u 38 months

- 15% nonunion
- 31% unsatisfactory results
- 25% require pain Rx
- 30% residual paresthesia
- 54% unpleased w/ cosmesis

Conservative Treatment

Hill et al. (1997)

- ***Initial** shortening >2 cm* associated with ***NONUNION***
- Final shortening > 2 cm with unsatisfactory results
- Authors recommend ORIF of severely displaced clavicle fractures

Conservative Treatment

Hill et al. (1997)

- Initial shortening >2 cm associated with nonunion
- ***Final** shortening > 2 cm* with *UNSATISFACTORY RESULTS*
- Authors recommend ORIF of severely displaced clavicle fractures

Conservative Treatment

Hill et al. (1997)

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- **Final** shortening > 2 cm with unsatisfactory results
- ***Authors recommend ORIF of severely displaced clavicle fractures***

Conservative Treatment

Nordqvist et al (1998)

	n	Good	Fair	Poor
Undisplaced fractures	71	66 (93%)	5 (7%)	0 (0%)
Displaced two fragment fractures	69	57 (83%)	11 (16%)	1 (1.4%)
Displaced comminuted fractures	85	62 (73%)	23 (27%)	0 (0%)
All fractures	225	185 (82%)	39 (17.3%)	1 (0.4%)

Conservative Treatment

- ***Previous studies*** looking at clavicle fractures used surgeon based or x-ray outcome measures
  - ***Equate union with success***
- Newer studies have begun to use patient based outcomes:
  - SF 36
  - DASH
  - Constant score

Conservative Treatment

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- ***Newer studies*** have begun to use ***patient based outcomes:***
  - SF 36
  - DASH
  - Constant score

Conservative Treatment

- Are patients really doing as well as previously reported in the literature?

Conservative Treatment

Nowak et al. (2004) – 208 pts

- Nonunion (7%)
- Some form of sequelae (46%)
- ***Patients with continued symptoms***
  - Comminuted fractures
  - Older patients
  - Complete displacement

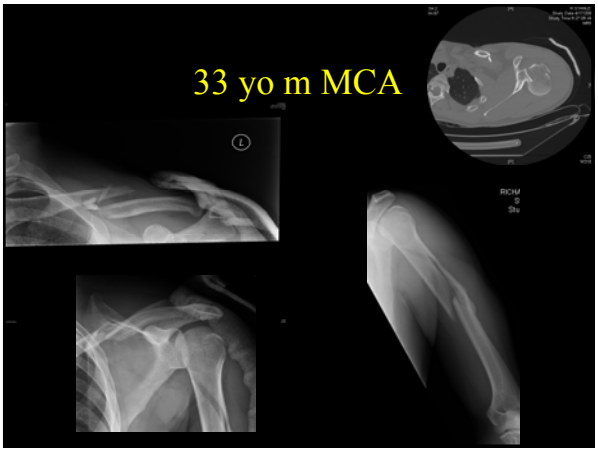
Conservative Treatment

- Lazarides et al (2006)
  - 132 pts
  - Relevance of shortening?
  - ***(25.8%) were dissatisfied with the result of their management***
    - **>18mm males**
    - **>14mm females**

Conservative Management

- McKee (2006 JBJS)
- 30 non-op tx'd displaced clavicle fxs (avg 55mo FU)
  - 67-85% strength ± endurance compared to contralateral
  - Constant score 71
  - DASH 24.6
- ***Conclusion:***
  - ***Residual disability***
  - ***Correlation w/ loss of muscle strength often unrecognized by physicians***

33 yo m MCA



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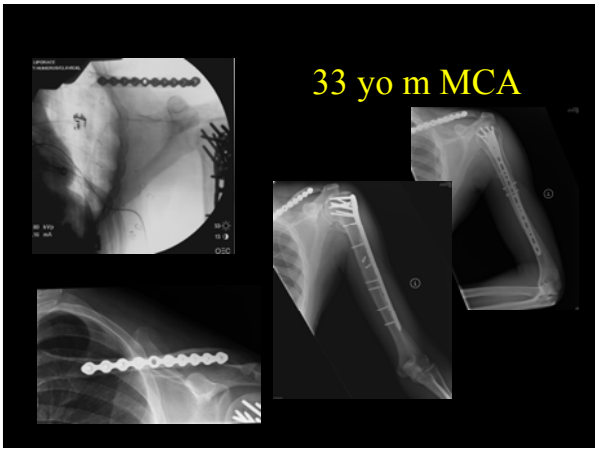


Is the non-union rate really less than 1%?

