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Delayed surgery for displaced fracture of the anatomic neck and spine of the scapula: a case report and literature review

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Scapular fractures constitute only 0.4% to 0.9% of all fractures and approximately 3% to 5% of all fractures of the shoulder girdle.[3] Fractures of the scapular neck account for 7% to 25% of scapular fractures.[1,6,13] Although anatomic neck fractures (ANFs) of the scapula have been documented, the existence of ANF is controversial.[4,15] Bartoníček et al[4] verified the existence of ANF by reporting 4 published cases of radiographically confirmed ANF and 2 of their own cases. Because the ANF fragment has no ligamentous connection with the scapular body and clavicle, it is fundamentally unstable and often requires surgery.[2] We report a patient with an ANF without typical valgus displacement associated with a displaced scapular spine fracture that was reduced and fixed 7 weeks after the injury occurred.

Case report

A 51-year-old right-hand-dominant healthy male laborer sustained an injury to his left shoulder when a heavy wooden branch fell on him. He was diagnosed with ANF and coracoid fracture that were initially treated at an orthopedic clinic with an arm sling for 4 weeks, after which pendulum exercise was commenced. A displaced scapular spine fracture that had been overlooked was discovered 5 weeks after the fracture, and the patient was referred to our hospital. He had no relevant family or medical history.

On physical examination, the patient's left fingers were edematous. The skin over and below the scapular spine had a healed laceration and scratches. There were no neurologic deficits in the left shoulder or arm. Contractions of the deltoid and infraspinatus (ISP) muscles were palpable, although muscle strength could not be determined due to pain. Active range of motion (ROM) of the left shoulder was 10° total elevation, 5° external rotation, and internal rotation to L4 (active ROM of the right shoulder was 135°, 40°, and T7, respectively), and passive ROM of the left shoulder in these directions was 90°, 15°, and L1, respectively.

Radiographs showed an ANF with a long spike of the lateral scapular border that had a 1-cm inferior displacement, a coracoid fracture, an inferiorly displaced scapular spine fracture, and subluxation of the acromioclavicular joint. Computed tomography (CT) revealed callus formation at the ANF and coracoid fracture (Fig. 1). Magnetic resonance imaging (MRI) demonstrated typical findings of subacute muscle contusions in the supraspinatus (SSP), ISP, and posterior half of the deltoid muscles (Fig. 2).[8]

At 7 weeks after the accident, we performed open reduction and internal fixation of the fractures under general anesthesia to smooth the SSP gliding floor. The patient was placed semiprone, and the left arm was abducted by 90°. A vertical incision was made from the posterior border of the clavicle to the middle of the lateral scapular border. After the fascia was cut along the posterior border of the deltoid, the deltoid was retracted superolaterally.

The fracture lines of the lateral scapular border were released through the interval between the teres major and teres minor. The deltoid was then split distally from the fracture site of the scapular spine. The upper fracture line was released after developing the interval between the ISP and teres minor and retracting the ISP inferiorly.

The glenoid fragment was reduced and fixed with 2 wire loops, although the reduction was incomplete. The fracture of the scapular spine was easily reduced by resecting the fibrous tissue and primitive callus occupying the fracture site and was fixed with a reconstruction plate, screws, and transosseous wire loops. The coracoid fracture was stable and was left untouched (Fig. 3).

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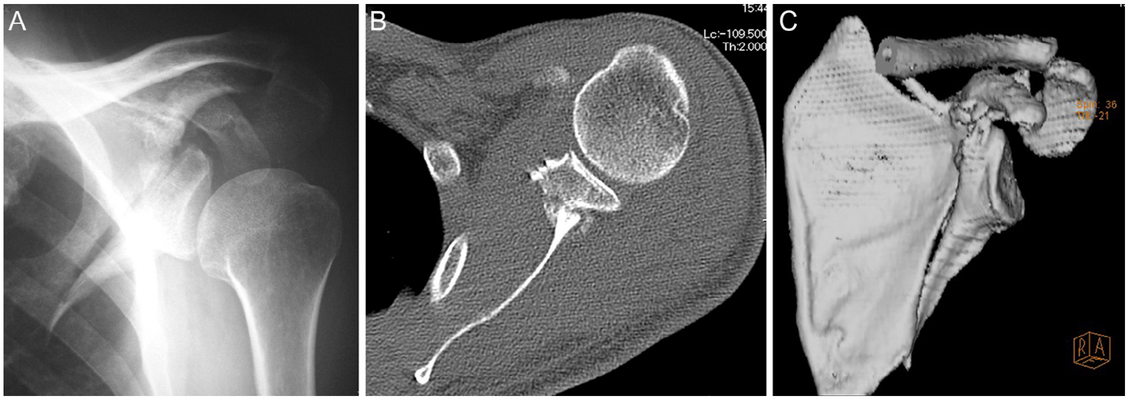

