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Treatment of Neer type II fractures of the lateral clavicle using distal radius locking plates combined with TightRope augmentation of the coraco-clavicular ligaments

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Abstract
Introduction Neer type II lateral clavicle fractures are inherently unstable and debate continues regarding optimal treatment. The purpose of this study was to review the outcome of Neer type II lateral clavicle fractures treated using a novel technique, which incorporates a superiorly placed distal radius locking plate combined with TightRope™ fixation to augment the coraco-clavicular ligaments.
Methods Between 2007 and 2010, a total of 31 Neer type II fractures were managed operatively at our institution. Clinical outcomes were assessed using the SPADI, DASH, Constant, and Taft scores. Subjects were evaluated at 6 weeks, 3, 6 months, and 1 year. For the latest follow-up (mean 38.7 months), all patients were telephoned by an independent research associate and interviewed to establish SPADI and DASH scores. Radiological union was evaluated using standard views including an antero-posterior view, an angled (Zanca) view, and a trans-scapular view.
Results Bony union was achieved at a mean follow-up of 6.3 ± 4.1 weeks. At the 1-year follow-up, the AC joint remained reduced radiologically in all cases. At 1 year, the mean Constant score was 95.6 ± 4.82, the DASH score was 3.45 ± 3.02, and the SPADI score was $2.58 + 1.94$. At the latest follow-up, at a mean of $38.7 + 14.8$ months, the DASH score was 0.6 ± 2.1 and the SPADI score was 0.6 ± 2.
Conclusion Surgical fixation of Neer type II lateral clavicle fractures using a 2.4-mm distal radius locking plate in combination with TightRope™ suture augmentation results in a predictable outcome, preserving excellent shoulder function while maintaining a low complication rate.

Keywords Lateral clavicle fracture · Neer type II · Distal radius plate fixation · TightRope™

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Introduction

Neer type II fractures are potentially unstable and are particularly difficult to control. Type II fractures are often significantly displaced, because the trapezius and sterno-cleidomastoid muscles both pull the medial fragment superiorly [1–4]. These fractures can be horizontally or vertically unstable if either the conoid or trapezoid ligaments are also ruptured [2, 5, 6].

As a result of the significant mechanical demands related to these specific anatomic considerations, type II fractures are difficult to stabilize by non-operative methods and have a 30 % rate of non-union [1, 2]. Recognizing the high incidence of non-union, the frequency of local complications, and the subsequent shoulder dysfunction evident in his series, Edwards [5] recommended operative treatment for type II fractures and others concurred [3, 6–10]. Many operative techniques have been described to stabilize Neer type II fractures, including sling fixation [11], tension band wires [12–14], K-wire fixation [15], use of a site-specific hook plate [13, 16], screw fixation [3], use of Knowles pins [17], open Endo-button fixation [18], suture anchors and suture tension bands [6],and double plate fixation [19]. In addition, arthroscopic techniques using suture fixation [20, 21] and a double button device (TightRope^{TM}) have been suggested [22]. Many of these procedures are associated with complications including wire migration, screw loosening or breakage, loss of reduction, acromio-clavicular joint degeneration, subacromial impingement, acromial and periprosthetic clavicle fractures, and rotator cuff damage with the hook plate [11, 17, 23].

Recently, several small case series [7, 8, 24] have advocated the use of distal radius locking plates for lateral clavicle fractures. These plates reportedly match the contours of the lateral clavicle, providing strength and stability while stabilizing small, comminuted fragments. There is little risk of iatrogenic damage to the AC joint, subacromial space or rotator cuff, a potential issue associated with some implants used for these injuries. Designed with a low profile, these plates are not usually prominent and do not often require removal. However, use of these implants does not address the disruption of the CC ligament, and therefore does not restore vertical or horizontal stability to the injury.

The purpose of this study was to review the clinical outcome of Neer type II lateral clavicle fractures treated using a novel technique, which incorporates a superiorly placed distal radius locking plate combined with TightRope^{TM} fixation through the base of the coracoid process to augment the coraco-clavicular ligaments.

