Humeral Diaphyseal Fractures: Which Ones to Fix and Selecting the Right Approach

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Objectives

- To review the current evidence
- To identify **patients** at risk for nonunion
- To identify **fracture patterns** at risk for nonunion
- To recognize the importance of early intervention
- To review surgical approach and tips and tricks

Clinical Case

45 year old female

BMI = 30.5

Right hand dominant

Nonsmoker

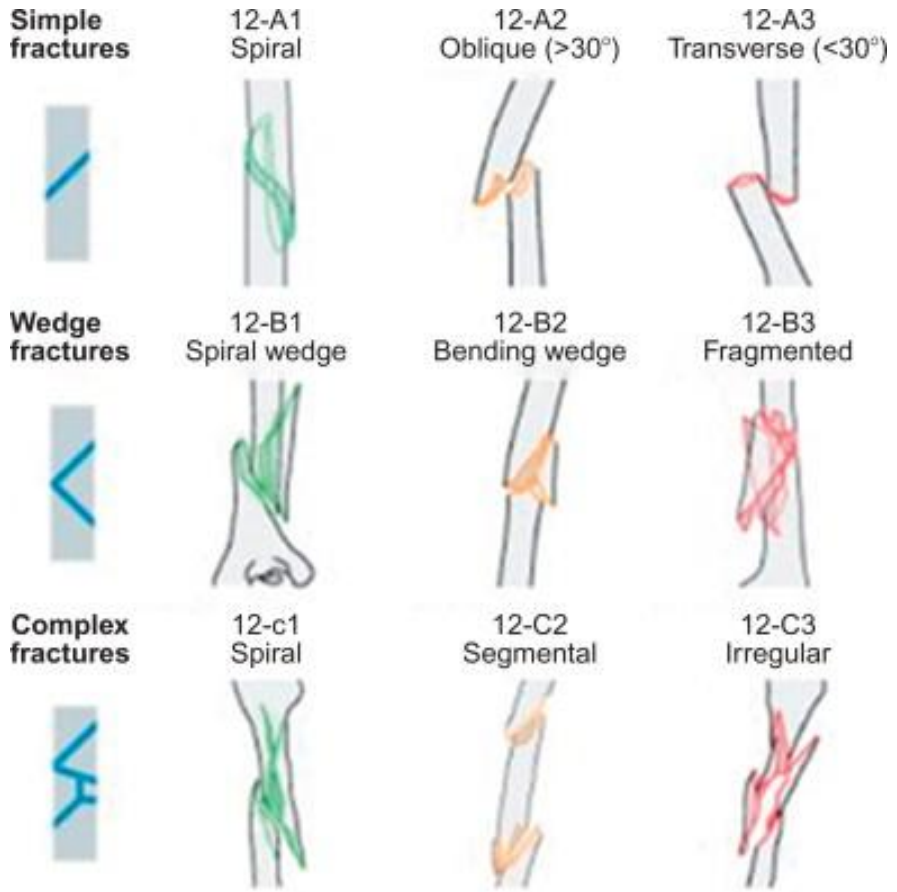
Current Evidence

- Fractures of the humeral diaphysis occur in a bimodal distribution and represent 3 to 5% of all fractures
- Humeral diaphyseal fractures were historically treated non-operatively using splints, braces, slings
  - **Nonunion rates reported up to 33%**
- Many studies are limited by retrospective study designs, lack of PROMs, poor follow-up, non-randomization, small sample sizes

Current Evidence – COTS Trial

- **Study Design:** Multicentre randomized controlled trial across 12 participating sites

- **Inclusion Criteria**
  - 18 years or older with skeletal maturity
  - Displaced humeral diaphyseal fracture (AO/OTA 12-A, B, C)
  - Fracture amenable to both treatments
  - Within 21 days from injury
  - No additional injuries to the extremity



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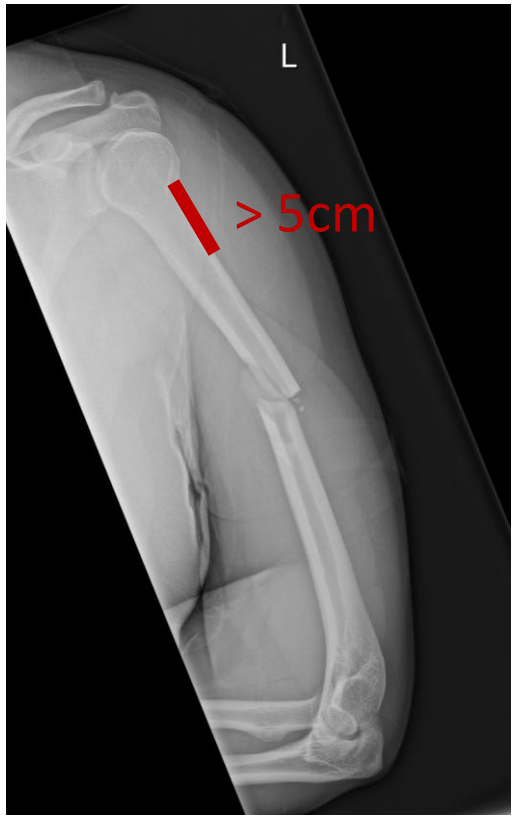
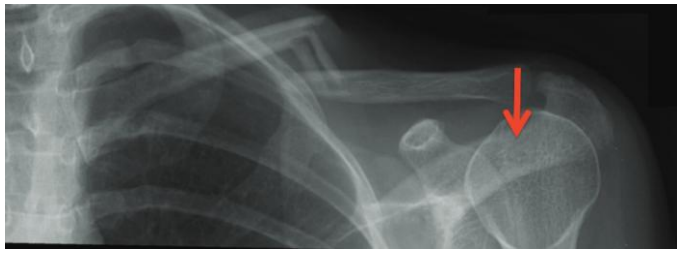


Current Evidence – COTS Trial

- **Exclusion Criteria:**
  - Open fracture
  - Neurovascular injury **requiring repair**
  - Active infection at the surgical approach site
  - Prior injury, degenerative conditions, or congenital conditions to the affected extremity
  - **Polytrauma with other extremity fractures**
  - Metabolic bone disorder that may impair healing
  - Pathologic fracture
  - Unable to attend follow-up



