The Coracoidal Insertion of the Coracoclavicular Ligaments

An Anatomic Study

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Background: Current surgical procedures restoring a dislocated acromioclavicular joint aim to perform an anatomically correct and biomechanically stable reconstruction. However, the coracoidal insertions for the coracoclavicular ligaments have not yet been defined.

Purpose: The objective was to evaluate dimension and orientation of the coracoclavicular footprints with respect to bony landmarks for use in anatomic reconstruction of the coracoclavicular ligament complex.

Study Design: Descriptive laboratory study.

Methods: Twenty-three (17 female, 6 male) fresh-frozen cadaveric human shoulders were dissected, and the coracoclavicular ligaments including the coracoid and the lateral clavicle were exposed. After measurement of bony coracoidal dimensions, the ligaments were dissected and the insertion sites as well as the footprint centers were identified and marked. Each coracoclavicular insertion dimension and its distance to the bony landmarks was recorded. Sex-related differences were calculated.

Results: The mean total coracoidal length was 43.1 ± 2.2 mm. The distance from the tip of the coracoid to the precipice, the point at which the undersurface of the coracoid changes from a horizontal to a vertical direction, measured 20.3 ± 2.6 mm. The mean distance from the conoidal center to the medial coracoidal boarder and to the precipice was 1.7 ± 0.7 mm and 16.4 ± 2.4 mm, respectively. The mean distance from the trapezoidal center to the medial border and to the precipice was 8.7 ± 3 mm and 10.9 ± 2.4 mm, respectively. The mean distance between the footprint centers was 10.1 ± 4.2 mm.

Conclusion: Reproducible dimensions and orientation of the coracoclavicular footprints are given.

Clinical Relevance: Coracoidal anatomic landmarks can be used intraoperatively for an anatomic reconstruction of the coracoclavicular ligaments.

Keywords: coracoclavicular ligaments; acromioclavicular joint; acromioclavicular joint instability; anatomic reconstruction; shoulder

Biarthrodial acromioclavicular (AC) joint stability is passively provided by the integrated function of the AC ligaments, the coracoacromial ligament, and, foremost, the coracoclavicular (CC) ligaments.[6,8,13] The CC complex, consisting of the conoid and the trapezoid ligament, is considered the prime suspensory restraint of the AC joint against superior and posterior translation of the distal clavicle with respect to the scapula.[13,19] In AC joint dislocations, classified by Rockwood as types IV through VI, the CC ligaments are ruptured and surgical treatment is recommended.[32] As most operative techniques do not restore the ligament shape and stability of the native AC joint, resulting in complications such as persistent instability and procedure failures,[9,21,22,24] new evidence suggests addressing the CC ligament complex in an anatomic fashion to improve the clinical outcome and minimize the complication rate.[6,14,19] Recently, different methods have been described for anatomic replacement of the CC ligaments.[10,17,24,37] For that reason, the anatomy of the coracoid, the clavicle, the CC ligaments, and their clavicular insertions has been described to precisely render the AC joint

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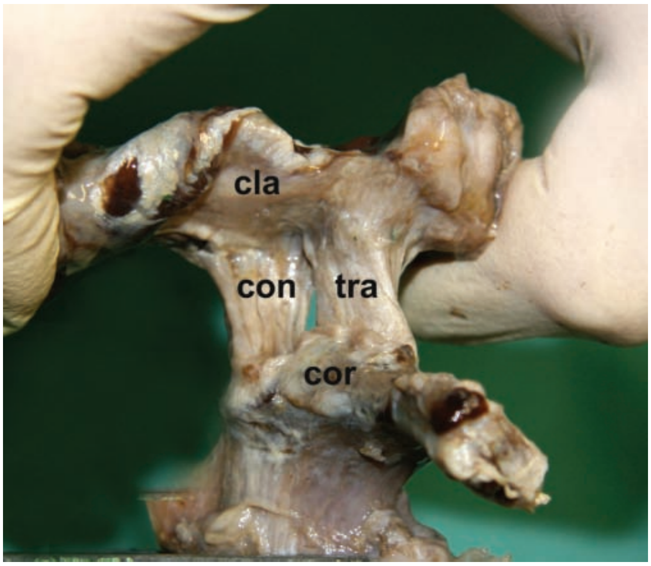