Materials and methods

Subjects

Between 2007 and 2010, a total of 31 patients (23 males, 8 females) with an average age of 30.3 ± 14.6 years (14–59) underwent surgical stabilization (Figs. 1, 2a, b). The mechanism of injury was a bicycle accident in ten cases, motorbike accident in six cases, fall from a horse in two cases, assault in three cases, fall from a mechanical bull in one case, fall from a skateboard in two cases, a simple fall in four cases, a direct contact injury in Rugby in one case, and an automobile accident in two cases. Ten patients were stabilized definitively within 24 h, 3 patients presented late (14, 14, 49 days), and the remaining 18 were treated between 2 and 10 days after injury. The mean time between injury and surgery was 5.6 days, but only 3.8 days if the three late presentations were excluded. All 31 of these cases were operated on by the same three surgeons at one institution.

Fig. 1 Neer type II fracture with vertical displacement of the medial fragment

Outcome measures

The main outcome measures consisted of the shoulder-specific Constant score [25], the upper extremity-specific Disabilities of the Arm, Shoulder and Hand (DASH) score [26], the Shoulder Pain and Disability Index (SPADI) score [27], and the TAFT score [28]. Radiographic union was evaluated using an antero-posterior view, supplemented by an angled (Zanca) view and trans-scapular view. Stress views were not obtained as several authors [29–31] have demonstrated the lack of efficacy of this technique. Radiographs were obtained every 2 weeks and reviewed by two independent research associates. Similar to Lee et al. [13], radiographic union was defined as evidence of bridging callus across the fracture or obliteration of the fracture lines.

Operative technique

With the patient in the beach chair position, a 6–8 cm incision was made along the anterior border of the lateral clavicle. The fracture was reduced as anatomically as possible and a 2.4-mm volar distal radius locking plate (Synthes®) was selected; the specific plate employed depended on the fracture configuration and size of the lateral fragment. To accommodate the drill hole for the TightRope^{TM} system, an L-plate or oblique L-plate was used and placed on the superior aspect of the clavicle, parallel to the posterior border. Three locking screws were

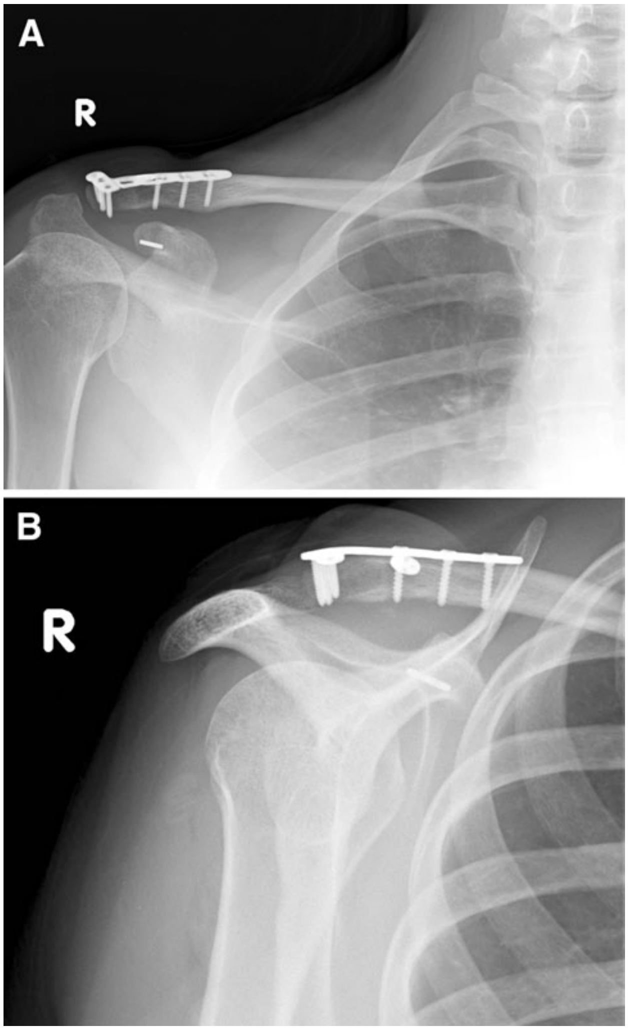

Fig. 2 **a**, **b** The same case at 3 months, demonstrating fixation with a volar distal low-profile 2.4-mm L-plate and Tightrope^{TM}. The fracture has united and the AC joint reduced