Figure 1 Radiography and computed tomography scan at the first visit. (**A**) Radiography revealed an anatomic neck fracture with a long spike of the lateral scapular border. The fragment was displaced 1 cm inferiorly, and there was an inferiorly displaced lateral scapular spine fracture. (**B**) Computed tomography showed the typical fracture line at the anatomic neck with callus formation. (**C**) Three-dimensional computed tomography detected a coracoid fracture with a long spike of the superior scapular border with callus formation, an anatomic neck fracture without any rotation or angulation, subluxation of the acromioclavicular join, and an inferiorly displaced lateral scapular spine fracture without any callus formation.

Passive ROM exercises were begun on postoperative day 4 after protecting the shoulder using a sling, because rigid fixation had been achieved. Active ROM exercises were initiated at 5 weeks, and stretching and muscle strengthening exercises were introduced as a home program at 2 months postoperatively for 4 months. At 6 months, the active ROM for total elevation, external rotation, internal rotation, and horizontal adduction were 120°, 10°, T11, and 120°, respectively.

The patient had no pain with any movement, but muscle strength on the manual muscle test was 4+ for flexion and abduction and 3+ for external rotation (Fig. 4). At that time, the patient returned to his previous job but continued to tire easily. At 15 months postoperatively, the plate was removed because bone union had been completed and there was persistent tenderness around the plate (Fig. 5).

At the time of the final follow-up at 12 years postoperatively, active ROM limitations of the left shoulder compared with the right shoulder were 5°, 5°, 2 vertebrae, and 15° for total elevation, external rotation, internal rotation, and horizontal adduction, respectively, and the manual muscle test score was 5 for adduction, flexion and internal rotation, and 4 for external rotation. The Disabilities of the Arm, Shoulder and Hand score was 4.2,[16] and the Constant score ratio compared with the right shoulder was 95%.[11] MRI showed that the upper half of the ISP was atrophic, with obvious fatty infiltration and replacement of the medial portion with degenerative tissue (Fig. 6).[8] There were no clinical or imaging signs of osteoarthritis.

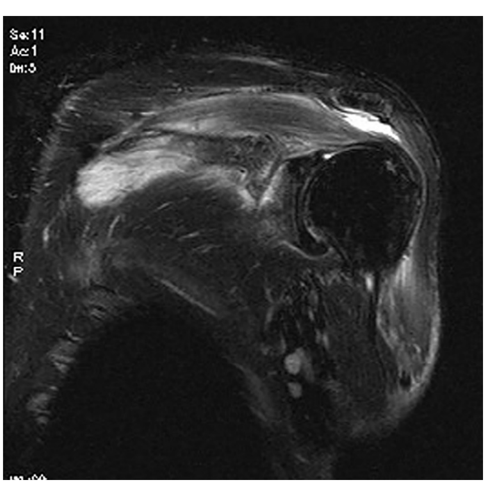

Figure 2 Coronal T2-weighted, fat-suppressed magnetic resonance images demonstrate feathery edema in the supraspinatus, infraspinatus, and posterior half of the deltoid muscle as well as a heterogeneous mass in the proximal part of the infraspinatus.