Figure 1. Fresh anatomic sample of a left coracoid process (cor) and lateral clavicle (cla) with prepared posteromedial conoid (con) and anterolateral trapezoid (tra) ligaments.

anatomy.[2,16,30,31] Even though Harris et al[16] previously described the geometric dimensions of the CC ligaments, there are, to our knowledge, no data describing the coracoidal insertion of the conoid and trapezoid ligaments with respect to reproducible bony landmarks. Such information is necessary to achieve correct anatomic CC ligament placement during surgery, in particular because 2-tunnel AC joint reconstruction techniques have been described lately.[4,5,33] Therefore, the goals of this investigation are (1) to evaluate the anatomy of the coracoid and the CC ligament insertion sites and (2) to identify the individual orientation of each CC footprint with respect to the coracoid to aid in optimal tunnel placement during anatomic 2-tunnel CC ligament replacement.

MATERIALS AND METHODS

Specimens

In this investigation, 23 fresh anatomic human cadaveric shoulders (8 paired female, 1 unpaired female, 1 paired male, and 4 unpaired male) from 14 specimens were used. After dissection of the deltoideus, the lateral half of the clavicle as well as the complete coracoid including the CC ligaments were harvested. The conoid and the trapezoid were identified and prepared (Figure 1). The coracoidal footprint of each ligament was clearly identified and precisely prepared. Afterward, each footprint insertion area was circumferentially marked with a pen, and the ligaments were dissected leaving a short ligamentous stump (Figure 2). Mediolateral and anteroposterior footprint dimensions were measured, and each center was marked accordingly (Figures 2 and 3).

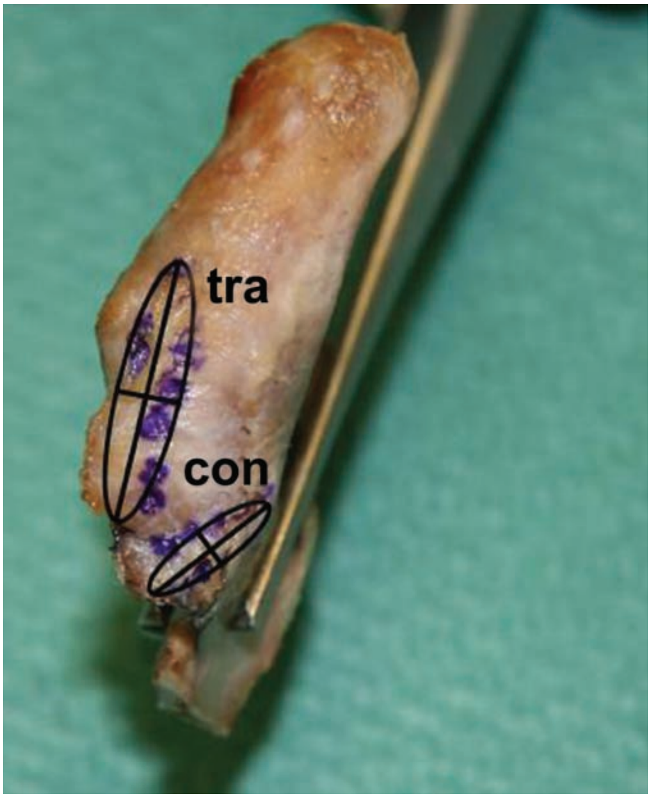

Figure 2. Superior view of a left coracoid process after resection of the coracoclavicular ligaments. The conoid (con) as well as the trapezoid (tra) footprints are marked with a pen. Each footprint center is exemplary defined.

Measurements

Measurements (in millimeters) were recorded by 3 observers blinded to the specimens and each other, using a caliper with an accuracy of 0.1 mm (Mitutoyo, Maplewood, New Jersey). Each observer performed each measurement once. Interclass correlation coefficient (ICC) with calculated confidence intervals (CI) assessed intertester reliability of each measurement. Coracoidal measurements (Figures 3 and 4) included (1) distance from the tip to the base (length), (2) distance from the tip to the precipice (specific point at which the coracoidal undersurface propagation changes from a horizontal to a vertical direction), (3) height of the tip, (4) height of the base, (5) width of the tip, (6) width of the base, (7) width of the precipice, (8) width at the conoid footprint, and (9) width at the trapezoid footprint.