Probably NOT!

- Robinson *et al* JBJS 2004
- Brinker *et al* JBJS 2005
  - *–15-20% NONUNION RATES FOR DISPLACED FRACTURES*
  - – Can be as high 47% in displaced comminuted fractures in women!

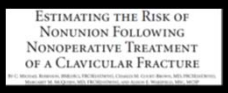
Nonunion risk

- Hill 1999: 15%
- Smith 2000: 14%
- Robinson 2003: 21%
- McKee 2003: 18%
- Virtanen 2012: 50%

Diaphyseal Clavicle Fractures

- Nonunion risk?
  - Robinson, JBJS 2004 → 4.5%
    - Advancing age
    - 100% displacement
    - Comminution
    - Female gender

    → 20%



Meta-analysis 2144 fractures

Zlowodzki *et al* JOT 2005

- Non-union rate 15.1% for DISPLACED non-op tx
- Patients prefer sling for non-op
- Plate fixation reduced risk of non-union
- Antero-inferior plating better tolerated
- IM fixation may have less unions than plates
- ***Displacement, age, comminution and female gender predictive of non-union and dysfunction***

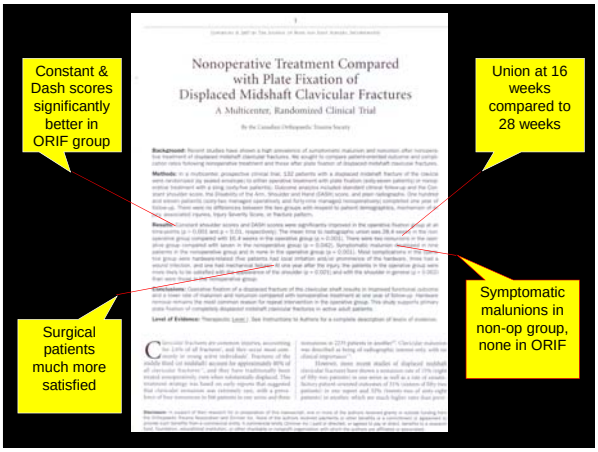
Diaphyseal Clavicle Fractures

- Well….
  - Virtanen et al:
  - Randomized trial plate vs sling
  - At one year, no difference in Constant, DASH, or pain scores between groups
  - 24% nonunion in nonop patients.
  - 0% in op group
- Displaced <1.5 **CLAVICLE DIAMETER**, no nonunion
- Displaced >1.5 **CLAVICLE DIAMETER**, 50% nonunion

Virtanen et al: JBJS 94A 1546-53, 2012

Non-operative treatment does not give universally great results.

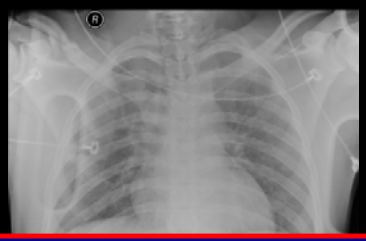
But is surgery better?



Plating vs. Non-op

- Union rates better (not statistically signif)
- Sxs w/ malunion problem in non-op group (9/49)
- 1 year, operative pts. much more satisfied w/appearance & function

21 yo s/p MVA w/ non-op C-spine injury in Miami-J collar



POTENTIAL FOR INSTABILITY!

21 yo s/p MVA w/ non-op C-spine injury in Miami-J collar

Comes for Spine office follow-up 2 wks s/p injury!

21 yo s/p MVA w/ non-op C-spine injury in Miami-J collar

Comparative Studies

- ***Complications in operative group 23/62 (37%)***
  - 5 with hardware complaints
  - 3 wound infections
  - 1 mechanical failure
  - 8 *transient* brachial plexus symptoms
  - 2 abnormalities of AC or SC joint
- Complications in non-op group 31/49 (63%)
  - 1 developed complex regional pain syndrome
  - 7 transient brachial plexus symptoms
  - 3 abnormality of AC or SC joint

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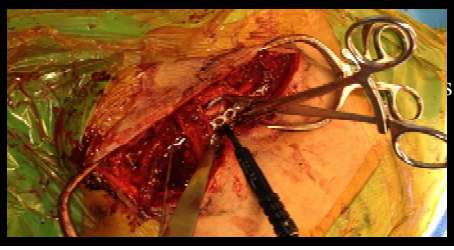
Does surgery cause non-unions?