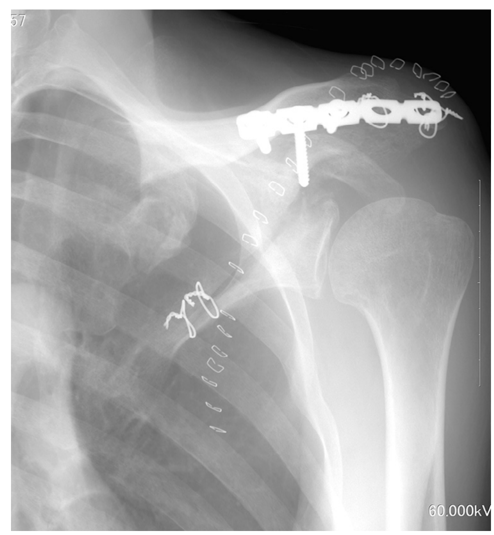

Figure 3 Radiography performed 1 week postoperatively shows fracture fixation with the wire loops for the anatomic neck fracture and a reconstruction plate and screws for the spine fracture, with the lateral end fixed with 3 transosseous wire loops to prevent impingement of the rotator cuff by the screw tip.

Discussion

Historically, ANF of the scapula has been recognized as a type of scapular neck fracture. Fractures of the surgical and anatomic necks of the scapula were described in detail in 1849.[5] Over the subsequent decades, only a few cases of ANF were demonstrated by anatomic dissection or radiography, although some authors described ANFs with or without drawings.[6,12] In 1916, Hitzrot and Bolling[15] then stated that they doubted the existence of this type of fracture, because they could find no ANF in their own cases and could not find any case of ANF proven by radiography in the literature.

Figure 4 Photograph taken 6 months postoperatively shows the healed laceration and scratches on and below the scapular spine and marked muscle atrophy of the infraspinatus.

Some researchers misunderstood the definition of an ANF and presented incorrect radiographs and CT images regarding ANF prevalence.[9,17] In 1984, 2 cases of ANF were definitively demonstrated radiographically.[14] In 2013, Bartoníček et al[4] presented 2 cases of ANF with clear radiographs and three-dimensional CT scans and reported that they found only 4 radiographically documented cases of ANF in the literature; they reported 2 additional ANF cases in the subsequent year.[6] To date, there are 11 reported cases of the ANF in which the details of the fracture are adequately described or radiographically proven.[2,4,6,7,12,14,18]

The causes of ANF in the reported cases are varied, and the details of the fracture cause were specified in only 5 cases[2,4,7]; hence, the pathomechanism is still uncertain. To our knowledge, our patient is the ninth radiographically proven case of ANF, and the fracture cause was a direct impact from the superoposterior direction (Table I).

In ANF, the cephalad portion of the vertical fracture line runs in the coracoglenoid notch, which is lateral to the coracoid base, and the caudal portion crosses the lateral border of the scapular body, forming a short spike of the lateral border.[4] Therefore, the glenoid fragment is always formed by the glenoid fossa and a short spike of the lateral border.[4] The cephalad fracture line in our patient ran in the typical place, but the spike of the lateral border was longer than that reported in other cases. This longer spike may have been caused by the direction of the added force and individual differences in bony architecture.

Hardegger et al[14] showed that the fracture fragment in ANF cases was most commonly displaced distally and laterally due to the pull of the long head of the triceps muscle inserting into the infraglenoid tubercle. Imaging analysis of the six radiographically documented cases showed that the glenoid fragment plus the humeral head was displaced distally in 5 cases; the glenoid fragment was also rotated into a valgus position, and the lower part of the fracture site was opened up.[4] Thus, ANF is the only fracture of the scapula with an associated increase in the glenopolar angle.[4] ANFs with marked anterior angulation have also been reported, however.[2,6] We analyzed the radiographs and three-dimensional CT images of the 6 previously reported ANFs with typical fragment formation and displacement and found that the glenoidal contact area with the humeral head had shifted upwards. The cause of this shift is thought to be due to the restraint to downward movement of the humeral head caused by the pull of the rotator cuff and deltoid muscles. This stabilizes the fracture fragment in the valgus position because the tension of the rotator cuff works as a compressive force transmitted by the humeral head in the upper portion of the fracture fragment and the long head of the triceps works as the separating force in the lower portion. The main cause of the noticeable valgus displacement of the fracture fragment is the downward displacement of the fracture fragment, and the upwards movement of the interface between the humeral head and the glenoid fossa.

In the present patient, the fracture fragment was moderately displaced in a downward direction without rotation, and the interface between the humeral head and the glenoid fossa remained in the normal position. The interface may have remained in the normal position because of the loss of the upward pull of the powerful deltoid muscle due to the displaced scapular spine fracture. In addition, the origins of the subscapularis and teres minor across the lower part of the fracture line and the muscle belly of the teres major running adjacent to the long spike of the lateral scapular border may have prevented valgus deformity caused by the pull of the long head of the triceps.