Current Evidence – COTS Trial

- **Primary Outcome:** Disability Shoulder, Arm, Hand (DASH) score
  - Constant Shoulder Score
  - Short Musculoskeletal Functional Assessment (SMFA)

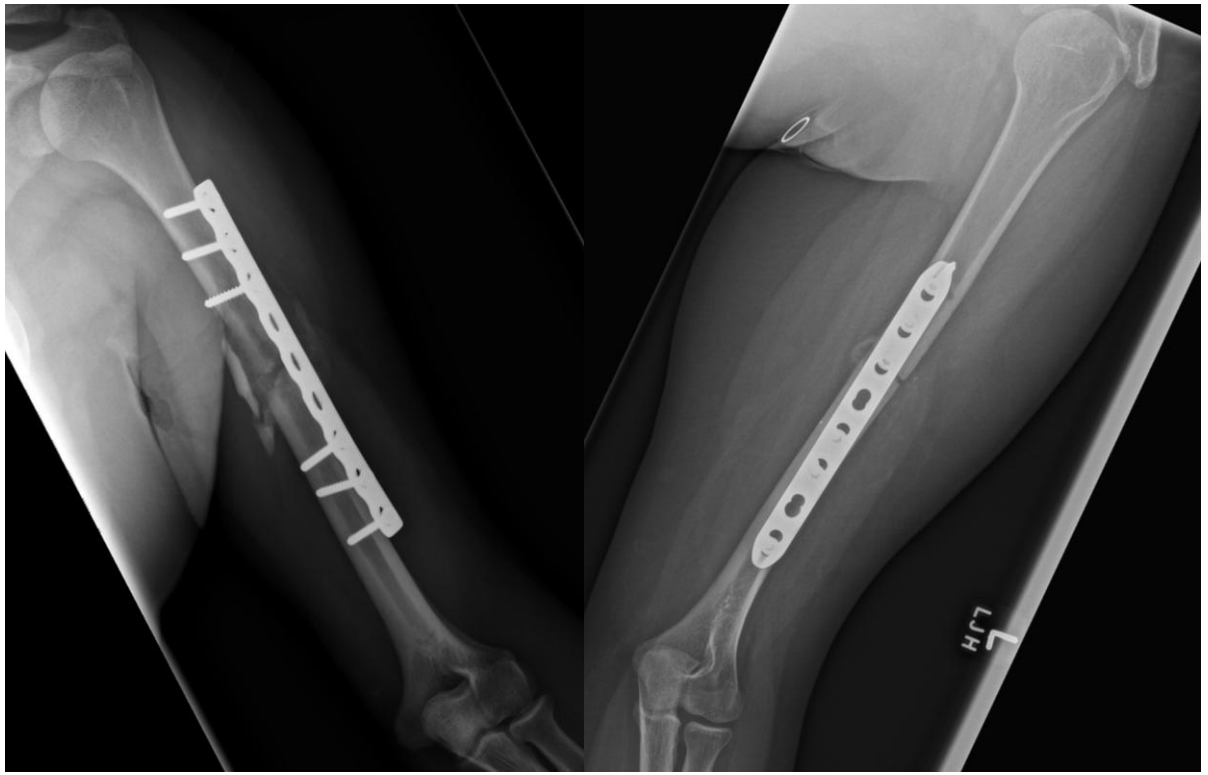
- **Secondary Outcomes:**
  - **Clinical**
    - Range of motion
    - Complications
  - **Radiographic**
    - Time-to-union
    - Angulation

	Baseline	2 weeks	6 weeks	4 months	6 months	12 months
DASH / SMFA	✓	✓	✓	✓	✓	✓
Constant Score			✓	✓	✓	✓
Clinical evaluation		✓	✓	✓	✓	✓
Radiographic evaluation	✓	✓	✓	✓	✓	✓

Current Evidence – COTS Trial

- **Randomization:** Block permuted, variable block sizes, stratified by site

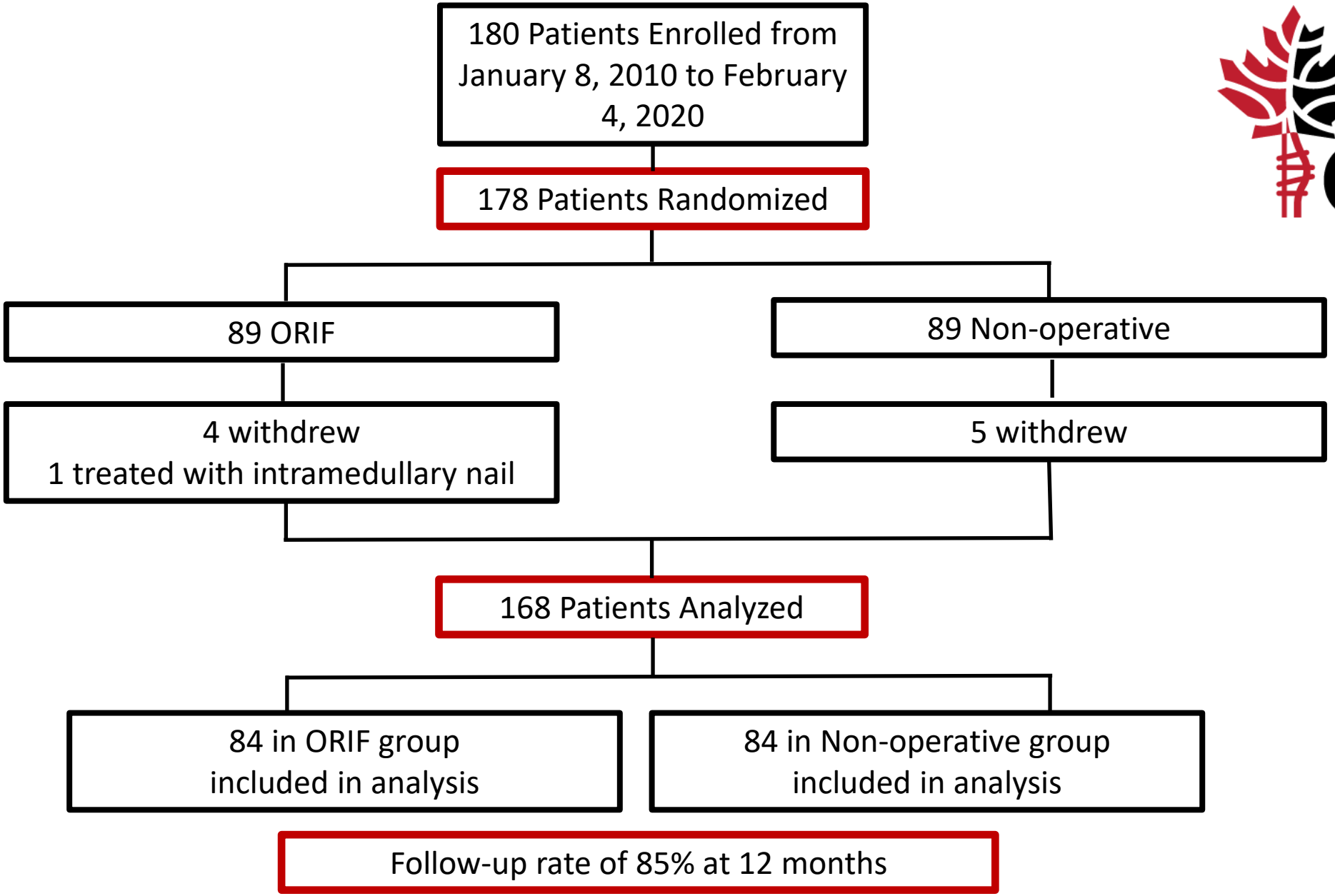
- **ORIF**
  - 3.5mm or 4.5mm plate
  - Splinting or sling for 7-10 days
  - Standardized physiotherapy included
    ROM at 10-14 days, then strengthening
    by 6-8 weeks as tolerated



