Anatomy and Biomechanics of the Acromioclavicular Joint

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Introduction

· Injuries and degenerative pathology prequently involve the AC joint.
· Understanding of Anatomy and mechanics of the AC joint is mandatory for treating joint pathology.

Acromioclavicular Joint

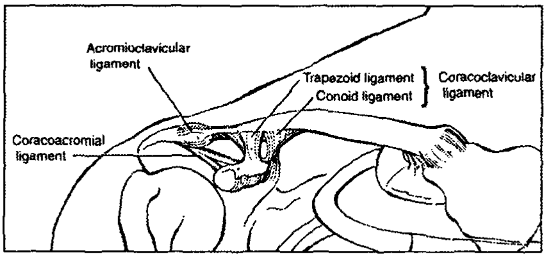


Fig. 1.

· Diarthrodial joint
· Fibrocartilaginous disk
→ Varying size and shape
→ Complete disk: less than 10% (DePalma, Clin Orthop, 59)
→ Degenerative change: with age

Joint Morphology

· Variations in the inclination of AC joint

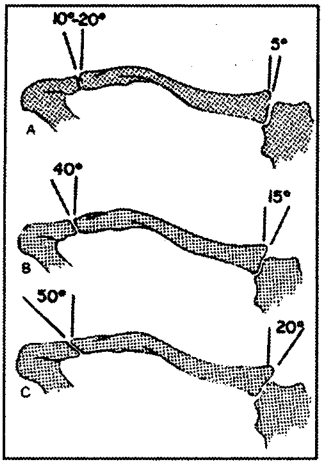


Fig. 2. (DePalma, Surg of Shoulder, 73)

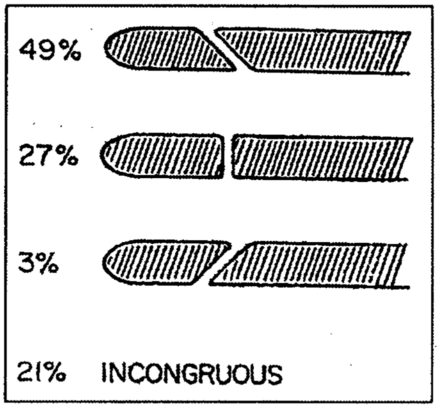


Fig. 3. (Urist, JBJS, 43)

→ No correlation between inclination and AC arthritis
(Petrone & Nirschl, AJSM, 78)
→ More vertical, more susceptible to osteolysis
: higher force was concentrate at the distal clavicle.
(Pitchford & Cahill, Oper Tech Sports Med, 97)

· Joint size
→ Length
- Vertical: 9 mm
- AP:19 mm
→ Width
- Normal: 1-3 mm
- Decrease with age
- Joint space greater than 5(F)-7(M) mm
: pathologic finding (RA, etc)

Ligamentous Anatomy

· AC joint capsule and ligament
→ Capsule: thin
→ Ligament: heavy
→ 22.9 mm in length (Klassen, Oper Tech Sports Med, 97)

· Superior AC ligament

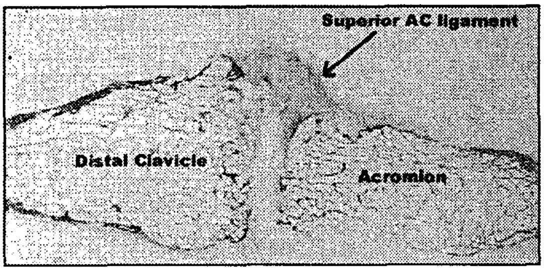


Fig. 4.

