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Case Report

Intraoperative Computed Tomography Use for Sternoclavicular Joint Plating of a Medial Clavicle Fracture

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Abstract

Introduction: Surgical fixation of medical clavicle fractures using sternoclavicular plating presents risks to structures in the mediastinum. Intraoperative fluoroscopy is limited in its ability to assess screw placement in the sternum. Intraoperative CT can be used to assess fracture reduction and plate and screw placement though it has been minimally reported in the literature.

Case report: We present a case report of the use of intraoperative CT for treatment of a comminuted medial clavicle fracture with anterior SC joint dislocation and acromioclavicular (AC) joint separation.

Discussion: O-arm provides a powerful tool for assessment of intraoperative plate and screw positioning in the treatment of medial clavicle fractures.

Keywords: Medial clavicle fracture; Sternoclavicular joint plating; Intraoperative computed tomography; O-arm; Acromioclavicular joint separation; Sternoclavicular joint; Clavicle fracture

Introduction

A medial third clavicle fracture is a rare injury accounting for approximately 2% of clavicle fractures [1,2]. Traditionally, these fractures have been treated conservatively with surgical intervention reserved for open fractures, threatened skin, or neurovascular involvement. Studies have suggested unsatisfactory results with nonoperative treatment of displaced medial clavicle fractures with nonunion rates reported as high as 15% 18 and up to half of patients being symptomatic more than a year after a medial clavicle fracture [3,4]. However, given the infrequency of medial clavicle fractures and the low operation rate, there is a limited number of operative cases reported in the literature and a lack of consensus on operative treatment. Sternoclavicular plating for restoration of the sternoclavicular (SC) joint is a technique that has been described in the literature with good results in small samplings of patients [5,6,7,8,]. The technique involves spanning the SC joint with a temporary plate screw construct from the medial clavicle to the sternum to gain adequate purchase, increase rigidity, and limit motion in medial clavicle fractures with planned removal once adequate healing has occurred. However, a surgical fixation that crosses the SC joint can have severe consequences including screw or drill penetration into the thoracic cavity with risk to vessels, nerves, and soft tissues of the mediastinum and surrounding the heart and lungs [9].

To further complicate matters, intraoperative fluoroscopy is limited in its ability to assess placement screws in the sternum placing structures deep to the sternum at increased risk [10]. Intraoperative computed tomography has previously been minimally reported in the use of assessment of the clavicle, with

only one case report utilizing CT to assess reduction of posterior sternoclavicular joint dislocations [11]. Intraoperative CT can be a powerful tool in treatment of medial clavicle fractures to assess fracture reduction and plate and screw placement. We present a case report of the use of intraoperative CT for treatment of a comminuted medial clavicle fracture with anterior SC joint dislocation, acromioclavicular (AC) joint separation.

Case Report

This is a case of a 56-year-old right-hand dominant otherwise healthy male who was involved in a bicycle accident causing him to flip over the front of his bike and land directly onto his left shoulder. He initially presented to the emergency department on the date of his injury with left shoulder pain and prominence over the SC joint. His initial workup included three-view radiographs of the left shoulder (Figure 1) and CT of the chest, which demonstrated a left comminuted medial clavicle fracture with intra-articular involvement and anterior displacement of the clavicle relative to the sternum (Figure 2). The clavicle was length unstable and had rotational malalignment. He also had an ipsilateral AC joint separation with posterior displacement of the clavicle in relation to the acromion (type IV) which had become incarcerated in the trapezius. The patient was clinically stable, had no evidence of neurovascular compromise and the fracture was closed. Consequently, he was discharged from the emergency department with follow-up in orthopedic clinic that week.