Current Evidence – COTS Trial

- **Randomization:** Block permuted, variable block sizes, stratified by site

- **Non-operative**
  - Sugartong splint for 10-14 days
  - Functional brace until evidence of healing
  - Standardized physiotherapy included ROM at 2 weeks after functional brace applied, with strength measured beginning at 6 weeks

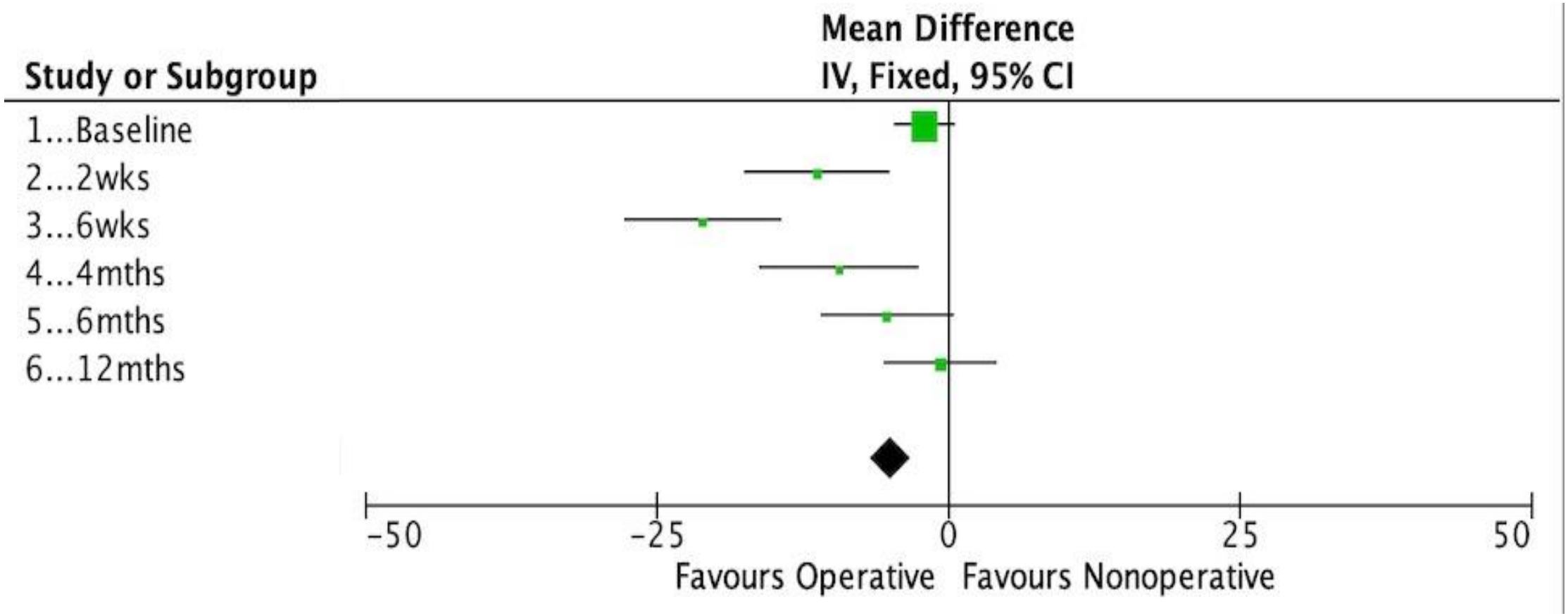


CANADIAN ORTHOPAEDIC TRAUMA SOCIETY
COTS

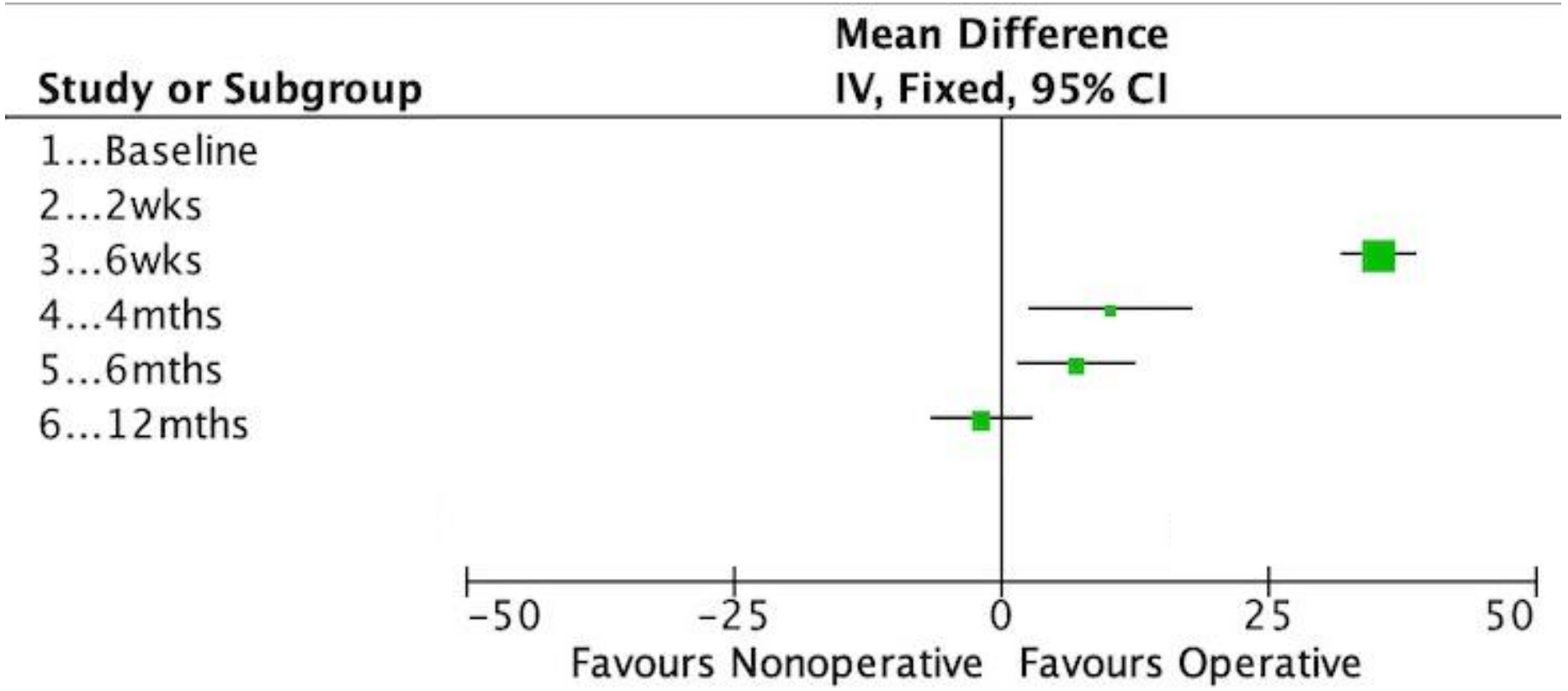
	ORIF (N=84)	Non-operative (N=84)	p-value
Sex			
Female	33 (39.3%)	32 (38.1%)	0.87
Male	51 (60.7%)	52 (61.9%)	
Age, years			
Mean (SD)	41.7 (17.2)	45.4 (16.5)	0.16
Median [Min, Max]	38.5 [18.0, 77.0]	47.0 [18.0, 86.0]	
Smoker			
Former smoker	17 (20.2%)	19 (22.6%)	0.74
Non-smoker	49 (58.3%)	50 (59.5%)	
Smoker	18 (21.4%)	14 (1.2%)	
BMI			
Mean (SD)	27.2 (6.2)	27.8 (8.7)	0.64
Median [Min, Max]	26.0 [14.5, 52.4]	26.6 [2.61, 61.7]	
Missing	3 (3.6%)	2 (2.4%)	
Previous Conditions			
0	33 (39.3%)	34 (40.5%)	0.08
1	51 (60.7%)	50 (59.5%)	
AO-OTA Classification			
12-A	60 (71.4%)	70 (85.4%)	0.93
12-B	23 (27.4%)	10 (12.2%)	
12-C	1 (1.2%)	2 (2.4%)	

CANADIAN ORTHOPAEDIC TRAUMA SOCIETY
COTS

Results - DASH



Results – Constant Shoulder Score



Current Evidence – COTS Trial

- For isolated, closed humeral diaphyseal fractures:
- **ORIF:**
  - Low incidence of iatrogenic nerve injury (1.2%), or infection requiring surgery (1.2%)
  - Early shoulder strength, ROM, radiographic alignment will be improved
  - Strength and ROM will be limited for 4 months

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- **ORIF:**
  - Low incidence of iatrogenic nerve injury (1.2%), or infection requiring surgery (1.2%)
  - Early shoulder strength, ROM, radiographic alignment will be improved

- **Non-operative:**
  - Fracture union may take 4-6 months
  - 13.1% chance of non-union, requiring surgery
  - Strength and ROM will be limited for 4 months

ORIF provides earlier functional recovery and more rapid fracture healing

Risk Factors for Nonunion

- Reported risk factors for non-union have included:
  - Current smoking status
  - Increased age
  - Elevated BMI
  - Unstable fracture patterns
  - Non-operative treatment

Rämö, L. et al., JAMA Surgery, 2020; Cannada et al., J. Surg. Orthop. Adv. 2021; Ring et al., J Trauma. 2007; Ekholm et al., J Orthop Trauma. 2006; van de Wall et al., J Shoulder Elbow Surg. 2020.

Patients at Risk for Nonunion

- 13 nonunions
  - 11 in the non-operative group (13.1%)
  - 2 in the ORIF group (2.4%)
- Logistic regression model for non-operative group:

Predictor	Odds Ratio	95% Confidence Interval	p-value
Age	1	0.96 – 1.05	0.861
Sex (female)	3.23	0.74 – 17.24	0.132
Body Mass Index (BMI)	1.16	1.04 – 1.33	**0.014**
Smoker [Former Smoker]	0.66	0.66 – 4.62	0.698
Smoker [Non-smoker]	1.41	0.18 – 7.91	0.707

- 8.6% nonunions in former smokers
- 9.4% nonunions in current smokers
- 7.0% nonunions in nonsmokers

Fractures at Risk for Nonunion

- 13 nonunions
  - 11 in the non-operative group (13.1%)
  - 2 in the ORIF group (2.4%)

- All non-unions occurred in simple AO/OTA A-type fractures:
  - A1 = 38.5%
  - A2 = 23.1%
  - A3 = 38.5%

Risk factors for nonunion:

Elevated BMI

Simple fracture patterns

Fractures at Risk for Nonunion

- All 11 patients with non-unions in the non-operative group underwent surgical intervention
  - ORIF without bone graft (n = 7)
  - ORIF with iliac crest bone graft (n = 5)