Coracoclavicular ligament footprint measurements and distances to bony landmarks (Figures 3 and 5) included conoid mediolateral (A) and anteroposterior dimensions (B), as well as the distance from the footprint center to the medial (C) and lateral (D) coracoidal border, to the base (E), the tip (F), and the precipice (G); and trapezoid mediolateral (H) and anteroposterior (I) dimensions, as well as the distance from the footprint center to the medial (J) and lateral (K) coracoidal border, to the base (L), the tip (M),

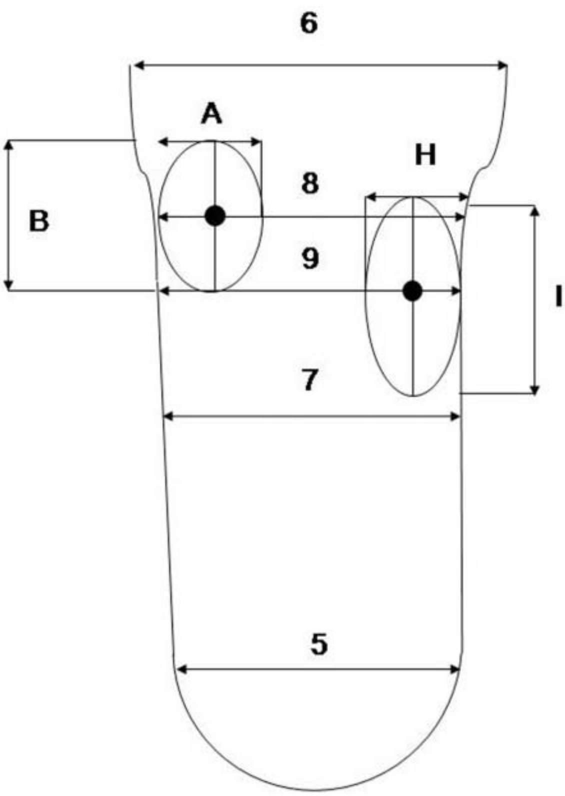

Figure 3. Coracoid process and coracoclavicular footprint measurements from a superior view (left coracoid). The numbers and letters are explained in the Measurements section of the article text.

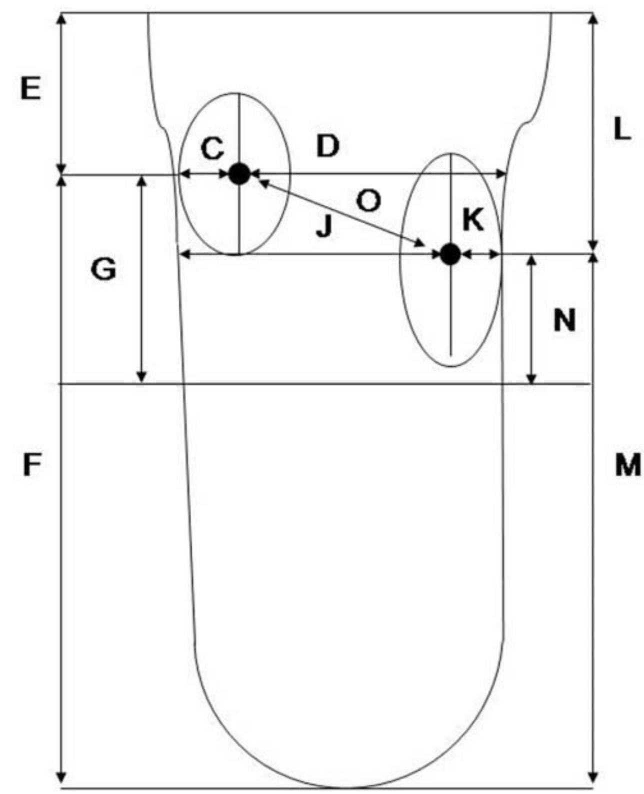

Figure 5. Coracoclavicular footprint dimensions from a superior view (left coracoid). The letters are explained in the Measurements section of the article text.