placed into the distal fragment, and three non-locking screws were inserted medially. Blunt dissection was carried out to expose the superior aspect of the coracoid process. A single 4-mm tunnel was made through the clavicle, centered at the level of the coracoid and anterior to the plate. Care was taken to preserve an anterior bone bridge of at least 3–5 mm to minimize the risk of an anterior cortex fracture. The 4-mm drill bit was then centered on the coracoid process as posterior as possible to avoid anteriorization of the clavicle and AC joint as the TightRope^{TM} device was secured. The TightRope^{TM} device was then introduced through both tunnels with a Nitinol wire meniscal suturing device (Arthrex$^{®}$) and suture shuttle technique. Reduction was achieved by inferior and anterior translation of the clavicle by the surgical assistant, and the TightRope^{TM} device was then tightened and secured with a minimum of five reverse knots.

Postoperative protocol and follow-up

Patients were treated in a sling for the first 4 weeks. Pendulum exercises and active assisted flexion and abduction exercises below the horizon (90° abduction and flexion) were commenced 24 h after surgery. The sling was removed after 4 weeks and a graduated physiotherapy regimen was commenced with a goal of full range of motion at 8 weeks. Strengthening exercises were only allowed once full range of motion was achieved, provided radiological and clinical fracture union was confirmed. Each patient was evaluated using the SPADI, DASH, Constant scores at 6 weeks, 3, 6 months, and 1 year, and the TAFT score at 12 months. For the latest follow-up, all patients were telephoned by an independent research associate and interviewed to establish final SPADI and DASH scores. Two patients were lost to follow-up during the first 12 months (6.5 %); no further loss to follow-up occurred during the remaining follow-up period and the total loss to follow-up was 6.5 %. However, both patients were contacted during the final follow-up and the results of their SPADI and DASH scores were included. The mean follow-up of those remaining patients who form the study cohort was 38.7 ± 14.8 months (13–59).

Results

Table 1 provides on overview of patient demographics including age, gender, and mechanism of injury, as well as the Constant, DASH, TAFT, and SPADI scores at 12 months, and SPADI and DASH scores at the latest follow-up. Bony union was achieved at a mean follow-up of 6.3 ± 4.1 weeks. At the 1-year follow-up, the AC joint remained reduced anatomically on plain radiographs in all cases. Table 2 and Fig. 3 demonstrate the Constant, SPADI, and DASH scores at intervals from 6 weeks to 1 year, and both the DASH and SPADI scores at the latest follow-up at 38.7 months. Thirteen type II a and 18 type II b were treated. The mean Constant score for type II a was 97.3 ± 3.7 and 94.3 ± 5.2 for type II b fractures. The DASH scores (II a: 3.4 ± 3.7; II b: 3.4 ± 2.2) and SPADI scores (II A: 2.6 + 2.4; II B: 2.5 + 1.3) for both types II a and II b were very similar for both fracture types. These between-type differences were not significant ($p =$ 0.1–0.9). Similar to Herrmann et al. [10], the Constant score results at 1 year were divided into excellent (90–100), good (80–89), satisfactory (70–79), and fair (<70); there were 24 (77.4 %) excellent and 5 (16.1 %) good results. The mean Taft scores were 11.3 ± 0.7 for type II a fractures and 11.4 ± 0.7 for type II b fractures. None of the patients demonstrated any clinical tenderness at the ACJ during the 12 months follow-up examination.