- Average time to surgical intervention
  - 18.3 (± 10.5) weeks




Poor Function with Nonunion

DASH Score

- Significantly worse (higher) scores at all timepoints for those who were initially treated non-operatively and went on to non-union requiring surgical intervention

	Union in Non-operative Group	Non-union in Non-operative Group	p-value
2 weeks	66.7 (17.8)	80.3 (10.8)	**0.004**
6 weeks	53.2 (21.2)	70.7 (20.6)	**0.038**
4 months	27.2 (23.4)	54.1 (20.7)	**0.002**
6 months	16.5 (18.4)	42.3 (28.1)	**0.036**
12 months	8.2 (13.5)	31.4 (25.2)	**0.036**

Poor Function with Nonunion

Constant Shoulder Score

- Significantly worse (lower) scores at all timepoints for those who were initially treated non-operatively and went on to non-union requiring surgical intervention

	Union in Non-operative Group	Non-union in Non-operative Group	p-value
6 weeks	26.6 (15.5)	10.8 (6.7)	**< 0.0001**
4 months	60.2 (23.6)	31.7 (24.2)	**0.005**
6 months	74.8 (17.2)	43.6 (21.8)	**0.002**
12 months	83.6 (14.4)	67.1 (16.2)	**0.036**

Early Identification of Nonunion Risk

- COTS study non-union rate was low (13.1%)
  - **FISH trial 25% non-union rate** in non-operative group (30% required surgery)

- **Risk factors for non-union** with non-operative treatment
  - Elevated BMI
  - Simple fracture patterns

- Significantly worse PROMs at all timepoints when initially treated non-operatively and went on to nonunion requiring surgery
  - Early identification of risk for non-union is important in guiding decision-making

