Percutaneous tension band wiring in acute complete acromioclavicular joint dislocation

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Background
Dislocation of the acromioclavicular joint (ACJ) is a common orthopedic injury among athletes and victims of motor vehicle accidents, predominantly motorcycle crashes. There is a common view that early surgical management should be recommended for patients with Rockwood types IV-VI ACJ injuries, as it would prevent long-term sequelae, and also it is required for patients with grades III with heavy manual occupations, athletes, and so on. None of the body joints had been treated with such profuse different techniques in an attempt to properly restore its natural situation.

Patients and methods
The present study describes and evaluates a new technique of percutaneous application of temporarily dynamic compression design of tension band wiring in type III, IV, and V acute complete ACJ dislocations. Preserving the already injured ACJ capsule, ligaments, surrounding deltotrapezial fascia, and muscles from open surgical trauma is subsequently presumed to contribute in significant stability. All patients underwent surgical management by percutaneous tension band wiring. Patients were followed up from the viewpoint of functional and radiological results at 2, 6, 12, 18 weeks, and 1 year after surgery.

Results
A total of 30 adult patients were enrolled in the study; one male patient was lost to follow-up at the 12th week appointment (implant extraction); hence, he was excluded from the results. The mean age of the patients was 31.4 years. Overall, 28 were males and two females. Clinical outcomes were regarded as excellent in 25 cases, representing 86.2% (average score=92.65) and good in three cases (average score=85), including a re-wiring case. Two patients (6.8%) experienced partial reduction loss. However, there were no significant differences (P=0.236) between the right and left shoulders regarding coracoclavicular distance.

Conclusion
Percutaneous tension band wiring technique has shown to provide satisfactory clinical results and shoulder functions. It provides stable fixation, allows early motion exercise by minimizing surgical trauma to preinjured tissues, lowers the complications of rigid internal fixation, and reduces cosmetic problem in scar.

Keywords:
acromioclavicular joint, dislocation, percutaneous, tension band

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Introduction

Acromioclavicular joint (ACJ) is a sturdy structure that anchors the clavicle to the scapula [1]. Dislocation of ACJ is a relatively common injury, representing 9–12% of all shoulder injuries, with an overall incidence estimated at approximately 3–4 per 100 000 in the general population, and they mostly affect younger athletes [2–5]. The commonly used classification system for this injury was popularized by Rockwood and is based on joint stability as determined by the degree of disruption to the acromioclavicular (AC) ligaments, coracoclavicular (CC) ligaments, and surrounding deltotrapezial fascia [6].

Treatment of acute complete ACJ dislocation is still controversial; no other joint in body has been treated in 100 different techniques as the ACJ in attempt to properly restore its natural situation [1,5]. There is a common view that early surgical management should be recommended for patients with Rockwood types IV-VI ACJ injuries, as this has been shown to prevent long-term sequelae [7,8], and also it is required for patients with grades III with heavy manual occupations, overhead throwing athletes, and so on [9].

Surgical techniques are founded on two goals: ligament healing and ligament reconstruction. Ligament healing

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methods attempt to reduce the distance between the clavicle and the coracoid, which leads to primary healing of the CC ligaments. However, these methods are not suitable for chronic dislocations [9,10], because it is accepted that after 3 weeks from shoulder injury, AC and CC ligaments have lost their property to heal [11]. Surgical management of acute ACJ dislocation focused on realigning the torn ends of the ligaments during the temporary fixation, because it is accepted that in the acute phase, they still have healing potential [11,12].

The first surgical repair of an acute ACJ dislocation is credited to Sir Samuel Cooper who, back in 1861, used a loop of silver wire to approximate the clavicle and acromion process [13]. Tension band wiring was introduced in the early 70s of the last century and for decades used as a method of choice. A disadvantage of this technique has been considered to limit the movement of the arm above the horizontal till removal of implants, and frequent prominence of Kirschner (K) wires [14]. Development of minimally invasive interventions reduces the surgical trauma that was introduced by conventional open techniques. With theoretical advantages of a smaller scar, better esthetics, and less postoperative pain, it offers an attractive option for both the surgeons and the patients [15]. The aim of the study was to submit and evaluate a new technique of percutaneous application of temporarily dynamic compression design of tension band wiring, preserving the already contused ACJ capsule, ligaments, and surrounding deltotrapezial fascia in acute complete ACJ dislocation types III, IV, and V.