→ Thicker than inferior ligament: 2?5.5 mm
→ Insert into clavicle and musculotendinous aponeurosis of the deltotrapezial fascia
→ More defined insertion into distal clavicle (Salter, AJSM, 87)

· Distances of superior AC ligament (Renfree, JSES, 03)

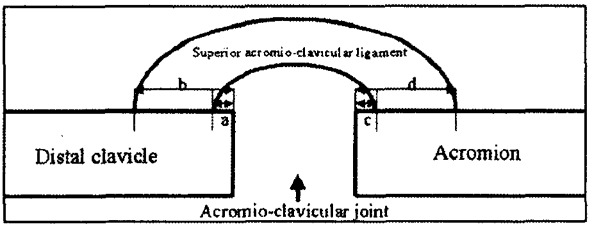


Fig. 5.

a, distance from articular surface of distal clavicle to lat. insertion point of sup. AC lig.; b, distance from articular surface of distal clavicle to med. insertion point of sup. AC lig.; c, distance from articular surface of acromion to med. insertion point of sup. AC lig.; d, distance from articular surface of acromion to lat. insertion point of sup. AC lig.

Insertion point	Mean distance (mm) (range)	
	Men	Women
a	1.4±0.33 (0.8~1.8)	0.7±0.63 (0~2.0)
b	5.5±1.7 (2.6~7.6)	3.6±0.78 (2.3~5.2)
c	1.1±0.37 (0.6~1.79)	2.0±0.5 (1.0~2.9)
d	8.1±0.75 (7.4~9.84)	4.7±0.98 (3.0~6.7)

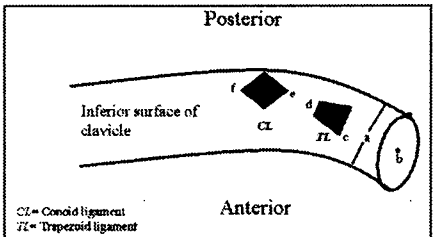
· Coracoclavicular ligament
→ Conoid (posteromedial) + trapezoid (anterolateral)
→ Trapezoid

- 0.8~2.5 cm in length and width (Salter, AJSM, 87)
- Mean 15.3 mm in length (Harris, JSES, 01)

→ Conoid

- 0.7~2.5 cm in length, 0.4?0.95 cm in width (Salter, AJSM, 87)

→ Distances of trapezoid and conoid ligament (Renfree, JSES, 03)



inferior surface of distal clavicle. *Shaded trapezoidal area* represents TL insertion, and *diamond-shaped area* represents CL insertion a, AP width of distal clavicle; *b*, center of articular surface of distal clavicle; *c*, lateral edge of TL insertion; *d*, medial edge of TL insertion; e, lateral edge of CL insertion; f, medial edge of CL insertion.

Fig. 6.

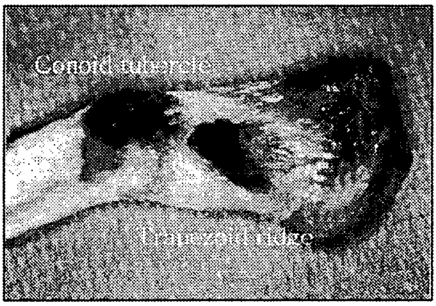


Fig. 7. TL and CL insertions stained with methyl-lene blue after digestion in bleach.

Insertion point	Distance of insertion (mm)	
	Men	Women
b-c	16.7±2.4	16.1±1.4
b-d	28.2±5.7	26.6±5.2
b-e	33.5±4.4	28.9±2.5
b-f	49.7±5.4	44.4±4.4

→ Geometric parameter (Harris, JSES, 01)

Dimension (mm)		Mean
1. Medial conoid length		19.4
2. Anterior trapezoid length		19.3
3. Conoid clavicular width		20.6
4. Conoid coracoid width		10.6
5. Trapezoid clavicular width		21.7
6. Trapezoid coracoid width		14.0
7. Conoid thickness	a. Superior	8.6
	b. Middle	5.9
	c. Inferior	4.4
8. Trapezoid thickness	a. Superior	16.0
	b. Middle	5.5
	c. Inferior	4.8
9. Distal clavicle		15.3

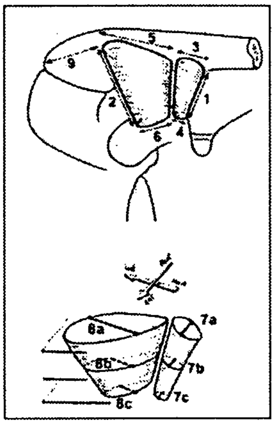


Fig. 8.