Shoulder girdle injuries are not commonly associated with ANFs. The documented injuries associated with ANF include intra-articular coracoid fracture, scapular body fracture with multiple rib fractures, acromioclavicular dislocation, and avulsion of the tendon of the long head of the biceps.[4,7,12] There have been no reports of the theoretically possible damage to the axillary nerve and suprascapular nerve.

In the present patient, the traumatic impact to the lateral scapular spine caused multiple injuries, including a displaced fracture of the lateral scapular spine, coracoid base fracture, acromioclavicular subluxation secondary to displacement of the scapular spine fracture, and marked contusion of the ISP. The ISP contusion led to permanent dysfunction of the ISP. MRI taken 12 years postoperatively showed that the upper half of the ISP was atrophic, with obvious fatty infiltration and replacement with degenerative tissue in the medial portion. These findings appear to indicate that the necrosis of the upper origin of the ISP resulted in the unloading of tensile forces and ultrastructural changes of the ISP, causing it to lose its origin, similarly to the condition caused by a rotator cuff tear.[8,22] This loss of the ISP origin and direct injury to the muscle belly certainly leads to obvious fatty infiltration.[19,21]

Regarding treatment options, there is some truth to the concept of a floating shoulder. A previous biomechanical experiment showed

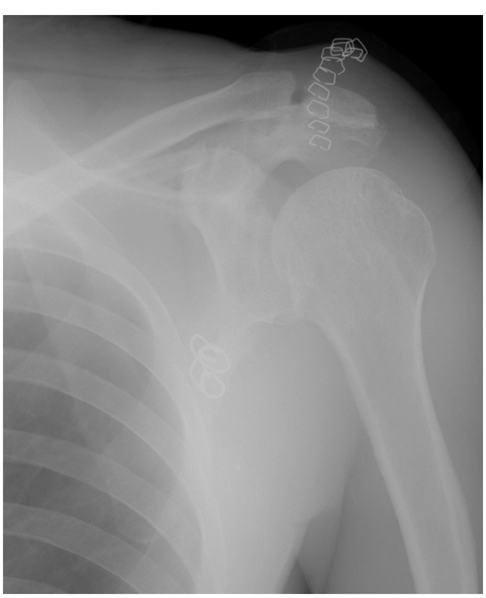

Figure 5 Radiography performed after plate removal shows bone union of all fractures and spontaneous reduction of the acromioclavicular subluxation due to reduction of the displaced scapular spine fracture.

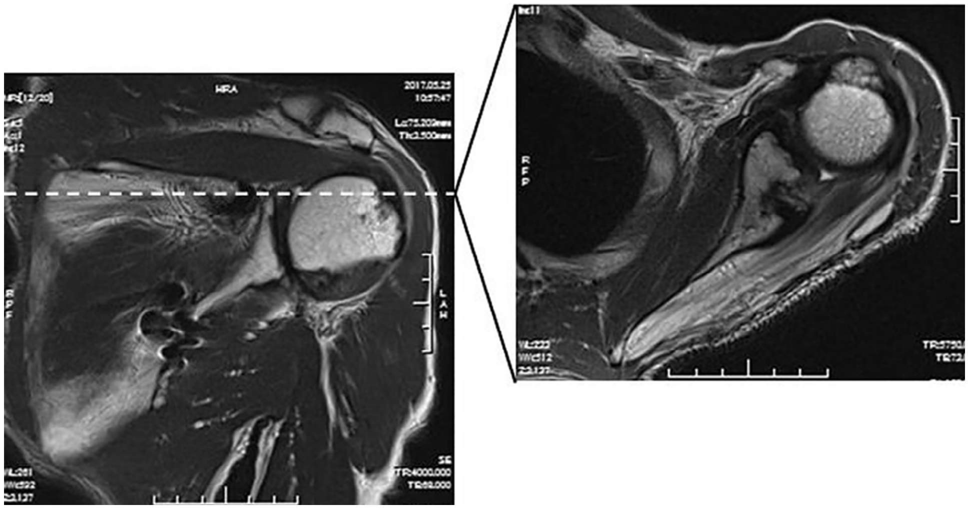

Figure 6 T2-weighted magnetic resonance images at 12 years after the accident show that the upper half of the infraspinatus is atrophic, with obvious fatty infiltration and replacement with degenerative tissue in the medial portion, corresponding with the part of the infraspinatus that was severely contused preoperatively. There were no abnormal findings in the supraspinatus and deltoid muscles.