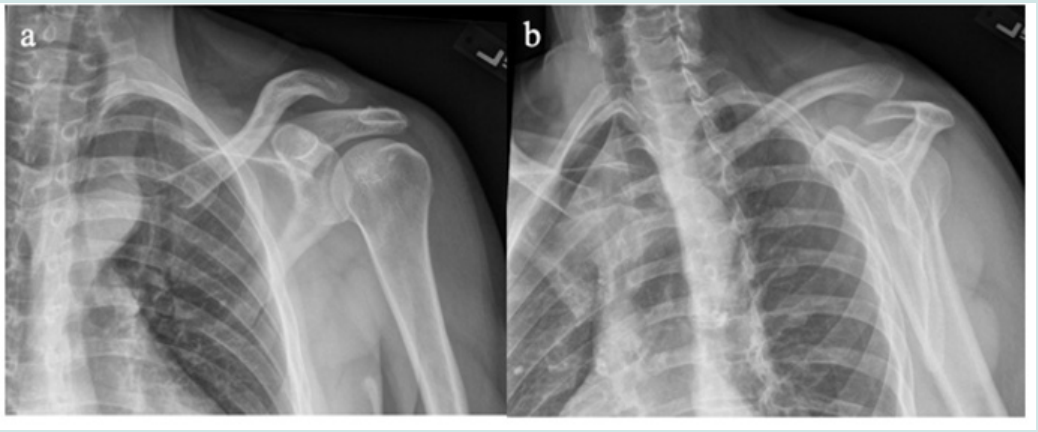

Figure 1: Grashey (a) and Scapular-Y(b) x-rays of left shoulder taken the day of the injury showing left AC joint separation.

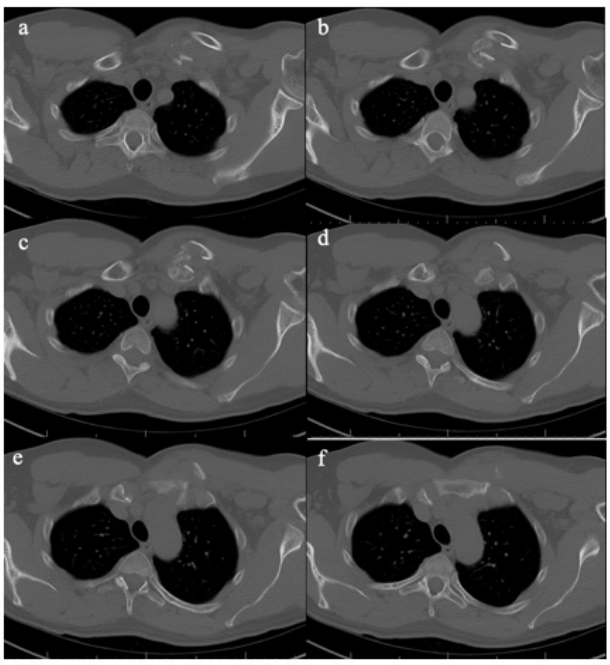

Figure 2: Cranial to caudal axial cuts (a-f) of the chest CT taken the day of the injury showing a left comminuted medial clavicle fracture with intra-articular involvement and anterior displacement of the clavicle relative to the sternum.

Two days later he presented to clinic for discussion regarding management of his injuries. Further information was gathered that he has had no prior injuries or surgeries to his left arm, he works as a janitor, and is a former smoker who quite greater than 10 years ago. On exam, his skin was intact. He had significant tenderness to palpation over the AC joint and obvious deformity at the AC and SC joints. His active range of motion was 100° of forward flexion and 100° of abduction. Distal circulatory, motor, and sensory exam was intact. Pre-operative counseling was performed and a surgical plan was developed to first reconstruct the coracoclavicular ligaments and restore the acromioclavicular joint. Plans were made for CC ligament reconstruction with a semitendinosus allograft in order to closely recreate the strength of the native CC ligaments while avoiding excess hardware complications. The medial clavicle and sternoclavicular joint could then be assessed for the need of any surgical fixation with potential bridge plating of the sternoclavicular joint due to inadequate medial clavicle bone stock for solely clavicle fixation. A hardware removal 6-8 weeks following surgery would be planned to initiate range of motion and activities of daily living.

In the operating room, the patient was placed in a well-padded supine position on a radiolucent Jackson table with a 1-liter bag between his shoulder blades and general endotracheal anesthesia induced. In addition to intraoperative fluoroscopy (C-arm), O-arm scanning was made available due to the proximity of screws to the mediastinum and the inability of C-arm to adequately ascertain the length of the screws in the sternum for the bridge plating. The AC joint was addressed first. An 8 cm vertical incision centered on the tip of the coracoid and extending proximally. The deltopectoral interval was able to be identified and dissected. Both of the coracoclavicular ligaments were disrupted. The acromioclavicular ligaments were also completely torn. The pectoralis minor was partially released medially and the coracoacromial ligament was partially released laterally. A right-angle suture passer was used to bring two braided polyethylene tapes around with coracoid (Fibertape, Tigertape, Arthrex, Naples, FL) as well as a withdrawal stitch.