Patients and methods

Patients visiting the Emergency Hospital, Mansoura University, from October 2009 to April 2016 with unilateral acute complete ACJ dislocation types IV, V, and III (if lateral clavicular end was elevated by ≥75% of width of acromial process articular surface) were considered for inclusion in the study. Diagnosis was founded on the clinical and radiological results of the patients. The study was conducted after obtaining approval from the relevant Institutional Review Board (IRB). The present study was also approved by the Ethics Committee. A written informed consent was obtained from all patients enrolled in the study.

Clinically patients had prominent lateral end of clavicle, local bruising, and local tenderness; the affected shoulders were neurovascular free in all patients and had no associated injuries. Radiographic evaluation was done by taking three views: a true anteroposterior view (AP) view of the ACJ (Zanca view) with 10° cephalad view for both ACJ [16], where complete dislocation was diagnosed in type III if lateral end of the clavicle was elevated by at least 75% of width of the articular surface of acromial process [1]; axillary lateral view, to visualize anterior or posterior displacement of clavicle; and stress view, with 5 kg weight in both hands when patient is standing upright and pulling back his/her shoulders [16].

Surgical technique (Figs. 1 and 2):

All patients were managed by percutaneous tension band wiring (PC-TBW) and were operated by the same surgeon. Our technique was carried out in a beach chair position under image intensifier control. A trial of anatomical closed reduction of the ACJ was first accomplished manually and confirmed by AP and axillary image views, to ascertain the potentiality and accuracy of reduction before assembling fixation (Fig. 1a,b). Then, we drove 1.6-mm K-wires from the acromion to clavicle orthogonal with ACJ axis, and radiographically checked for its position and the re-accomplished manual joint reduction (Fig. 1c,d), followed by the second K-wire in parallel plane with the previous one (Figs. 1e, 2a) while maintaining the reduction. Emphasis was placed on optimum positioning of the K-wires across ACJ and lateral clavicle.

Then, both wires were driven to exit their tips out from the end of straight distal clavicular segment almost near to the conoid process region (33.5–45-mm medial to the lateral clavicular edge) [11,17]. A small incision upon the tips of K-wires medially was done (Fig. 2a), and a metal sleeve was used to drive the wires through it and out of the incision avoiding soft tissue injuries (Fig. 1e). Tension band wiring with No 0.9 cerclage wire was percutaneously assembled using a double smooth-ended 1.8-mm K-wire with one pierced end (Fig. 2b), which was manually introduced, gliding intimately and rubbing to the overlying periosteum of the acromion and lateral clavicular segment, passing through the reduced ACJ to deliver the cerclage wire forth and back (Figs. 1f,g, 2c) around both ends of K-wires assembling in a figure-of-eight fashion. The distal ends of cerclage wire were tightened to dynamically compression and stabilize the ACJ together with the transfixing K-wires, avoiding excessive compression of the articular surfaces (Figs. 1h, 2d). Smooth bending of the K-wires ends and the cerclage wire knot was done using a right-angle-bended ender nail under image intensifier control, and then skin closure of the two incisions and dressing were done.