that the attached ligaments mainly maintain the stability of the glenoid fragment of a scapular neck fracture.[23] Arts and Lunette[2] claimed that ANFs are unstable and require operative treatment because the coracoclavicular and coracoacromial ligaments that contribute to the stability of the fracture fragment do not attach to the fragment. However, the glenoid fragment of the ANF appears to be stable because the tension of the rotator cuff muscles surrounding it prevents further displacement and compresses the fracture line through the humeral head.

One study presented 5 patients with ANF with only 1 patient treated surgically,[12] whereas another study reported a good outcome after conservative treatment of a 25-year-old man with ANF.[6] Because the displacement of the fracture fragment varies, the treatment method also varies, depending on the direction and degree of the displacement. Euler et al[12] suggested that there are 2 types of ANF: stable ANF with medial impaction and ANF that is tilted by the long head of the triceps. They recommended conservative treatment for the former type.

Concerning the surgical management of scapular neck fractures, Goss[13] stated that surgery should be considered in patients with substantial displacement (≥1 cm) or angulations (≥40° in the coronal or transverse plane). Similarly, Bartoníček et al[6] recommended operative treatment for fractures with a displacement of more than 1 cm or a glenopolar angle of less than 26° or more than 55°. In our patient, the fracture fragment inferiorly displaced 1 cm without any rotation or angulation. However, we performed surgery to exclude the possibility of damage to the undersurface of the SSP gliding over the bony abnormality created by the displaced ANF.

ANF surgery is commonly performed using the posterior approach, but this type of fracture does not require an extensive development or the muscle detachment or release described by Judet.[20] The posterior deltoid-splitting approach with dissection of the interval between the ISP and teres minor make it possible to expose the posterior shoulder area.[24] When a broader operative field is needed, an approach from the posterior edge of the deltoid enables exposure of the middle lateral scapular border through the interval between the teres minor and teres major.[10] In both approaches, muscle release is unnecessary.

Fracture fixation has been performed using screws, plates, wire loops, and Kirschner wires.[4,6,7,12,14,18] In our patient, the inadequate dissociation of the fibrous union in the superior and anterior area made it impossible to reduce the fragment completely. Because the healing process of scapular fractures progresses quickly due to a rich blood supply, these fractures should be operated on early when surgery is indicated.

Table I
Reported anatomic neck fracture cases that were promptly described or radiographically proven

Year	Author	Patients			Associated injuries	Displacement of fracture fragment*	Treatment
		Age	Sex	Side			
1984	Hardegger[14]	44	?	L	?	30° valgus, not so inferior	Surgical
		24	?	R	?	Anteroinferior displacement, valgus	Surgical
1992	Euler[12]	?	?	?	Intra-articular coracoid fx.		Surgical
1995	Bauer[7]	34	M	R	Scapular body & serial rib fx.	Slightly valgus	Surgical
		47	M	R	ACJ dislocation		Surgical
1999	Arts[2]	33	M	L	None	Anterior angulation	Surgical
2005	Jeong[18]	?	?	L	?	Slightly valgus	Surgical
2013	Bartoníček[4]	49	M	L	None	Typical inferior displaced, valgus, GPA 56°	Surgical
		51	F	R	Avulsion of long head of the biceps	Severely inferior displaced & valgus, GPA 70°	Surgical
2014	Bartoníček[6]	36	M	L	None	GPA 40°, anterior angulation	Surgical
		25	M	R			Conservative
	Our case	51	M	L	Lateral scapular spine and coracoid fx., ACJ subluxation	Displaced 1 cm inferiorly	Surgical

L, left; *R*, right; *M*, male; *fx.*, fracture; *ACJ*, acromioclavicular joint; *F*, female; *GPA*, glenopolar angle.
* All cases were radiographically proven.