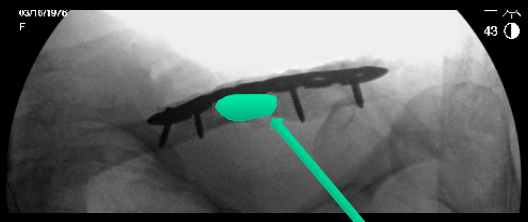
Probably NOT!

- Modern 'biology friendly' methods gives excellent union rates with surgical treatment!
-

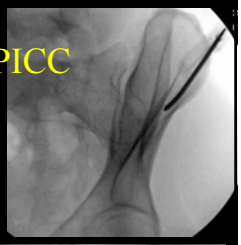


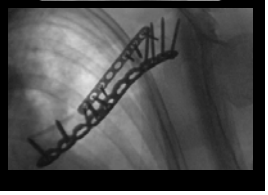
But it can…

What to do…



After 6 wks PICC



1.5 years Full Function / No Pain

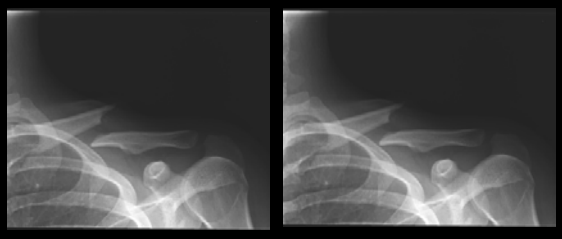

Does a clavicle malunion impact function?
(Is this more than a cosmetic issue?)

YES!

And function aside, would you want to look like this?

Operative Fixation

19 yo female s/p MVA w/ DR fx



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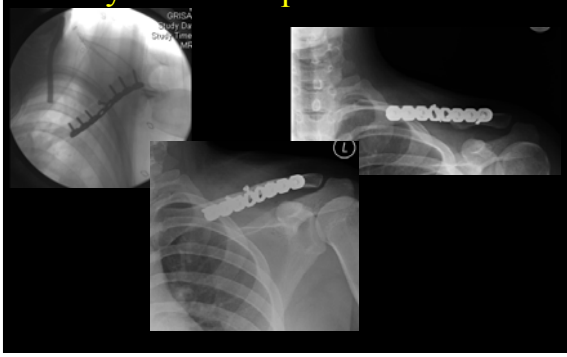


Operative Treatment

- Variety of methods used
  - Intramedullary fixation
  - Open reduction and plate fixation
    - Superior
    - Anterior-inferior
    - Pre-contoured
  - External fixation

Intramedullary Fixation

- Many variations of IM fixation have been described over the past 40 years including
  - Kirschner Wires
  - Hagie Pins
  - Knowles Pins
  - Elastic Nails
  - Cancellous Screws
  - Rockwood Clavicle Pin

Intramedullary Fixation

Study	IM Type	Union	Non Union	Complications/Results
Ngarmukos et. al (1998)	K-Wires	110/110	None	6 sup. wound infections, 3 hardware migration (wires removed before union), 8 frozen shoulders Hardware removed in 89/110 No functional results reported
Chu et al. (2002)	Knowles pins	77/78 (3 pts w/ delayed union- 9, 9 and 15 months)	1/78	2 prominent hardware (required revision), 1 loss of fixation (required revision) Avg shoulder function 97% vs. contralateral side
Chuang et al. (2006)	Cannulated Screws	30/31 healed by 12 weeks, 1 patient healed at 18 wks	None	1 superficial wound infection No implants removed 29/31 excellent result, 1 good, 1 fair (delayed union)