Figure 1

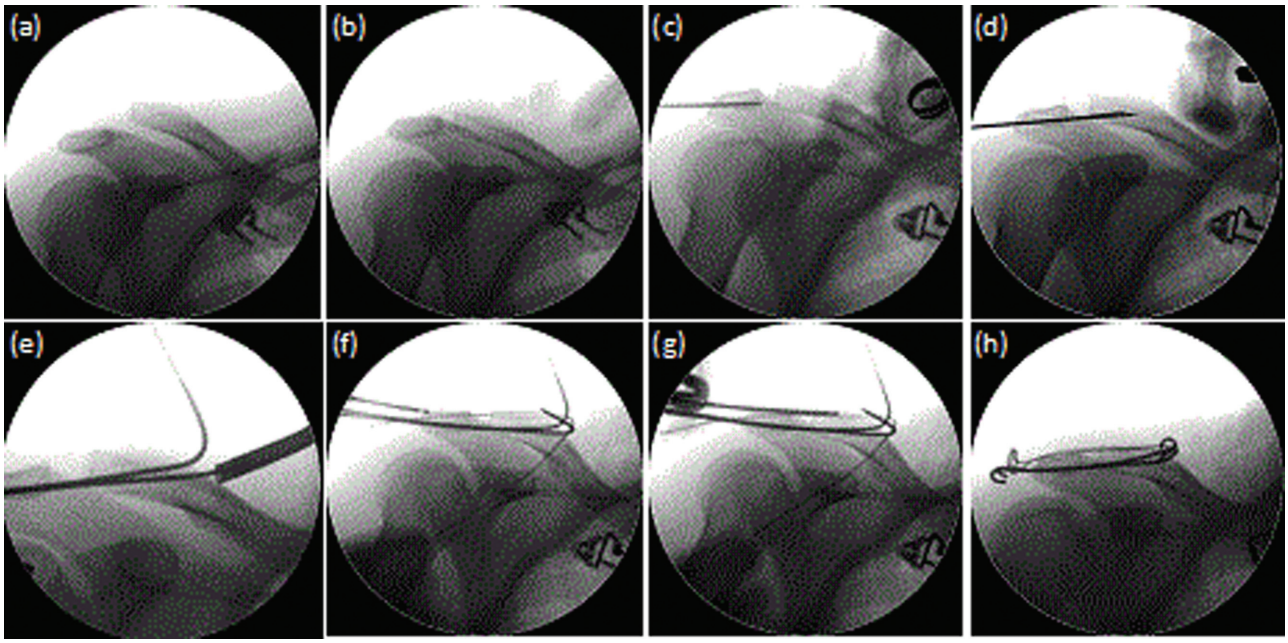
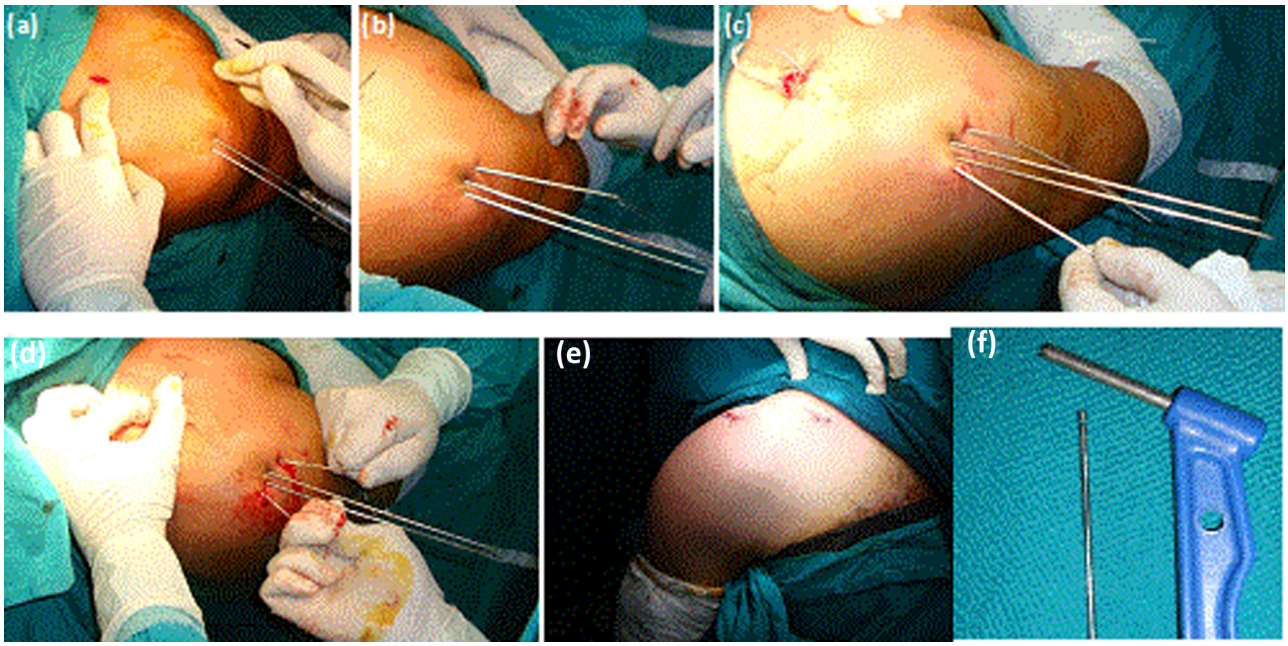