Table 1 Results of the 31 subjects treated with the 2.4-mm volar distal locking plate and TightRope™

Patient number	Age (years)	Gender	Neer	Follow-up 12 months				Last follow-up		
				Constant	DASH	TAFT	SPADI	Months	DASH	SPADI
1	16	m	II a	100	5	12	3	59	0	0
2	50	m	II a	93	1	11	2	57	0	0
3	28	m	II a	94	2	11	3	56	0	0
4	13	m	II a	100	2	12	2	54	0	0
5	12	m	II a	99	1	12	1	53	0	0
6	14	m	II a	100	3	12	1	52	0	0
7	21	m	II b	Lost to follow-up			53	0	0	
8	49	m	II b	89	4	10	5	52	0	0
9	29	m	II a	98	1	12	1	46	0	0
10	15	m	II b	100	2	11	2	52	0	0
11	40	m	II a	98	2	11	3	47	0	0
12	31	f	II b	93	2	12	1	43	0	0
13	26	m	II a	100	3	12	1	40	3	6
14	56	f	II b	Lost to follow-up			39	0	0	
15	14	m	II a	100	2	12	2	30	0	0
16	18	m	II b	100	2	12	1	27	0	0
17	40	m	II a	98	3	11	2	27	0	0
18	24	m	II b	88	7	10	4	20	0	0
19	27	f	II a	95	5	10	3	23	0	0
20	53	f	II a very comminuted	87	16	10	11	19	0	0
21	20	m	II b	100	2	12	3	18	0	0
22	53	m	II b	82	9	11	5	18	0	0
23	16	m	II b	100	2	12	2	13	0	0
24	23	f	II b	97	5	11	3	19	0	0
25	41	f	II b	94	3	11	2	18	0	0
26	54	f	II b	89	6	11	3	47	10	11
27	59	f	II b	98	2	12	2	46	0	0
28	18	m	II b	93	2	12	3	34	0	0
29	24	m	II b	100	1	12	1	20	4	9
30	30	m	II b	92	3	11	2	24	0	0
31	27	m	II b	94	2	12	1	30	0	0
Mean	30.30			95.55	3.45	11.38	2.58	38.7	0.6	0.6
SD	14.60			4.82	3.02	0.73	1.94	14.8	2.1	2

Table 2 Results of the Constant, SPADI, and DASH scores at intervals from 6 weeks to 1 year, and SPADI and DASH score at the final mean follow-up at 38.7 months

	Constant	DASH	SPADI
6 weeks	50.2 ± 12.7 (29–71)	63.5 ± 15.1 (35–89)	75.8 ± 12.5 (48–95)
3 months	76.7 ± 12.4 (48–95)	27 ± 15.5 (7–63)	30.1 ± 15.7 (11–65)
6 months	89.1 ± 7.2 (70–98)	6.7 + 5.7 (1–27)	7.6 ± 5.9 (1–32)
12 month	95.6 + 4.8 (82–100)	3.5 ± 3 (1–16)	2.6 ± 1.9 (1–11)
Final at 38.7 months		0.6 ± 2.1 (0–10)	0.6 ± 2 (0–11)

Two complications were observed in our study cohort. One patient (Table 1, Patient No. 15) presented with a superficial *Staphylococcus aureus* infection, which settled with a course of appropriate antibiotics. The second patient (Table 1, Patient No. 20) presented 6 months after surgery with a non-union and hardware failure requiring re-plating and bone grafting, and union was subsequently achieved 9 weeks later. His Constant score at 12 months after the