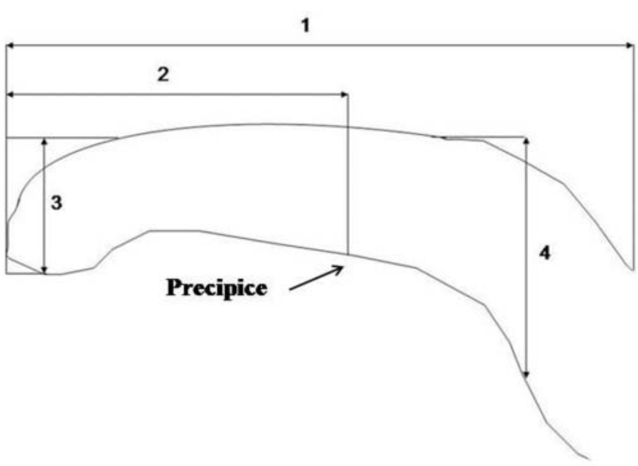

Figure 4. Coracoid process measurements from a lateral view. The numbers are explained in the Measurements section of the article text.

and the precipice (N). Furthermore, the direct distance between footprint centers was measured (O).

Ratios representing the distance of the defined landmarks (base, tip, precipice, and medial and lateral coracoidal border; see Figures 3-5) to each footprint center divided by the total anteroposterior coracoidal length and the total mediolateral coracoidal width at each footprint center were calculated. All values are expressed as means with standard deviations. An unpaired 2-tailed t test was performed to identify differences between measurements in male and female specimens. Significance was set at $P < .05$. Statistical analysis was performed using SPSS software version 15 (SPSS Science Inc, Chicago, Illinois).

RESULTS

The measurements (total, male, and female), including standard deviation and gender differences of the coracoid process as well as conoid and trapezoid footprints and their relation to the coracoidal landmarks, are shown in Tables 1 and 2, respectively. The mean coracoidal length (1) was 43.1 ± 2.2 mm. The distance from the tip of the coracoid to the precipice (2) was 20.3 ± 2.6 mm. The height of the tip (3) was 8.2 ± 1 mm, while the height of the base (4) was 14.9 ± 2.4 mm. The width of the tip (5) was 13.6 ± 2.1 mm, the width of the base (6) was 14.1 ± 2.9 mm, and the width of the precipice (7) measured 13.9 ± 1.6 mm. The average coracoidal width at the conoid footprint (8) was 12.1 ± 3.3 mm, while it measured 13.2 ± 2.7 mm at the trapezoid footprint (9). Except the coracoidal width at the tip (5), all male coracoidal measurements were significantly larger than female measurements. The conoid ligament footprint stretches along and downward the

TABLE 1
Total, Male, and Female Coracoidal Measurements[a]

Coracoidal Measurements	Total (N = 23)	Male (n = 6)	Female (n = 17)	*P* Value
1 Length	43.1 ± 2.2	46 ± 1.9	42 ± 1.4	.01
2 Tip to precipice	20.3 ± 2.6	22.9 ± 1.1	20 ± 2.1	.01
3 Height of tip	8.2 ± 1	9.6 ± 0.9	7.8 ± 0.9	.04
4 Height of base	14.9 ± 2.4	15.4 ± 1.3	13.6 ± 1.7	.04
5 Width of tip	13.6 ± 2.1	15.2 ± 1.5	13.1 ± 2.2	.05
6 Width of base	14.1 ± 2.9	16.7 ± 2.9	13 ± 1.7	.01
7 Width of precipice	13.9 ± 1.6	15.2 ± 1.9	13.8 ± 1	.03
8 Width at conoid footprint	12.1 ± 3.3	15.5 ± 3.2	11.2 ± 2.1	.01
9 Width at trapezoid footprint	13.2 ± 2.7	16.2 ± 2.2	12.4 ± 2	.01

[a]All values are expressed as mean ± standard deviation in mm. *P* value of unpaired 2-tailed *t* test was used to identify gender differences.