Image intensifier images (a, b) closed reduction trial of the ACJ before assembling fixation. (c) Insertion of 1.6-mm K-wires from the acromion to clavicle orthogonal with ACJ axis. (d) Insertion of second K-wire in parallel plane with the previous one while maintaining the reduction. (e) A metal sleeve receiving the wire out of the small incision, protecting the soft tissues. (f, g) The pierced end 1.8-mm K-wire gliding intimately and rubbing to the overlying periosteum of the acromion and lateral clavicular segment passing the reduced ACJ to deliver the cerclage wire forth and back around both ends of K-wires assembling in a figure-of-eight fashion. (h) The cerclage wire ends were tightened distally, and then bending of the K-wires ends and the cerclage wire knot. ACJ, acromioclavicular joint.

Figure 2



Surgical technique steps. (a) Dual K-wires were driven percutaneously to exit their tips out from a medial small incision. (b–c) The pierced end 1.8-mm K-wire percutaneously gliding intimately over the acromion, reduced acromioclavicular joint and lateral clavicular segment delivering cerclage wire No 0.9 cerclage forth and back, and assembling figure-of-eight fashion between both ends of K-wires. (d) The cerclage wire ends were tightened distally, avoiding excessive compression upon articular surfaces. (e) Skin closure. (f) A double smooth-ended 1.8 mm K-wire with one pierced end and metal sleeve.

Postoperatively, the patient's shoulder was immobilized in an arm sling for 4–6 weeks and was initially allowed to move fully and actively the elbow, wrist, and hand. Pendulum exercises were encouraged immediately. Passive abduction of the shoulder was allowed beneath the horizontal axis of elevation after

the second week. Active range of motion was progressively advanced from the sixth week onward. PC-TBW was extracted through the same dual surgical wounds for its application after 12 weeks postoperatively under control of image intensifier. Overhead abduction and return to work without restrictions were allowed 2 weeks after implant removal (14 weeks), whereas contact sports or heavy-duty manual efforts were avoided for 4–6 months.