Intramedullary Fixation

Study	IM Type	Union	Malunion/ Non Union	Complications/Results
Jubel et. al (2003)	Flexible Titanium Nail	57/58	1 nonunion (had revision w/ bone graft and plate fixation)	3 hardware prominence (underwent revision), 2 hypertrophic scar, 1 shortening of 1.5cm (comminuted fracture) Hardware removal at 8 mos in all pts Significant ↓ in pain and improved shoulder function at 3 days post op, Constant score 98 (100 max)
Kettler et al. (2007)	Flexible Titanium Nail	80/87	3 malunions, 4 nonunions (underwent revision- 2 healed, 2 persistent non unions	4 hardware migration (nails removed early), 4 hardware prominence, 4 hypertrophic scars, 2 pain Hardware removed in 82/87 pts Constant score 84 (100 max) DASH 6.4 (0-43, 0 = no dysfunction)

Plate Fixation

Plate Fixation

- Bostman et al (1997) studied plate fixation in fresh displaced clavicle fractures
- 103 pts with treated with Synthes AO/ASIF plates
  - 79/103 pts did well
  - ***24/103 (23%) suffered one or several complications***

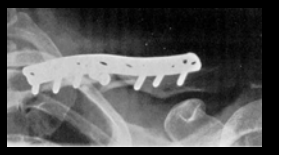


Plate Fixation

Bostman et al (1997)

- Complication risk increased by
  - Severely comminuted fracture (rr 5.15)
  - Alcohol intoxication on admission (rr 3.12)

Plate Fixation

Bostman et al (1997)

- Many fixed w/ tubular plate ????
- All fixed on superior surface

Conclusions: *"**Patient noncompliance** with the postoperative regimen could be suspected to have been a **major cause of the failures**… The method **should be reserved for patients who have trustworthy personal motives** for quick pain relief and recovery."*

Plate Fixation

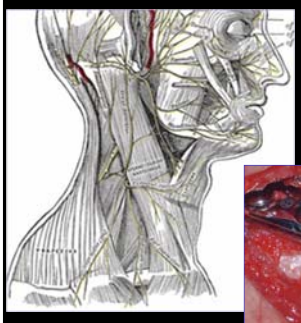
- Shen et al. (1999) studied plate fixation in fresh mid-shaft clavicle fractures
- ***3.5mm recon plates***
- 232 pts followed 4.4 years
  - 7/232 developed a nonunion
  - 14/232 developed a malunion
  - ***94% satisfied with overall results***

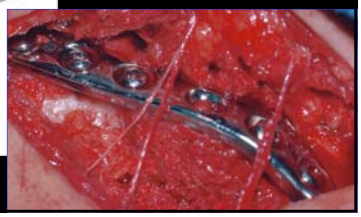
What about pre-contoured plates?

- Huang (2007 JBJS)
  -100 pairs cadaver clavicles
  -Max superior bow 37.2mm from AC jt
  -Mean magnitude 5.1mm ± 5.9mm

-Best fit: AA males
-Worst fit: Caucasian females
-More consistent Medially
-More variability Laterally

What to look out for…





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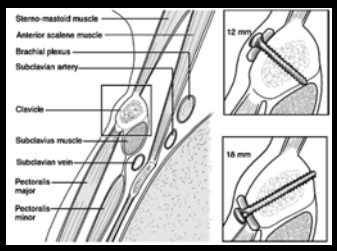
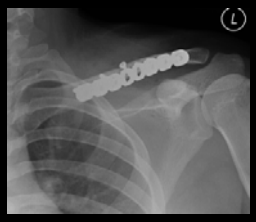


Any differences in where the plate is placed?

- Collinge et al (2006 JOT)
  - 58 patients (≥24 mo FU)
  - Acute fxs and Nonunions
  - Union
    - 9.5 wks acute fxs
    - 10.5 wks revision nonunions
  - ASES & SF-36 good or excellent in all w/o nerve injury



Any difference in plate type?