TABLE 2
Total, Male, and Female Footprint Measurements[a]

Footprint Measurements	Total (N = 23)	Male (n = 6)	Female (n = 17)	*P* Value
A Footprint conoid med-lat	4.4 ± 1.4	5.2 ± 1.4	4 ± 1	.04
B Footprint conoid AP	9.6 ± 2.5	11.3 ± 2	8.8 ± 2	.02
C Conoid to medial border	1.7 ± 0.7	2.2 ± 0.8	1.5 ± 0.6	.08
D Conoid to lateral border	10.3 ± 2	13.4 ± 3.6	9.6 ± 2.5	.01
E Conoid to base	6.3 ± 3	6.9 ± 1.8	4.6 ± 1.9	.03
F Conoid to tip	36.8 ± 3.7	39.7 ± 2.1	36.9 ± 3.1	.06
G Conoid to precipice	16.4 ± 2.4	16.7 ± 1.6	16.8 ± 1.7	.97
H Footprint trapezoid med-lat	5.7 ± 1.6	6.8 ± 0.8	5 ± 0.9	.01
I Footprint trapezoid AP	15.2 ± 2.5	16.2 ± 0.8	14.4 ± 2.8	.04
J Trapezoid to medial border	8.7 ± 3	10.9 ± 2.8	7.6 ± 1.7	.01
K Trapezoid to lateral border	4.4 ± 2.8	5.6 ± 1.5	3.8 ± 1.4	.03
L Trapezoid to base	12.1 ± 2.8	13.8 ± 4.3	10.3 ± 3.3	.06
M Trapezoid to tip	31.1 ± 3.3	33.2 ± 1.5	31.2 ± 3	.17
N Trapezoid to precipice	10.9 ± 2.4	9.2 ± 1.7	11.8 ± 1.7	.01
O Trapezoid to conoid	10.1 ± 4.2	14.2 ± 3.3	8.7 ± 3.5	.01

[a]All values expressed as mean ± standard deviation in mm. *P* value of unpaired 2-tailed *t* test was used to identify gender differences. AP, anteroposterior; med-lat, mediolateral.

coracoidal medial border (Figure 1). Conoidal footprint measurements were 4.4 ± 1.4 mm (mediolateral [A]) by 9.6 ± 2.5 mm (anteroposterior [B]). The distance from the conoidal center to the medial border was 1.7 ± 0.7 mm (C), to the lateral border 10.3 ± 2 mm (D), to the base 6.3 ± 3 mm (E), to the tip 36.8 ± 3.7 mm (F), and to the precipice 16.4 ± 2.4 mm (G). Trapezoidal footprint measurements were 5.7 ± 1.6 mm (mediolateral [H]) by 15.2 ± 2.5 mm (anteroposterior [I]). The distance from the trapezoidal center to the medial border was 8.7 ± 3 mm (J), to the lateral border 4.4 ± 2.8 mm (K), to the base 12.1 ± 2.8 mm (L), to the tip 31 ± 3.3 mm (M), and to the precipice 10.9 ± 2.4 mm (N). The distance between the 2 footprint centers was 10.1 ± 4.2 mm (O). As shown in Table 2, the majority of footprint dimensions and distances were significantly larger among male specimens. Additionally, there were no significant differences between left and right shoulders in paired specimens (n = 9) (data not shown). Interobserver agreement was ICC = 0.80 to 0.99 for all coracoid and footprint measurements. The mean 95% CI was 0.59 for the lower limit (range, 0.25-0.95) and 0.99 for the upper limit. Calculated ratios of each footprint distance to bony landmarks are indicated in Table 3.

DISCUSSION

According to the literature, 9% of all shoulder girdle injuries involve damage to the AC joint,[32] while sports-related injuries involving the shoulder have been estimated to comprise between 8% and 13% of all athletic injuries.[18] Out of these sports-related shoulder injuries, the AC joint separation accounts for 12% of dislocations of the shoulder girdle.[12,32] Traditional surgical techniques such as metallic screws, suture augmentation, pinning, plates, or autogenous tissue do not recreate anatomy and cannot provide the stability required to withstand common loads until biologic healing has appeared.[6,8,9,19,21,22] Furthermore, osteoarthritis, redislocation, pain, malfunction, or deformity are frequently

TABLE 3
Ratios of Each Footprint Center to Bony Landmarks[a]

Ratio	Male	Female
Length		
Conoid to base	14.8%	11.1%
Conoid to tip	85.2%	88.9%
Conoid to precipice	42.1%	45.1%
Width		
Conoid to medial border	14.1%	13.5%
Conoid to lateral border	85.9%	86.5%
Length		
Trapezoid to base	29.4%	24.8%
Trapezoid to tip	70.6%	75.2%
Trapezoid to precipice	27.7%	37.8%
Width		
Trapezoid to medial border	66.1%	66.7%
Trapezoid to lateral border	33.9%	33.3%