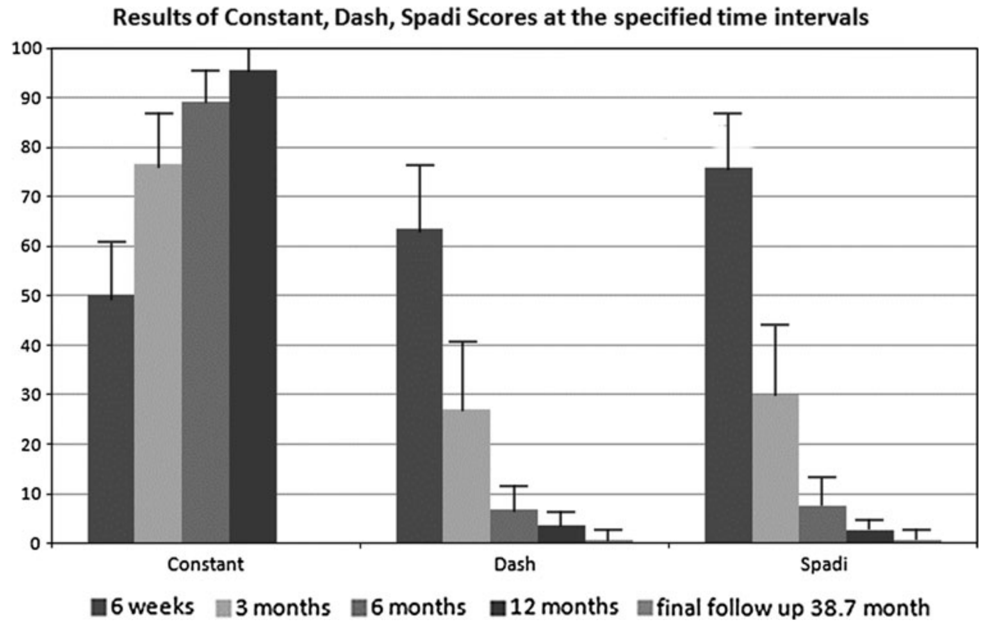

Fig. 3 *Graph* outlining the Constant, DASH, and SPADI scores at 6 weeks, 3, 6, and 12 months; the TAFT score at 12 months; and both the DASH and SPADI scores at the final follow-up at 38.7 months

injury was 87 and the DASH and SPADI scores at the final follow-up 19 months after the original injury were 0 and 0, respectively.

Discussion

Treatment of Neer type II fractures of the lateral clavicle remains controversial, perhaps indicating that they are not fully understood. These injuries are potentially unstable and have a greater risk of non-union [1, 2, 32]. The forces of the sternocleidomastoid and trapezius muscles pull the medial fragment posteriorly and superiorly. This characteristic displacement is further compounded by the pectoralis muscle and the effect of gravity, and the fragments may be widely separated [2, 13].

Neer type II fractures have been subdivided into two types based on the integrity of the CC ligaments. For type II a injuries, the CC ligaments remain intact, indicating that the lateral clavicle is structurally bound to the coracoid, scapula, and the weight of the entire upper limb. Stabilization of this injury using a superior locked plate alone suggests a failure of the surgeon to appreciate the nature of the deforming forces. This construct would rely entirely on the pull-out strength of several locked screws in the lateral fragment. The high rates of failure noted in comminuted or osteoporotic fragments should be expected, and coraco-clavicular interval reconstruction is therefore necessary to provide additional support to limit the potential early failure of internal fixation. We have observed partial injuries to the CC ligaments in our cohort of type II a injuries, and in all these cases horizontal instability was elicited; further evidence shows that these injuries may not be as stable as the current definition suggests.

Type II b injuries are even more challenging and difficult to control, as rupture of some or all of the CC ligament can result in both horizontal and vertical instability of the medial fragment [2, 5, 6], superimposed on the substantial loads discussed above. As with type II a injuries, a superior locked plate alone is unlikely to effectively stabilize this injury, although for very different reasons. The superior locked plate by itself cannot effectively neutralize the additional forces that would be expected to develop with range of motion. The additional forces resulting from this instability would predispose these constructs to failure of fixation, particularly with a comminuted or osteoporotic lateral fragment. After the fracture has been stabilized, it is important to examine both horizontal and vertical stability to assess CC-ligament integrity and reconstruct the CC ligaments to counteract this instability.