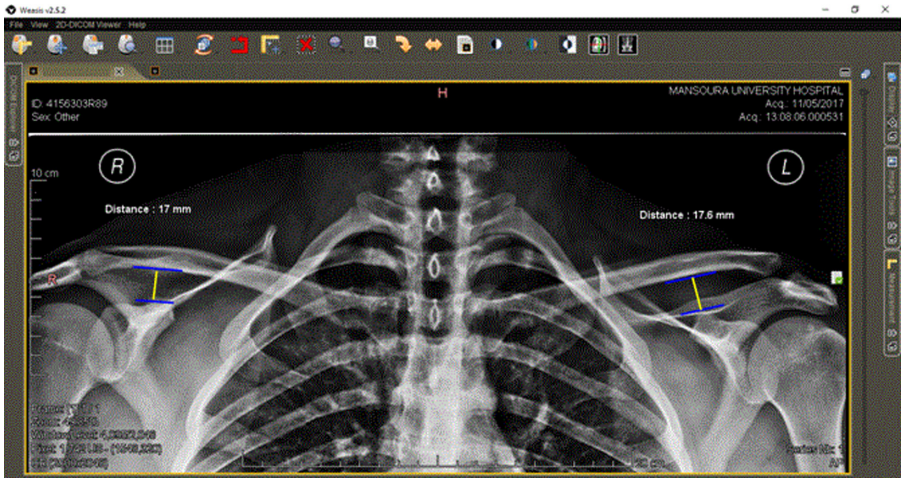
Results

Patients were followed up clinically and radiologically at 2, 6, 12, 18 weeks, and 1 year after surgery. Stress radiographs were performed 6 weeks after PC-TBW extraction and 1 year after surgery. Coracoclavicular distance (CCD) was digitally measured for bilateral shoulders using Weasis v2.5.2 medical viewer software [Digital imaging and communications in medicine (DICOM) has been released in 1993 by the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA)] for the AP radiograph file (Fig. 3) at 18 weeks and 1-year follow-up intervals, as an objective evaluation of our technique regarding ACJ stability and maintained reduction.

Functional outcome was assessed using the Imatani's scoring system [18]. It included assessment of pain, function, and movement of the shoulder. Four grades were categorized, and a satisfactory outcome included an excellent or good result (Table 1). This scoring system was used for being relatively simple and practical [19]. Patient satisfaction was also recorded at the times of follow-up in terms of shoulder strength, appearance, and whether return to the preinjury level of activity was regained or not. Complications were recorded and managed.

Results of 29 adult patients were recorded in the study, after exclusion of one patient who was lost to follow-up

Figure 3



Coracoclavicular distance (CCD): was measured digitally using Weasis v2.5.2 medical viewer software for bilateral shoulders anteroposterior radiographic files (partial reduction loss case).

Table 1 The scoring system by Imatani for acromioclavicular dislocation [18]

	Distribution	Score
Pain (40 points)	None	40
	Slight, occasional	25
	Moderate, tolerable, limits activities	10
	Severe, constant, disabling	5
Function (30 points)	Weakness (proportion of preinjury)	20
	Use of shoulder	5
	Change of occupation	5
Movement (30 points)	Abduction	10
	Flexion	10
	Adduction	10

Result: excellent (91–100), good (81–90), fair (61–80) and poor (<61).

at the time of implant extraction. All ACJ dislocations were caused by motor vehicle accidents, particularly motorcycle crashes. Patients' ages were between 22 and 43 years (mean: 31.4 years). Among them, two were housewives and the rest were males, employed in different types of jobs, ranging from office work to heavy-duty manual profession. The right dominant side was affected in 21 patients (72.4%), whereas eight patients were affected with the left nondominant side. The mean time of hospitalization before the surgery was 2.7±1.4 days (range: 1–5 days), and the mean time of follow-up was 14.2±4.4 months (range: 12–28 months). Satisfactory closed reduction under control of image intensifier could be achieved in all patients, not requiring resorting to open reduction. There were no postoperative complications, such infection, or failure of fixation, except for a housewife who required repeating the procedure, as she had broken wires 3 weeks postoperatively owing to lack of compliance with the postoperative regime in terms of heavy weight lifting and moving furniture. There were no acromial osteolysis detected on the latest radiographs of all patients.

Through the latest follow-up (Fig. 4) evaluation, the outcomes were regarded as excellent in 25 cases, representing 86.2% (average score=92.65); good in three cases (average score=85), including the re-wiring case, which were owing to occasional shoulder pain requiring analgesics occasionally; and fair in a heavy manual worker patient, who changed his occupation. In addition, he was recorded to have a repeat injury in football sports event 6 weeks postoperatively.