[a]The distance of each footprint center to bony landmarks (base, tip, precipice, medial and lateral coracoidal border) is indicated as a ratio in percentage of the total coracoidal length and the total coracoidal width (coracoidal width at the conoid footprint and at the trapezoid footprint center, respectively).

reported problems associated with the above-described traditional techniques in AC joint surgery.[15,22] Focusing on the different techniques, the screw fixation between the clavicle and the coracoid provides a very rigid technique and therefore carries the disadvantages of dissociation, loosening, and even breakage, probably resulting in a persistent instability; transarticular pins are nonanatomic and have been shown to frequently lead to recurrent dislocations and osteolysis.[11] Both techniques need a secondary operation for screw or pin removal, increasing the risk of a secondary instability.[3] A similar problem can appear in the use of a hook-plate fixation that more closely resembles the stiffness of the native AC joint, but it has been shown to be less stable than a screw and it furthermore requires an extended open approach as well as a secondary plate removal, where the hook is pulled out in between the acromion and the clavicle.[26] Synthetic loops potentially lead to erosion through the clavicle or coracoid, anterior displacement, and the risk of late infection.[36] The Weaver-Dunn procedure has been shown to be biomechanically weak,[17] and 2 independent studies demonstrated compromised results in patients who had residual subluxation or dislocation after surgery.[34,36] Residual symptoms and recurrent dislocations have led to the interest in creating modified techniques. Because it was shown that anatomic ligament positioning and replacement is crucial for optimal joint function and stability,[1,28,29] recent developments within AC joint surgery seek to address the CC ligament complex anatomically to gain optimal stability and function. The CC ligaments originate from separate broad areas at the inferior clavicle and taper cephalocaudally to smaller insertion sites at the posterior aspect of the coracoid. The conoid rises, proceeds, and inserts posterior to the trapezoid at the dorsum of the coracoid (Figure 1) to provide optimal stabilization in both the vertical as well as the horizontal plane during shoulder motion.[7,16,30,31] Each ligament has a different role in providing AC joint stability in response to various loading conditions.[8,20] In vitro biomechanical studies have concluded that anatomic AC joint reconstruction can provide physiologic stability and may improve the clinical outcome.[6,9,14,19,24] Dimakopoulos et al[10] were the first to describe an anatomic technique in vivo using double-loop sutures for repair of acute AC joint disruptions in 38 patients with good clinical outcome. However, comparable to other recently described surgical techniques for CC reconstruction, it is not completely anatomic.[23,24,32,38] All these techniques replace or reconstruct the CC ligaments with 1 structure or a single coracoidal insertion site, but they do not account for the separate anatomic role and insertion of each ligament.[8,20,25,27,37] Various anatomic studies have already evaluated the anatomy of the CC ligaments, the lateral clavicle, and the relation of the ligaments to the AC joint in detail.[2,16,30] Comparable to our measurements, Harris et al[16] furthermore described the coracoidal CC footprints to measure 10.6 mm by 4.4 mm (conoid) and 14 mm by 4.8 mm (trapezoid). To improve anatomic reconstruction, Rios et al[31] defined the exact clavicular insertion points of each CC ligament with respect to the lateral edge of the clavicle for intraoperative orientation during AC joint stabilization surgery. No such description is available for the ligamentous footprint of the coracoidal insertion sites. As a complex 3-plane motion pattern exists within the diarthrodial AC joint, restoration of the native anatomy is crucial for stability and function. Thus, it seems to be important to reestablish the native ligamentous footprint of both CC ligaments.[8,20,25] Therefore, this study describes the exact location of each CC footprint in relation to the mediolateral coracoidal borders, to the coracoidal base, tip, precipice, and to each other. Because it has recently been described that an anatomic double-bundle AC joint reconstruction leads to a favorable clinical outcome[5] and as well provides an initial stability superior to the native CC ligaments,[35] exact knowledge of each CC footprint location may assist the surgeon intraoperatively to improve the outcome.