Several very different methods of surgical treatment have been described, which can be divided into direct osteosynthesis, CC interval fixation, and trans-acromial techniques [6]. The most commonly described direct osteosynthesis method uses the clavicle hook plate, although the reported complication rate with this implant ranges from 14 to 68 % [13, 16, 33]. Coraco-clavicular interval reconstruction most often utilizes screw fixation [6], sling fixation [11], or arthroscopic suture fixation [20–22]. Unfortunately, some of these methods have also been associated with screw loosening or breakage, loss of reduction, acromio-clavicular joint degeneration, and bone erosion [11, 17]. Transacromial techniques, such as K-wire or tension band fixation, are at risk of hardware migration

[23], as well as the potential for damage to the AC joint leading to degenerative arthritis [34].

Recognizing the difficulties associated with isolated management of either the fracture or the ligaments, it is our contention there are genuine benefits derived from repair of both simultaneously. Combining these two techniques, stable fixation allows early mobilization of the involved extremity. A superiorly placed distal radius plate stabilizes the fracture site, and the CC-ligament complex is augmented anatomically using the TightRope™ (Arthrex®) suture device through the base of the coracoid. In our series of 31 patients, the implant-related complication rate was lower than with any other reported technique. No subject reported implant-related discomfort, possibly because of the low profile of the device. The distal fragments are often small, although in our series we placed a minimum of three locking screws in the distal fragment in every case, contributing to greater stability and strength. Placement of the Tightrope™ using arthroscopic techniques may conceivably result in a decrease in surgical morbidity and further reduce complication rates. However, in our experience, it is extremely challenging to place the guide jig correctly, either at the superior aspect of the clavicle or inferior to the coracoid. In almost all cases, the clavicular tunnel must be placed just anterior to the curvature of the plate, which inadvertently positions the guide pin too posterior in the coracoid to benefit from arthroscopic assistance.

Previous series [7, 8, 24] using a distal radius volar plate for lateral clavicle fractures have reported similar results. Additional suture augmentation is sometimes looped over the clavicle and around the coracoid, although erosion through bone is a potential risk. One advantage of the TightRope™ system is the potential to avoid bone erosion on either end, because the sutures are not looped around the clavicle or coracoid, but instead placed within a bone tunnel and then secured over a button superiorly.

The load to failure of the intact ligament complex has previously been reported by Motamedi et al. [35] to be 725 N, while Walz et al. [36] reported 552 N. The ultimate failure load of the trapezoid ligament is approximately 300 N, while the conoid ligament fails at 260 N [36]. In comparison, the load to failure of the TightRope™ system has been reported as 547 N by Walz et al. [36]. A single TightRope™ system is therefore strong enough to reliably reconstruct either of the CC ligaments individually, but may not be adequate to reconstruct the entire CC-ligament complex.

Neer [32] reported that the conoid ligament and medial part of the trapezoid ligament are often detached from the clavicle in type II injuries. Even this partial injury to the CC-ligament complex can render the suspensory mechanism incompetent, resulting in both horizontal and vertical instability. Fracture fixation with an isolated plate is unlikely to be successful under these conditions, and we believe it is imperative to augment the CC-ligament complex as well as stabilize the fracture. This opinion is shared by Jackson et al. [37] who suggest the role of the coracoclavicular ligament in providing additional stability had to that point not been fully appreciated.

One of the strengths of this study is that it reports the largest number of consecutive cases treated with a distal radius locking plate. This technique provides more stable support than plate fixation alone and allows early mobilization. Despite our aggressive early rehabilitation protocol, in only one case we observed loss of reduction and hardware failure.

This study has limitations, including its retrospective nature and the lack of a control group. However, the outcome scores were collected in a prospective fashion for 12 months after surgery. Considering the previously reported positive results with the use of a distal radius locking plate [7, 8, 24], and given the reported high complication rate with other described procedures for this condition, it could be argued that the inclusion of a control group was not necessary. In fact, it would have been difficult to obtain ethical approval to conduct a prospective randomized controlled trial. A further concern is the relatively short follow-up of 38.7 months. However, as demonstrated by the Constant, DASH, and SPADI scores, all patients had minimal disability during the follow-up period. Further changes in functional outcome would not be expected even with a longer follow-up interval.