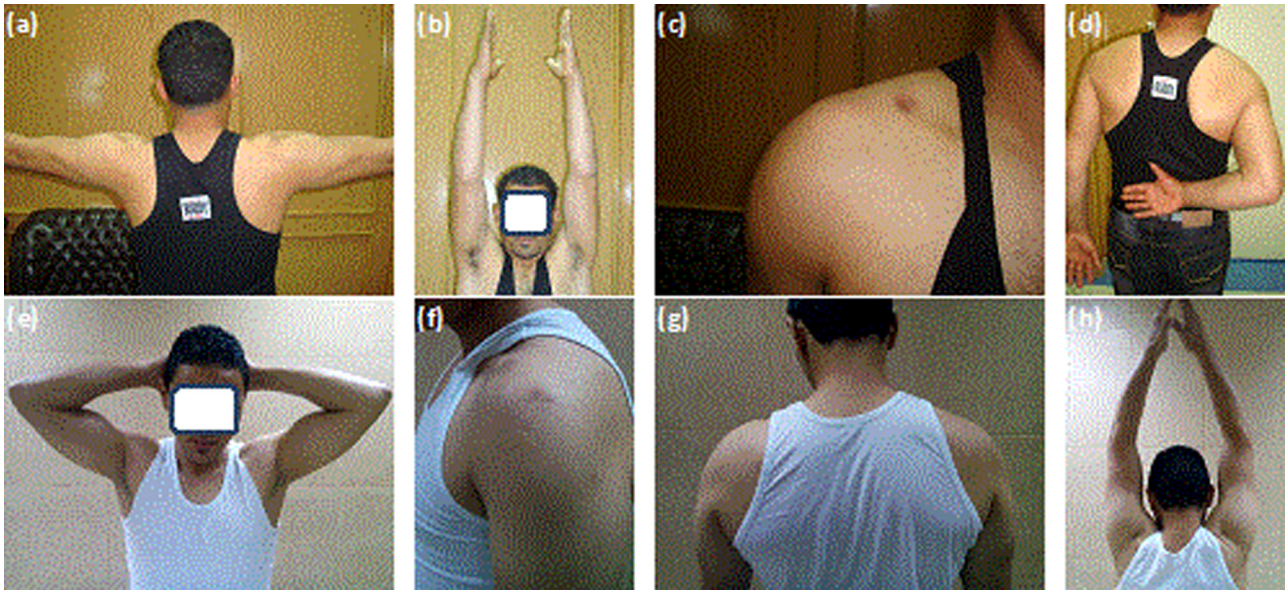
On final radiological follow-up, all the patients maintained complete reduction in the routine or stress AP radiographs of bilateral shoulders, except two patients (6.8%) who experienced partial reduction loss. However, there were no significant differences (P=0.236) of CCD between the right and left shoulders.

All the patients were satisfied with the appearance and functional recovery and were pleased with the cosmetic appearance of their shoulders, except for a female patient who complained of an excessive scar at the distal surgical wound and was solved by sacrectomy while extracting the implants; all patients were able to return to their preinjury level of daily activity.

Discussion

Treatment of acute complete ACJ dislocation is always controversial from various viewpoints; in consequence, plentiful methods of ACJ fixation have been described, but there are certain dilemmas as to which technique to be used [2,5,19]. Most of them reported high incidence of complications such as breakage or migration of implants, failure of fixation, or erosion of bone and subsequent loss of reduction. These difficulties may result in re-dislocation, infection, and prolonged rehabilitation [1].

Figure 4



Clinical outcomes: right shoulder operated patient: (a) side stretching exercise. (b) Overhead stretching exercise. (c) Front view appearance. (d) Backward stretching exercise. Left shoulder operated patient: (e) back of the head stretching exercise. (f) Side view appearance. (g) Back view in resting position. (h) Overhead stretching exercise.

Theoretically, anatomic reduction may avoid tenting the soft tissues and the skin. Thus, shoulder pain may be ameliorated. However, surgical reduction may extensively destroy the compromised soft tissues. The adverse effects may be aggravated if CA ligament reconstruction is added [19]. In practical scenarios, complicated attempts of repairs in a sophisticated manner are often difficult, because the ligaments are usually contused, shredded, and even sometimes not recognizable [15].