In conclusion, the knowledge of the exact anatomic insertion point of the conoid and trapezoid ligament at the coracoid process can assist the surgeon in performing anatomic reconstruction of the CC ligaments, treating an acute or chronic AC joint instability.

REFERENCES

1. Bernard M, Hertel P, Hornung H, Cierpinski T. Femoral insertion of the ACL: radiographic quadrant method. *Am J Knee Surg.* 1997;10:14-21.
2. Boehm TD, Kirschner S, Fischer A, Gohlke F. The relation of the coracoclavicular ligament insertion to the acromioclavicular joint: a cadaver study of relevance to lateral clavicle resection. *Acta Orthop Scand.* 2003;74:718-721.
3. Bosworth BM. Acromioclavicular dislocation: end-results of screw suspension treatment. *Ann Surg.* 1948;127:98-111.
4. Chernchujit B, Tischer T, Imhoff AB. Arthroscopic reconstruction of the acromioclavicular joint disruption: surgical technique and preliminary results. *Arch Orthop Trauma Surg.* 2006;126:575-581.
5. Choi SW, Lee TJ, Moon KH, Cho KJ, Lee SY. Minimally invasive coracoclavicular stabilization with suture anchors for acute acromioclavicular dislocation. *Am J Sports Med.* 2008;36:961-965.
6. Costic RS, Labriola JE, Rodosky MW, Debski RE. Biomechanical rationale for development of anatomical reconstructions of coracoclavicular ligaments after complete acromioclavicular joint dislocations. *Am J Sports Med.* 2004;32:1929-1936.