Conclusion

Surgical management of Neer type II lateral clavicle fractures using this technique appears to offer significant advantages compared to other methods. Fracture stabilization using a superiorly placed 2.4-mm distal radius locking plate combined with Tightrope™ augmentation of the CC ligaments results in a predictable outcome, with excellent shoulder function and a very low complication rate.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Neer CS (1984) Fractures and dislocations of the shoulder. In: Rockwood Jr. CA, Green DP (eds) Fractures in adults, Philadelphia: J. B. Lippincott, Philadelphia, pp 711–712. ISBN: 0397506236
2. Anderson K (2003) Evaluation and treatment of distal clavicle fractures. Clin Sports Med 22:319–326
3. Cheng ZJ, Hyun-Kim K, Byoung-Hyun M (2006) Surgical treatment for distal clavicle fracture associated with

coracoclavicular ligament rupture using a cannulated screw fixation technique. J Trauma 60:1358–1361
4. Jerosch J, Filler T, Peuker E, Greig M, Siewering U (1999) Which stabilization technique corrects anatomy best in patients with AC separation? An experimental study. Knee Surg Sports Traumatol Arthrosc 7:365–372
5. Edwards DJ, Kavanagh TG, Flannery MC (1992) Fractures of the distal clavicle: a case for fixation. Injury 23:44–46
6. Shin SJ, Roh KJ, Kim JO, Sohn HS (2009) Treatment of unstable distal clavicle fractures using two suture anchors and suture tension bands. Injury 40:1308–1312
7. Herrmann S, Schmidmaier S, Greiner S (2008) Stabilisation of vertical unstable distal clavicular fractures (Neer 2b) using locking T-plates and suture anchors. Injury 40:236–239
8. Kalamares M, Cutbush K, Robinson M (2008) A method for internal fixation of unstable distal clavicle fractures: early observations using a new technique. J Should Elb Surg 17:60–62
9. Wang SJ, Wong CS (2008) Extra-articular Knowles pin fixation for unstable distal clavicle fractures. J Trauma 64:1522–1527
10. Yoo JH, Chang JD, Seo YS, Shin JH (2008) Stable fixation of distal clavicle fracture with comminuted superior cortex using oblique T-plate and cerclage wiring. Injury 40:455–457
11. Webber MCB, Haines JF (2000) The treatment of lateral clavicle fractures. Injury 31:175–179
12. Badhe SP, Lawrence TM, Clark DI (2007) Tension band suturing for the treatment of displaced type 2 lateral end clavicle fractures. Arch Orthop Trauma Surg 127:25–28
13. Lee YS, Lau MJ, Tseng YC, Chen WC, Kao HY, Wei JD (2009) Comparison of hook plate versus tension band wire in the treatment of unstable fractures of the distal clavicle. Int Orthop (SICOT) 33:1401–1405
14. Mall JW, Jacobi CA, Philipp AW, Peter FJ (2002) Surgical treatment of fractures of the distal clavicle with polydioxane suture tension band wiring: an alternative osteosynthesis. J Orthop Sci 7:535–537
15. Flinkkilä T, Ristiniemi J, Hyvönen P, Hammleinen M (2002) Surgical treatment of unstable fractures of the distal clavicle: a comparative study of Kirschner wire and clavicular hook plate fixation. Acta Orthop Scand 73:50–53
16. Flinkkilä T, Ristiniemi J, Lakovaara M, Hyvönen P, Leppilahti J (2006) Hook-plate fixation of unstable lateral clavicle fractures. A report on 63 patients. Acta Orthop Scand 77:644–649
17. Jou IM, Chiang EP, Lin CJ, Cheng LL, Wang PH, Su WR (2011) Treatment of unstable distal clavicle fractures with Knowles pin. J Should Elb Surg 20:414–419