Clinical Case

45 year old female

BMI = 30.5

Right hand dominant

Nonsmoker

2-week Follow-up

Clinical Case

45 year old female

BMI = 30.5

Right hand dominant

Nonsmoker

6-week Follow-up

Clinical Case

45 year old female

BMI = 30.5

Right hand dominant

Nonsmoker

4-month Follow-up

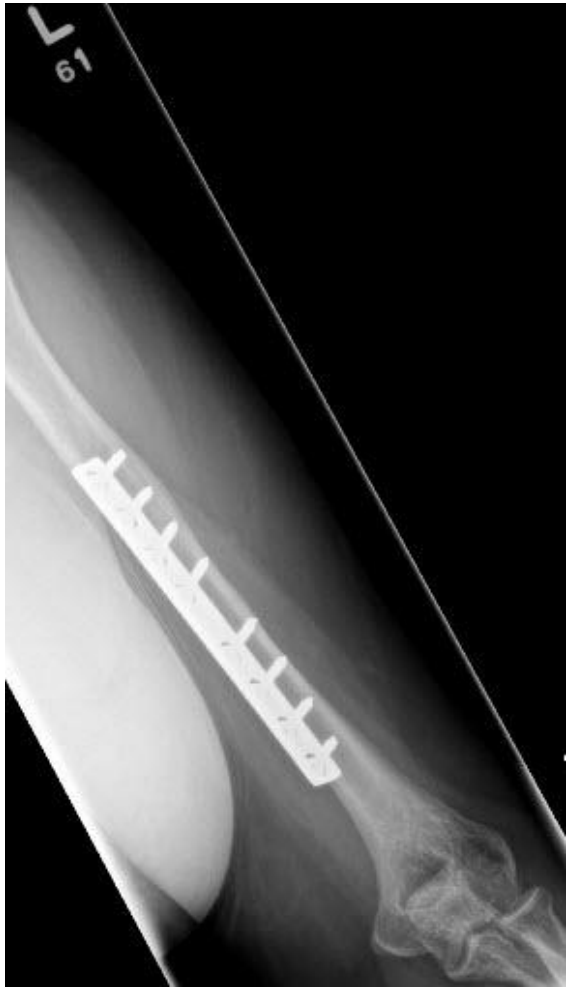
Clinical Case

45 year old female

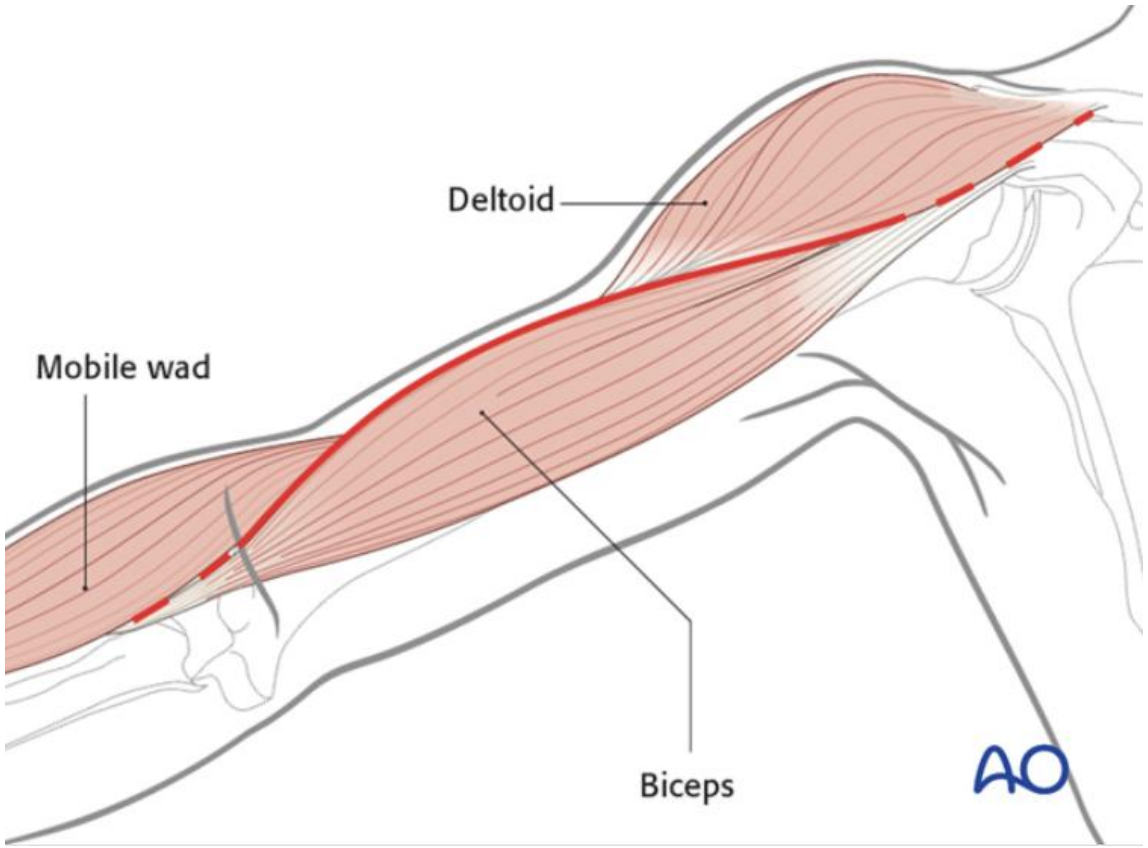
BMI = 30.5

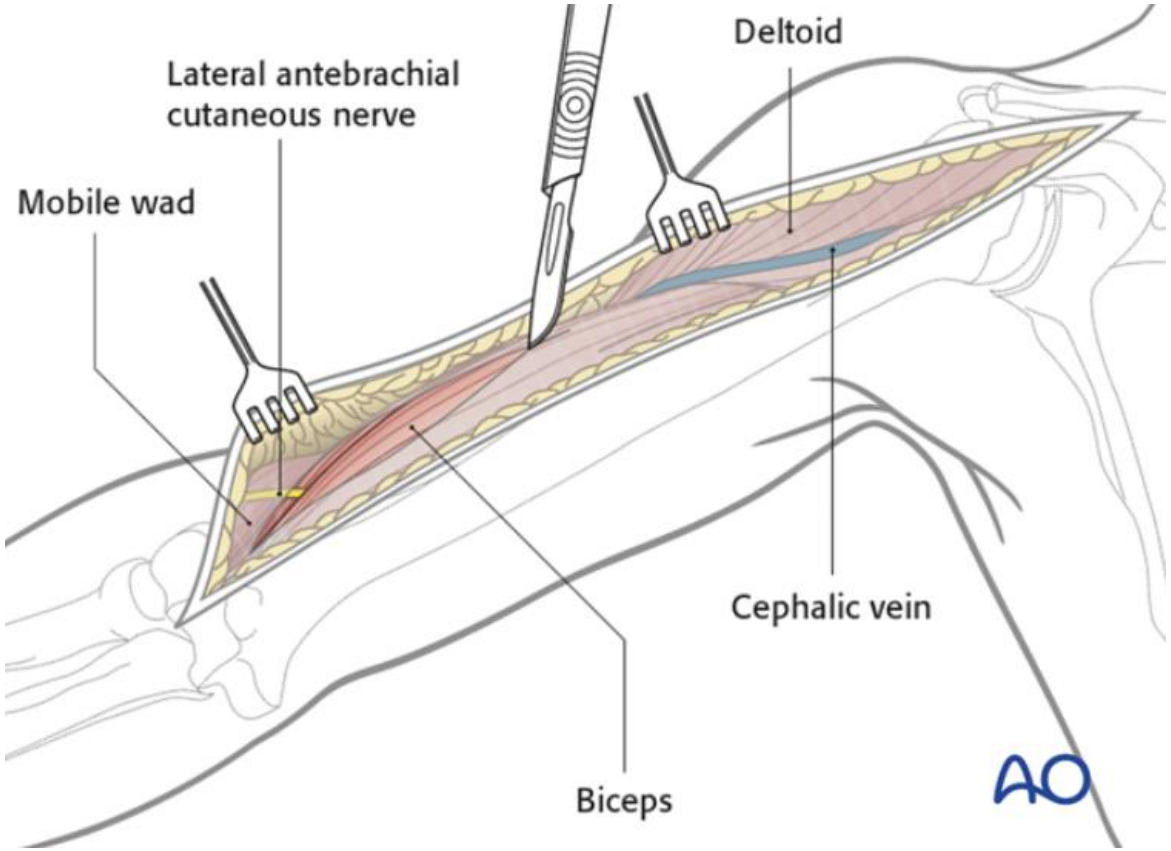
Right hand dominant

Nonsmoker



Surgical Approach





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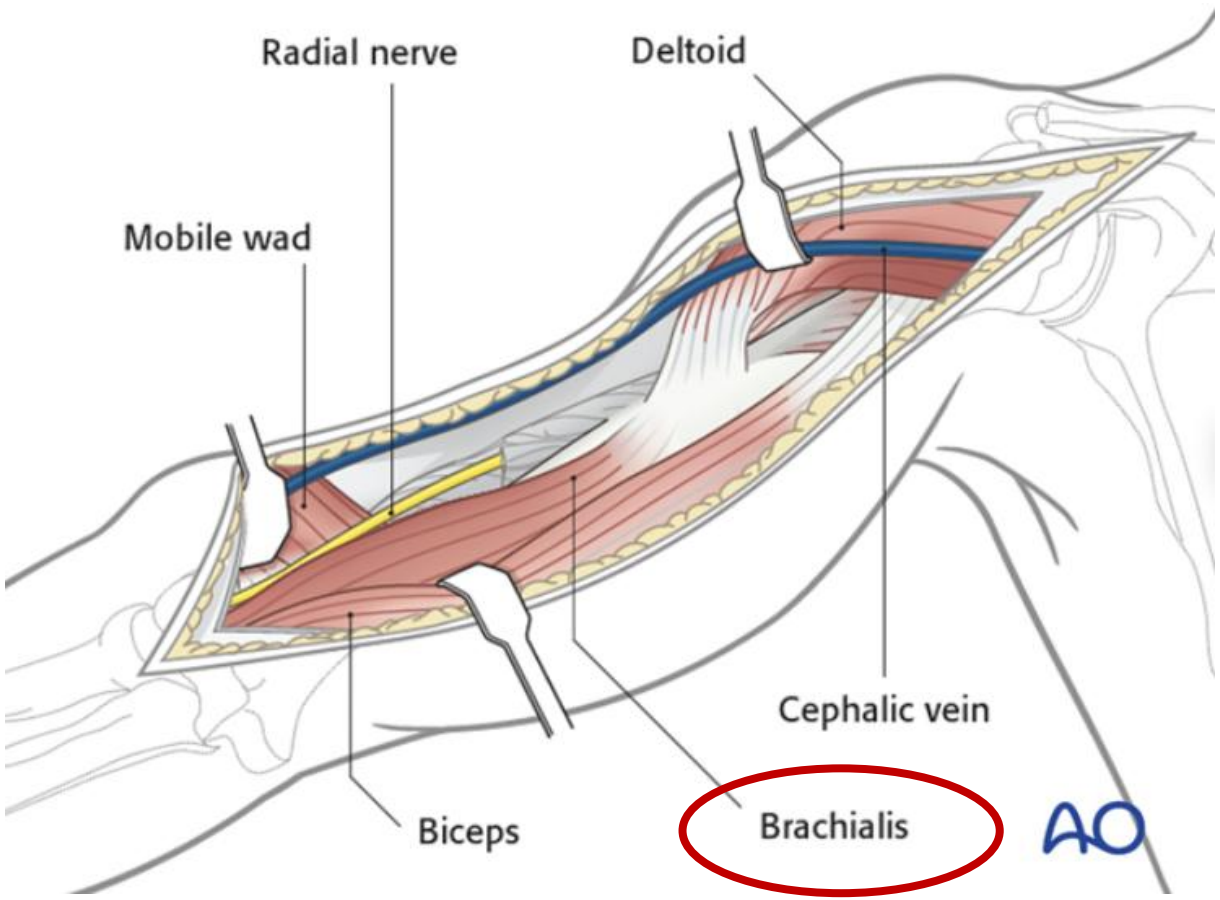