7. Costic RS, Vangura A Jr, Fenwick JA, Rodosky MW, Debski RE. Viscoelastic behavior and structural properties of the coracoclavicular ligaments. *Scand J Med Sci Sports.* 2003;13:305-310.
8. Debski RE, Parsons IM 4th, Woo SL, Fu FH. Effect of capsular injury on acromioclavicular joint mechanics. *J Bone Joint Surg Am.* 2001; 83:1344-1351.
9. Deshmukh AV, Wilson DR, Zilberfarb JL, Perlmutter GS. Stability of acromioclavicular joint reconstruction: biomechanical testing of various surgical techniques in a cadaveric model. *Am J Sports Med.* 2004;32:1492-1498.
10. Dimakopoulos P, Panagopoulos A, Syggelos SA, Panagiotopoulos E, Lambiris E. Double-loop suture repair for acute acromioclavicular joint disruption. *Am J Sports Med.* 2006;34:1112-1119.
11. Eskola A, Vainionpaa S, Korkala O, Rokkanen P. Acute complete acromioclavicular dislocation: a prospective randomized trial of fixation with smooth or threaded Kirschner wires or cortical screw. *Ann Chir Gynaecol.* 1987;76:323-326.
12. Flik K, Lyman S, Marx RG. American collegiate men's ice hockey: an analysis of injuries. *Am J Sports Med.* 2005;33:183-187.
13. Fukuda K, Craig EV, An KN, Cofield RH, Chao EY. Biomechanical study of the ligamentous system of the acromioclavicular joint. *J Bone Joint Surg Am.* 1986;68:434-440.
14. Grutter PW, Petersen SA. Anatomical acromioclavicular ligament reconstruction: a biomechanical comparison of reconstructive techniques of the acromioclavicular joint. *Am J Sports Med.* 2005;33: 1723-1728.
15. Guttmann D, Paksima NE, Zuckerman JD. Complications of treatment of complete acromioclavicular joint dislocations. *Instr Course Lect.* 2000;49:407-413.
16. Harris RI, Vu DH, Sonnabend DH, Goldberg JA, Walsh WR. Anatomic variance of the coracoclavicular ligaments. *J Shoulder Elbow Surg.* 2001;10:585-588.
17. Harris RI, Wallace AL, Harper GD, Goldberg JA, Sonnabend DH, Walsh WR. Structural properties of the intact and the reconstructed coracoclavicular ligament complex. *Am J Sports Med.* 2000;28:103-108.
18. Hill JA. Epidemiologic perspective on shoulder injuries. *Clin Sports Med.* 1983;2:241-246.
19. Jari R, Costic RS, Rodosky MW, Debski RE. Biomechanical function of surgical procedures for acromioclavicular joint dislocations. *Arthroscopy.* 2004;20:237-245.
20. Lee KW, Debski RE, Chen CH, Woo SL, Fu FH. Functional evaluation of the ligaments at the acromioclavicular joint during anteroposterior and superoinferior translation. *Am J Sports Med.* 1997;25:858-862.
21. Lee SJ, Nicholas SJ, Akizuki KH, McHugh MP, Kremenic IJ, Ben-Avi S. Reconstruction of the coracoclavicular ligaments with tendon grafts: a comparative biomechanical study. *Am J Sports Med.* 2003;31:648-655.
22. Mazzocca AD, Arciero RA, Bicos J. Evaluation and treatment of acromioclavicular joint injuries. *Am J Sports Med.* 2007;35:316-329.
23. Mazzocca AD, Conway J, Johnson S. The anatomic coracoclavicular ligament reconstruction. *Oper Tech Sports Med.* 2004;12:56-61.
24. Mazzocca AD, Santangelo SA, Johnson ST, Rios CG, Dumonski ML, Arciero RA. A biomechanical evaluation of an anatomical coracoclavicular ligament reconstruction. *Am J Sports Med.* 2006;34:236-246.
25. McClure PW, Michener LA, Sennett BJ, Karduna AR. Direct 3-dimensional measurement of scapular kinematics during dynamic movements in vivo. *J Shoulder Elbow Surg.* 2001;10:269-277.
26. McConnell AJ, Yoo DJ, Zdero R, Schemitsch EH, McKee MD. Methods of operative fixation of the acromio-clavicular joint: a biomechanical comparison. *J Orthop Trauma.* 2007;21:248-253.
27. Nicholas SJ, Lee SJ, Mullaney MJ, Tyler TF, McHugh MP. Clinical outcomes of coracoclavicular ligament reconstructions using tendon grafts. *Am J Sports Med.* 2007;35:1912-1917.
28. Nomura E, Inoue M, Osada N. Anatomical analysis of the medial patellofemoral ligament of the knee, especially the femoral attachment *Knee Surg Sports Traumatol Arthrosc.* 2005;13:510-515.
29. Palmer I. On the injuries to the ligaments of the knee joint: a clinical study. *Clin Orthop Relat Res.* 2007;454:17-22.
30. Renfree KJ, Riley MK, Wheeler D, Hentz JG, Wright TW. Ligamentous anatomy of the distal clavicle. *J Shoulder Elbow Surg.* 2003;12: 355-359.
31. Rios CG, Arciero RA, Mazzocca AD. Anatomy of the clavicle and coracoid process for reconstruction of the coracoclavicular ligaments. *Am J Sports Med.* 2007;35:811-817.
32. Rockwood CA WG, Young D. Disorders of the acromioclavicular joint. In: Rockwood CJ, Matsen FA III, eds. *The Shoulder.* 2nd ed. Philadelphia: WB Saunders; 1990:483-553.
33. Scheibel M, Ifesanya A, Pauly S, Haas NP. Arthroscopically assisted coracoclavicular ligament reconstruction for chronic acromioclavicular joint instability. *Arch Orthop Trauma Surg.* 2007 Dec 18 [Epub ahead of print].
34. Tienen TG, Oyen JF, Eggen PJ. A modified technique of reconstruction for complete acromioclavicular dislocation: a prospective study. *Am J Sports Med.* 2003;31:655-659.
35. Walz L, Salzmann GM, Fabbro T, Eichhorn S, Imhoff AB. The anatomic reconstruction of acromioclavicular joint dislocations using 2 TightRope devices: a biomechanical study. *Am J Sports Med.* 2008, in press.
36. Weinstein DM, McCann PD, McIlveen SJ, Flatow EL, Bigliani LU. Surgical treatment of complete acromioclavicular dislocations. *Am J Sports Med.* 1995;23:324-331.
37. Wellmann M, Zantop T, Petersen W. Minimally invasive coracoclavicular ligament augmentation with a flip button/polydioxanone repair for treatment of total acromioclavicular joint dislocation. *Arthroscopy.* 2007;23:1132.e1-e5.
38. Wolf EM, Pennington WT. Arthroscopic reconstruction for acromioclavicular joint dislocation. *Arthroscopy.* 2001;17:558-563.