- Liporace et al (JOT 2012)
  - 2.7mm vs 3.5mm (anterior)
  - No Difference
    - DASH, Constant
    - Time to union
    - Rate of union
  - 2.7mm
    - Lower re-op rate
    - Higher patient satisfaction w/ cosmesis

Anteroinferior 2.7-mm versus 3.5-mm plating of the clavicle: A biomechanical study

Nicholas Pulos[a], Richard S. Yoon[b], Snehal Shetye[c], Michael W. Hast[c], Frank Liporace[b], Derek J. Donegan[d,*]

- 2.7mm vs 3.5 mm
- Higher axial & Torsional loading with 3.5
- NO FAILURES under physiologic load with cycling in either group

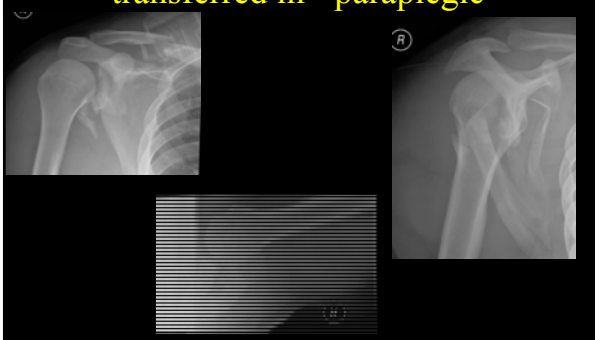
Any difference in delayed vs acute ORIF?

- Potter JM & McKee M (2007 JSES)
  - 15 acute vs delayed ORIF
  - No difference
    - Strength FF, abduction, ER
    - DASH score
  - Acute ORIF w/ better
    - Muscle endurance in FF
    - Constant score

Does correction of malunion help?

- McKee (2004 JBJS)
  - 15 patients
  - Avg shortening 2.9cm
  - Presented btw 1 and 15 yrs
  - F/U 20 months avg
  - ***Significant improvement in:***
    - ***DASH score***
    - ***Decreased shortening avg. 4 mm***

30 year old 3 weeks s/p MCA transferred in - paraplegic



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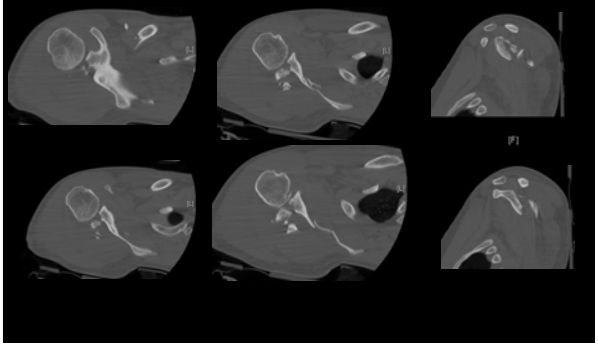

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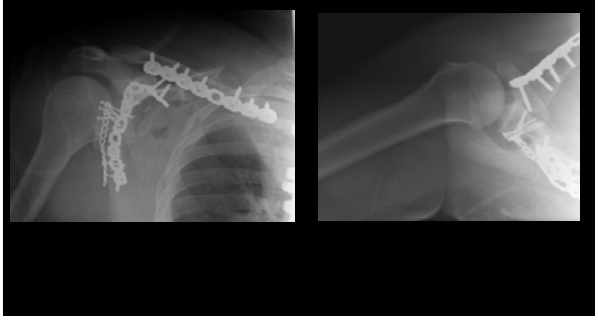

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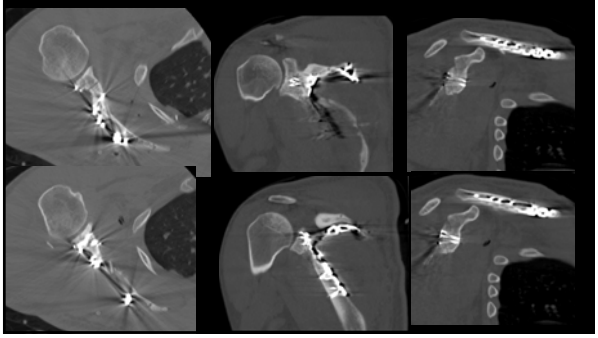

Conclusions

- Literature - variable quality
- Newer EBM and outcome studies support ORIF:
  - Shortened fractures
  - Severe displacement
  - Significant comminution
  - ? Floating Shoulder
- Plating may be preferable to intramedullary fixation
  - Anterior-inferior plating may be less symptomatic

Conclusions

Very important to understand the indications

&

Have an educated conversation w/ pts in the

21st century!!!


THANK YOU