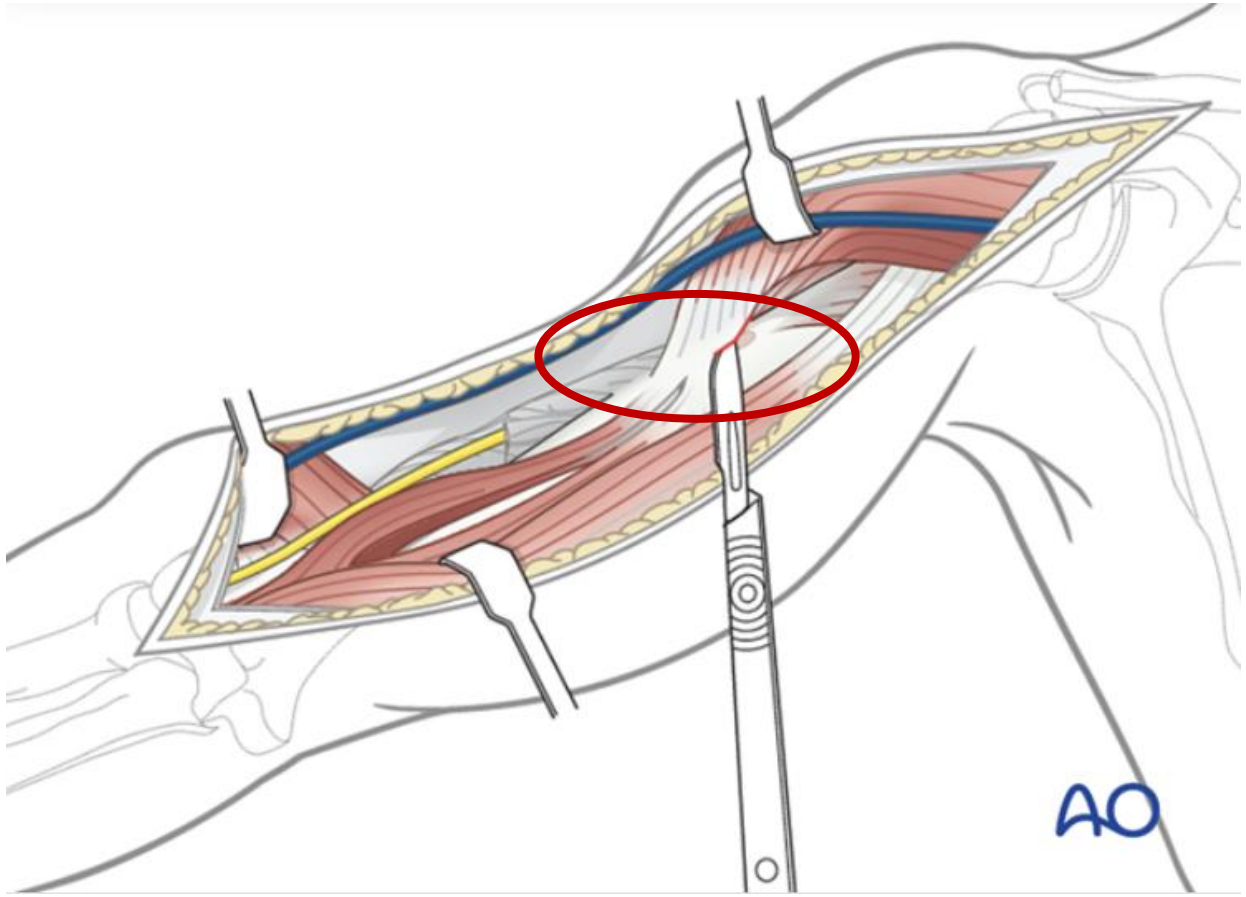

Caution with retractors in the distal 1/3 of the humerus to avoid iatrogenic radial nerve injury

Surgical Technique

- Single plate constructs are the traditional method for humeral diaphyseal fracture fixation

- Dual plate constructs may be advantageous
  - Less extensile dissection
  - Provisional fixation
  - Reduction aid
  - Increased screw density
  - Rotational control