- Conoid ligament
  - Clavicular attachment: conoid tubercle
  - Conoid insertion: posterior-most area of coracoid dorsum & post. coracoid precipice (conoid apophysis)
  - Clavicular insertion is twice as wide and thick as its coracoid insertion (inverted cone shape)
- Trapezoid ligament
  - Clavicular attachment: trapezoid ridge
  - Coracoid insertion: post. half of coracoid dorsum
- Coracoclavicular bursa
  : extended superiorly from the coracoid
- 3 anatomic variants of conoid lig. based on inf. attachment site

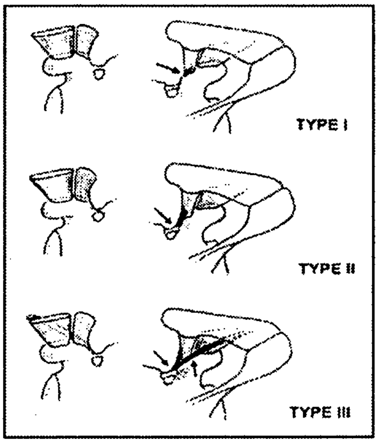


Fig. 9.

- Type I: common type
- Type II: 2 point attachment
  - Dorsum and post. coracoid
  - Sup. border of scapula via sup. transverse scapular lig.
- Type III: Type II with accessory conoid lat. fascicle
  - Arising inf-medially from lat. border of scapular notch
  - Coursing sup-laterally
  - Inserting lat. border of trapezoid insertion

· Clinical points

→ Resection of distal clavicle
  - Less than 11 mm: not violate trapezoid ligament

· Less than 24 mm: not violate conoid ligament
· Greater than 5.2 mm in women and 7.6 mm in men
: disrupt sup. AC ligament
· Safety margin to preserve the CC ligament
: 15 mm (Harris, JSES, 01)

→ Resection of medial acromion
· Greater than 4.7 mm in women and 8 mm in men
: disrupt sup. AC ligament

→ Resection of distal clavicle by an arthroscopic approach
· As little as 2.6 mm in male and 2.3 mm in female
: can violate sup. AC ligament

Stabilizer of AC Joint

· Capsular ligament: AC ligament
→ Superior ligament
· Most robust among AC ligament
· Reinforced by fascial attachment of deltoid and trapezius
· Extracapsular ligament: coracoclavicular ligament
· Dynamic stabilizer: deltoid and trapezius

Mechanical Properties of Supporting Ligaments

· Strength to failure
: AC ligament complex 〉 conoid ligament 〉 trapezoid ligament
· Site of breakage
: midsubstance 〉 origin
· Involvement of ligament
→ Isolated rupture from the insertion of origin: unusual
→ Mixed rupture with midsubstance: usual

Mechanics of AC Ligament

· Contribute for many direction of displacement and rotation of clavicle
· Greater amount to constraint at small degrees of displacement
: correspond to "physiologic load" in ROM of daily living
· According to amount of force
→ Small displacement in ant. & sup. direction

: AC ligament resist 50% and 65% of force

→ Large displacement

: conoid ligament contribute 70% and 60% (Fukuda, JBJS, 86)

· Act as a primary constraint for post. displacement & post. axial rotation of clavicle

· Debski et al (JBJS, 01)

→ If transect the AC joint

: 100% displacement in both ant. & post. directions

→ Inf. AC ligament

: 50% of restraint in all direction

· Klimkiewicz et al (JSES, 99)

→ Sup. AC ligament

: 56% of the resistance to post. direction force

· Debski et al (JBJS, 01)

→ If AC joint is disrupted, such as distal clavicle excision

· Increased forces in CC ligament

· Unable to control ant-post. translation or rotation of distal clavicle

Mechanics of Coracoclavicular Ligament

· Conoid ligament

→ Primary role in constraining ant. & sup. rotation & displacement of distal clavicle

→ With large displacement, its force increases

- · Sup. displacement: 60% of total
- · Sup. rotation: 82% of total
- · Ant. displacement: 70% of total
- · Ant. rotation: 72% of total (Fukuda, JBJS, 86)