18. Robinson CM, Akhtar MA, Jenkins PJ, Sharpe T, Ray A, Olabi B (2010) Open reduction and endobutton fixation of displaced fractures of the lateral end of the clavicle in younger patients. J Bone Joint Surg [Br] 22:811–816
19. Kaipel M, Majewski M, Regazzoni P (2010) Double-plate fixation in lateral clavicle fractures—a new strategy. J Trauma 69:896–900
20. Checchia SL, Doneux PS, Miyasaki AN, Fregoneze M, Silva LA (2008) Treatment of distal clavicle fractures using an arthroscopic technique. J Should Elb Surg 17:395–398
21. Nourissat G, Kakuda C, Dumontier C, Sautet A, Dourssounia L (2007) Arthroscopic stabilization of Neer type 2 fractures of the distal part of the clavicle. Arthroscopy 23:674e1–674e4
22. Pujol N, Philippeau JM, Richou J, Lespangnol F, Graveleau, Hardy P (2008) Arthroscopic treatment of distal clavicle fractures: a technical note. Knee Surg Sports Traumatol Arthrosc 16:884–886
23. Clark RL, Milgram JW, Yawn DH (1974) Fatal aortic perforation and cardiac tamponade due to a Kirschner wire migrating from the right sternoclavicular joint. South Med J 67:316–318
24. Yu C, Sun YH, Zhao CQ, Shi DW, Wang Y (2009) Treatment of distal clavicle fracture with distal radius volar locking compression plate. Chin J Traumatol 12:299–301
25. Constant MR, Murley AH (1987) A clinical method of functional assessment of the shoulder. Clin Orth Relat Res 214:160–164
26. Gummesson C, Atroshi I, Ekdahl C (2003) The Disabilities of the Arm, Shoulder and Hand (DASH) outcome questionnaire: longitudinal construct validity and measuring self-rated health change after surgery. BMC Musculoskelet Disord 16:11
27. Hill CL, Lester S, Taylor AW, Shanahan ME, Gill TK (2011) Factor structure and validity of the shoulder pain and disability index in a population-based study of people with shoulder symptoms. BMC Musculoskelet Disord 12:8
28. Taft TN, Wilson FC, Oglesby JW (1987) Dislocation of the acromioclavicular joint. J Bone Joint Am 69A:1045–1051
29. Bossart PJ, Jouce SM, Manaster BJ, Packer SM (1988) Lack of efficacy of "weighted" radiographs in diagnosing acute coracoclavicular separation. Ann Emerg Med 17:20–24
30. Yap JJ, Curl LA, Kvitne RS, McFarland EG (1999) The value of weighted views of the acromioclavicular joint. Results of a survey. Am J Sports Med 27:806–809
31. Mazzocca AD, Spang JT, Rodrigues RR, Rios CG, Romeo AA, Arciero RA (2008) Biomechanical and radiographic analysis of partial coracoclavicular ligament injuries. Am J Sports Med 36:1397–1402
32. Neer CS (1968) Fractures of the distal third of the clavicle. Clin Orth Relat Res 1968(58):43–50
33. Renger RJ, Roukema GR, Reurings JC, Raams PM, Font J, Verleisdonk EJ (2009) The clavicle hook plate for Neer type II lateral fractures. J Orthop Trauma 23:570–574
34. Kona J, Bosse MJ, Staheli JW (1990) Rosseau RL (1990) Type II distal clavicle fractures: a retrospective review of surgical treatment. J Orthop Trauma 4:115–120
35. Motamedi AR, Blevins FT, Willis MC, McNally TP, Shahinpoor M (2000) Biomechanics of the coracoclavicular ligament complex and augmentations used in its repair and reconstruction. Am J Sports Med 28:380–384
36. Walz L, Salzmann GM, Fabbro T, Eichhorn S, Imhoff AB (2008) The anatomic reconstruction of acromioclavicular joint dislocations using 2 TightRope devices: a biomechanical study. Am J Sports Med 36:2398–2406
37. Jackson WFM, Bayne G, Gregg-Smith SJ (2006) Fractures of the lateral third of the clavicle: an anatomic approach to treatment. J Trauma 61:222–225