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Disclaimer

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References

1. Ada JR, Miller ME. Scapular fractures. Analysis of 113 cases. Clin Orthop Relat Res 1991;(269):174-80.
2. Arts V, Louette L. Scapular neck fractures; an update of the concept of floating shoulder. Injury 1999;30:146-8.
3. Bartoníček J. Scapular fracture. In: Court-Brown CM, Heckman JD, McQueen MM, Ricci WM, Tornetta P, editors. Rockwood and Green's fractures in adults. 8th ed. Philadelphia: Lippincott Williams & Wilkins; 2015. p. 1475-502 ISBN 9781451195088.
4. Bartoníček J, Frič V, Tuček M. Fractures of the anatomical neck of the scapula: two cases and review of the literature. Arch Orthop Trauma Surg 2013;133:1115-9. http://dx.doi.org/10.1007/s00402-013-1783-9
5. Bartoníček J, Kozánek M, Jupiter JB. Early history of scapular fractures. Int Orthop 2016;40:213-22. http://dx.doi.org/10.1007/s00264-015-2821-8
6. Bartoníček J, Tuček M, Frič V, Obruba P. Fractures of the scapular neck: diagnosis, classifications and treatment. Int Orthop 2014;38:2163-73. http://dx.doi.org/10.1007/s00264-014-2434-7
7. Bauer G, Fleischmann W, Dussler E. Displaced scapular fractures: indication and long-term results of open reduction and internal fixation. Arch Orthop Trauma Surg 1995;114:215-9.
8. Blankenbaker DG, Tuite MJ. Temporal changes of muscle injury. Semin Musculoskelet Radiol 2010;14:176-93. http://dx.doi.org/10.1055/s-0030-1253159
9. Bozkurt M, Can F, Kirdemir V, Erden Z, Demirkale I, Başbozkurt M. Conservative treatment of scapular neck fracture: the effect of stability and glenopolar angle on clinical outcome. Injury 2005;36:1176-81. http://dx.doi.org/10.1016/j.injury.2004.09.013
10. Brodsky JW, Tullos HS, Gartsman GM. Simplified posterior approach to the shoulder joint. A technical note. J Bone Joint Surg Am 1987;69:773-4.
11. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res 1987;(214):160-4.
12. Euler E, Habermeyer P, Kohler W, Schweiberer L. Scapula fractures–classification and differential therapy. Orthopäde 1992;21:158-62 [in German].
13. Goss TP. Fractures of the glenoid neck. J Shoulder Elbow Surg 1994;3:42-52.
14. Hardegger FH, Simpson LA, Weber BG. The operative treatment of scapular fractures. J Bone Joint Surg Br 1984;66:725-31.
15. Hitzrot JM, Bolling RW. Fractures of the neck of the scapula. Ann Surg 1916;63:215-36.
16. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (Disabilities of the Arm, Shoulder and Hand). Am J Ind Med 1996;29:602-8.
17. Izadpanah M. Osteosynthese in scapula fractures. Arch Orthop Unfallchir 1975;83:153-64, German.
18. Jeong GK, Zuckerman JD. Scapula fractures. In: Zuckerman JD, Koval KJ, editors. Shoulder fractures. New York: Thieme; 2005. p. 199-222 ISBN 1588903109.
19. Joe AW, Yi L, Natarajan A, Le Grand F, So L, Wang J, et al. Muscle injury activates resident fibro/adipogenic progenitors that facilitate myogenesis. Nat Cell Biol 2010;12:153-63. http://dx.doi.org/10.1038/ncb2015
20. Judet R. Surgical treatment of scapular fractures. Acta Orthop Belg 1964;30:673-8 [in French].
21. Kang JR, Gupta R. Mechanisms of fatty degeneration in massive rotator cuff tears. J Shoulder Elbow Surg 2012;21:175-80. http://dx.doi.org/10.1016/j.jse.2011.11.017
22. Kaplan PA, Helmus CA, Dussault R, Anderson MW, Major NM. Tendons and muscles. In: Musculoskeletal MRI. Philadelphia: W.B. Saunders; 2001. p. 55-87 ISBN 0-7216-9027-0.
23. Williams GR Jr, Naranja J, Klimkiewicz J, Karduna A, Iannotti JP, Ramsey M. The floating shoulder: a biomechanical basis for classification and management. J Bone Joint Surg Am 2001;83:1182-7.
24. Wirth MA, Butters KP, Rockwood CA Jr. The posterior deltoid-splitting approach to the shoulder. Clin Orthop Relat Res 1993;(296):92-8.