Contributions (%) of individual ligaments to constraint of the AC joint

	Small displacement*			Large displacement †		
Displacement	Conoid	Trapezoid	AC	Conoid	Trapezoid	AC
Ant. translation	35	16	49	70	18	12
Post. translation	7	4	89	9	1	90
Ant. rotation	55	20	25	72	20	8
Post. rotation	55	16	29	47	38	15
Sup. rotation	40	20	40	82	5	13
Sup. translation	23	9	68	62	15	22
Axial translation (distraction)	35	0	65	8	1	91
Axial translation (compression)	40	47	13	9	75	16

*Average corresponding constraint forces are ten N. & torques are 0.6 Nm.

† Average corresponding constraint forces are ninety N. & torques are 4.5 Nm.

→ Significant sup. displacement of distal clavicle

: imply disruption of conoid ligament

· Trapezoid ligament

→ Contribute the least to sup. & horizontal displacement

→ Most of constraint (75%) against axial compression of clavicle toward the acromion at higher displacement

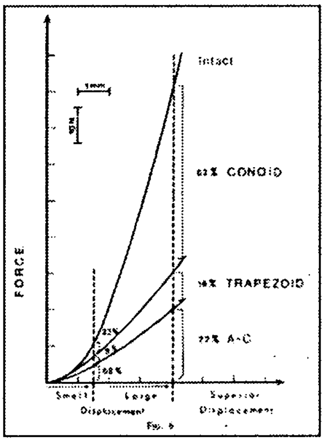


Fig. 10.

· Analogous to ACL of the knee (Fukuda, JBJS, 86)

→ Length of conoid ligament

- Increase moderately with ant. rotation
- Lengthen with sup. rotation

→ Length of trapezoid ligament: similarly

· Changing force after transection of AC lig.

→ Under post. load

- Force in TL: increase 66% (50% greater than in CL)
- Under sup. load

→ Force in CL: greatest (50% greater than in AC lig.)

→ Force in either TL or CL in response to higher load: not change

- Under ant. load

→ Force in conoid lig

: increase greater than 200% (compared with 100% increase in TL)

Deltoid and Trapezius

· Fiber of deltoid and trapezius blend with fiber of sup. AC lig.

· Dynamic stabilizer
→ Deltoid
: dynamic suspensory support
→ Upper portion of trapezius
: fascial attachment over dorsum of clavicle, extending to AC joint

· Why symptoms are often absent clinically after even type III injuries?
→ Forced direction of deltoid
63° superiorly in resting position
4° superiorly at 60° abd. (Perry, Biomech of Shoulder,88)
→ A portion of ant. deltoid insert on clavicle medial to AC joint
: these force vector make it suited to prevent excessive sup. migration of distal clavicle (Wulker, Appl Biomech, 98)

· Clinical point
→ Imbrication of deltotrapezial fascia over the joint
: to reinforce the stability AC joint reconstruction

Joint Biomechanics

· Motion (Rockwood, The Shoulder, 98)
→ Rotation through axis of clavicle: 45°
→ Among 45°, only 5-8° actually occur through AC joint.

· Controversies about motion of AC joint
→ Minimal axial rotation of clavicle at AC joint
- Required for normal shoulder elevation.
- Any fusion of AC joint violate mechanical problem.
(Klassen, Oper Tech Sports Med, 97)
→ Lost shoulder motion after fusion or fix the clavicle to scapula: little effect
(Rockwood, The Shoulder, 98)
→ High stress exist in AC joint.
: as illustrated by implant failure and migration, loss of reduction
(Sim, Clin Orthop, 95 & Weinstein, AJSM, 95)

- Clinical considerations
  → High compressive force
    - Occur from musculature driving distal clavicle into acromion during exercise
    - Osteolysis in weightlifter
      (Pitchford, Oper Tech Sports Med, 97 & Slawski, AJSM, 94)
  → Friction force is minimal.
    : as the clavicle grides smoothly over the acromion (Debski, JBJS, 01)
  → High degree of rotation and shear force
    : another risk factor for degeneration of AC joint (Fung, JSES, 01)