Once surgical treatment is chosen, the principle of reducing destruction of soft tissues and proving sufficient stability should always be followed [19]. Percutaneous techniques result in fewer complications but are technically demanding [20]. Our main goal was to depict a technique for percutaneously fixing ACJ temporarily with TBW, and the second goal was to evaluate this procedure with other analogous techniques in literatures.

Stabilization of the AC joint with K-wires is an exacting procedure. K-wire migration, which is relatively rare, can have serious sequelae [21]. In our technique, this unpleasant complication was avoided, as the dual K-wires used were positioned through the acromion into the clavicle in an accurate positioning under control of image intensifier, and their medial ends passed through the cortical bone of the clavicle at the superior posterior wall at the bending zone between the lateral and middle third of clavicle, in the region of the conoid tubercle, giving anchor later on to the cerclage wire medially.

The etiology of shoulder pain associated with complete ACJ dislocation is varied, which can be induced by many bony or soft tissue factors solely or concomitantly [19]. PC-TBW technique avoided unnecessary bony and soft tissue surgical trauma, by looping of the cerclage wire around the medial ends of the transfixing K-wires, rather than passing through the clavicular bony component, and assembling the TBW percutaneously, preserving the deltotrapezial fascia and muscles from surgical trauma, which might subsequently contribute to positive outcome with respect to shoulder pain and stability.

The goal in treatment of ACJ dislocation is the healing of short ligaments during temporary fixation [10]. Ligament healing does not necessarily require rigid temporary fixation, as the ligament and muscle attachment healing process can continue for years after the injury and the temporary stabilization [22]. We used TBW with two smooth-ended 1.6-mm K-wires that gave enough stability to allow early mobilization, and the only case who sustained repeating procedure had broken wires 3 weeks postoperatively because of violent manual shoulder effort in the form of heavy weight lifting and moving furniture. Articular perforation with wires is not considered a cause of early AC degeneration, as it is also seen after conservative treatment and CC fixation [23]. None of our patient had acromial osteolysis on the latest follow-up radiographs, a complication noted in literatures when using larger dimension wires (more than 2 mm) [1].

The time of PC-TBW removal was predetermined for all of our patients, at 12 weeks of the surgery, having the privilege of previous literature recommendations. Virtanen and colleagues suggest that stabilization should be long enough for the healed ligaments and muscle aponeurosis to be able to tolerate the mechanical load, such as using temporary 6–8-week ACJ stabilization. Occasionally, it leads to ligament healing failure during this period [10]. Wilkie, 2010, mentioned that fixations should be removed once the biological healing of ACJ has consolidated, as implant failures may result. Therefore, the average timing of removal is around 12 weeks after surgery [15].

It was yet believed that a complete anatomic reduction was not a prerequisite for regaining adequate shoulder function. A partial loss of reduction did not appear to influence the overall functional results [24,25]. Two of our patients (6.8%) experienced partial reduction loss. However, there were no significant differences between the right and left shoulder CCD (P=0.236), as measured digitally with actual scales of radiological digital files using Weasis v2.5.2 medical viewer; One of the patients was among the excellent functional outcome major group (score=92.65), whereas the other one had good results (score=85); both of them were deemed satisfactory functional results.

The simple step of cutting and bending a K-wire, which is performed in open techniques, becomes a challenge; burying the cerclage wire knot may be a difficult task [20]. In PC-TBW, use of the smooth-ended 1.8 mm K-wire with one pierced end guaranteed to percutaneously pass the cerclage wire, as well as the right-angle-bended ender nail, helped bending the ends of K-wires and cerclage wire knot through very small portal incisions, which diminished the cosmetic problem in scar. All patients were delighted with the esthetic outcome, except for a female patient, who mentioned an excessive keloid at the distal surgical wound, which was solved with sacrectomy during implant extraction.

Conclusion

PC-TBW technique combines the advantages of rigid internal fixation and minimally invasive surgery, providing satisfactory clinical results and excellent shoulder functions, with less pain and low incidence of complications, and it also reduces cosmetic problem in scar. It could be a new option for treatment of acute complete ACJ dislocation.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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