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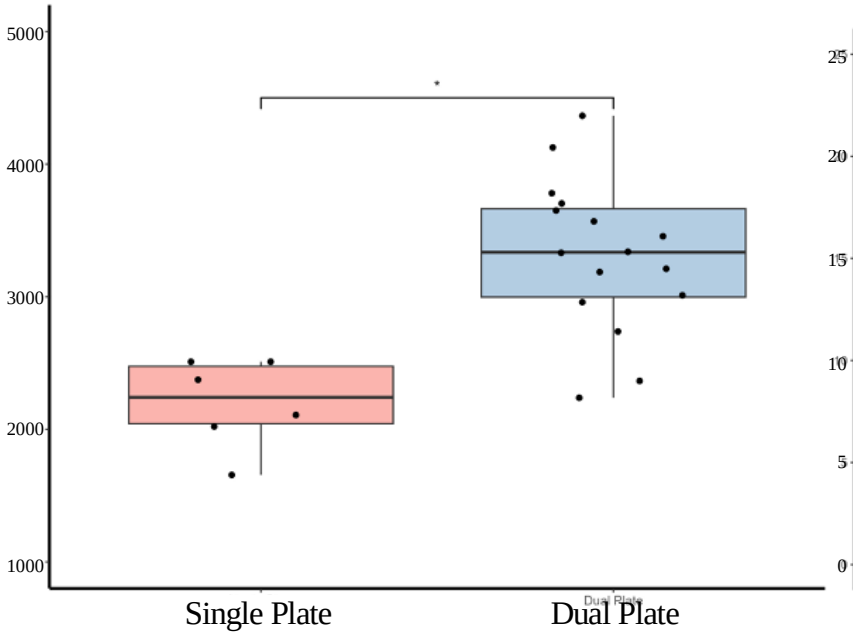
FOOTHILLS MEDICAL CENTRE OTS ORTHOPAEDIC TRAUMA SERVICE

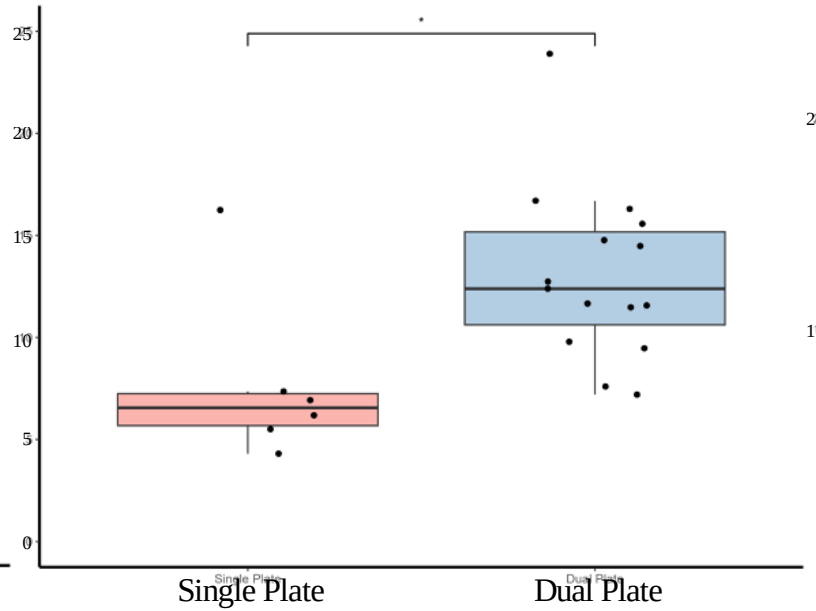
1. Group A: 3.5mm LCP anterolateral plate (9 hole)
2. Group B: 3.5mm LCP anterior (8 hole), 2.7mm LCP lateral (8 hole)
3. Group C: 3.5mm LCP anterior (8 hole), 1/3 tubular lateral (5 hole)
4. Group D: 2.7mm LCP anterior (10 hole), 2.7mm LCP lateral (8 hole)

Results

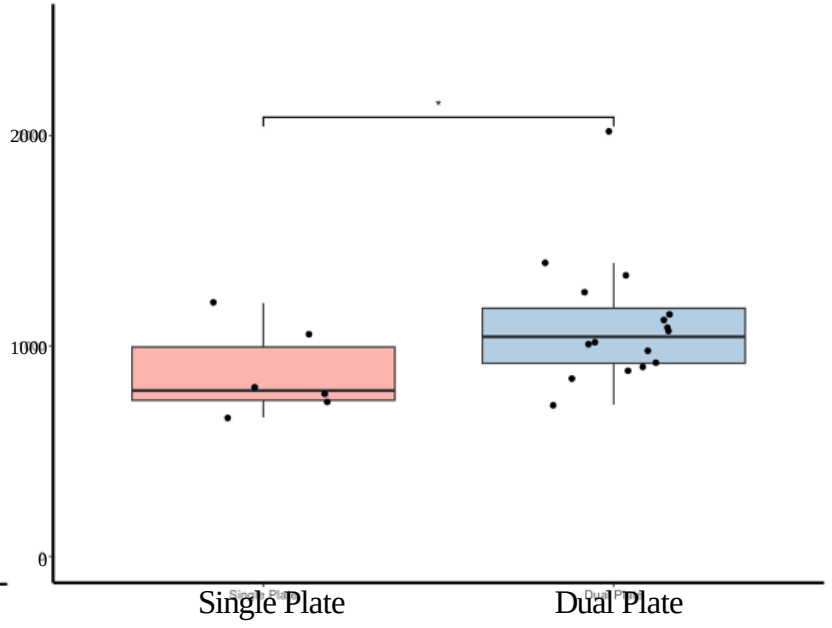
Figure 1: Comparison of compressive, medial bending, and torsional stiffness between single and dual plate constructs.



Compressive Stiffness (N/mm)



Medial Bending Stiffness (N/mm)



Torsional Stiffness (N/mm)

**indicates statistically significant difference.*

- First study to examine biomechanical differences of single vs dual-plate constructs

- Data supports the hypothesis that **dual-plate constructs have higher stiffness**
  - Axial loading, medial bending, torsional

- **No significant difference** between different dual-plate constructs

Objectives

- To review the current evidence
  - **Earlier functional recovery with ORIF**
- To identify **patients** at risk for nonunion
  - **Elevated BMI**
- To identify **fracture patterns** at risk for nonunion
  - **Simple fracture patterns**
- To recognize the importance of early intervention
  - **Poor outcomes with delayed nonunion surgery**
- To review surgical approach and tips and tricks
  - **Anterolateral for most, posterior for more distal**
  - **Consider dual plating as an adjunction**

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