Attention was then turned to the dissection of the superior clavicle. The superior clavicle was found just barely underneath the skin and it was incarcerated through the trapezius. It was mobilized until it could be reduced and verified on anterior-posterior and 15-degree cephalic tilt fluoroscopy views. The trapezial fascia was clearly torn and the AC joint capsule was also disrupted. Two 5.5 mm drill holes were then drilled two centimeters apart and centered over the coracoid. 17 Sutures were passed through these and the semitendinosus allograft was pulled around the coracoid using the withdrawal stitch. One tape was crossed but the other was not creating a U and figure-of-eight construct. Provisionally, the tape that was in a U was held with a clamp, and then live fluoroscopy stress views were obtained to demonstrate that there was no displacement of the AC joint after reduction. Consequently, the rest of the suture and the graft was pulled through and potted medially, tensioned appropriately, and potted laterally. The residual was cut off. Repeat AP and 15-degree cephalic tilt fluoroscopy stress views of the AC joint demonstrated no displacement.

Attention was then turned to the medial clavicle. On C-arm imaging, the fracture did not appear to have improved its alignment. Consequently, a separate incision was made running from the sternum to the shaft of the clavicle and allowed for identification of the fracture planes which were inferiorly displaced and the debris was posterosuperior. There was one piece of de-vascularized bone that was free. A hole was drilled in this to hold later with a suture through the plate. It was used as an autograft. The superior SC fascia was also on a piece of the medial fragment. This piece was secured with a figure-of-eight suture of #2 high-tensile polyethylene (Fiberwire, Arthrex, Naples, FL). They selected an appropriately contoured plate and placed this on, selecting a 16-hole lateral clavicle plate flipped and placed medially (Acumed, Hillsboro, Oregon). The length was assessed by looking at anteroposterior fluoroscopic views of the sternum. After plate placement, the sternal holes were filled to create a length-stable bridging construct through the sternum (Figure 3).

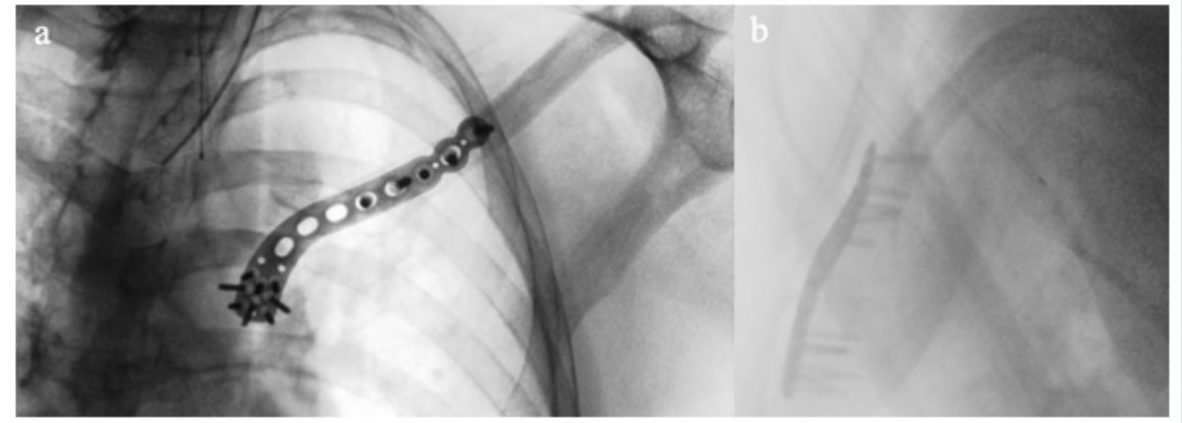

Figure 3: Intraoperative C-arm A/P (a) and lateral (b) view of the left clavicle and SCJ bridging construct with fixation in the sternum and the shaft of the clavicle.

Shaft reduction was verified to be adequate with plain fluoroscopy. The O-arm was then used to confirm the reduction and assess the posterior length of the screws as they were aimed toward the mediastinum. After intraoperative CT imaging, several screws were found to be long and changed to shorter screws. This had not been possible to assess with the fluoroscopic C-arm images. Appropriate length screws were confirmed with the O-arm (Figure 4). Most screws were unicortical. The bicortical screws, which were used to create a biomechanically stronger construct, were only 1 mm or less deep to avoid the critical structures posterior to the sternum. A total of 3 O-Arm spins were required. The wound was copiously irrigated and laterally reapproximated with 0 Vicryl, 2-0 Vicryl, and 3-0 Monocryl. Medially, it was approximated with 0 Vicryl, 2-0 Vicryl and 3-0 Monocryl. Local infiltration with 10 mL of Exparel mixed 50/50 with 10 mL of 0.25% bupivacaine without epinephrine was performed in the supraclavicular nerve distribution. The closure was with 3-0 interrupted Monocryl sutures. Steri-Strips and a sterile nonadherent dressing were applied. A sling was placed.

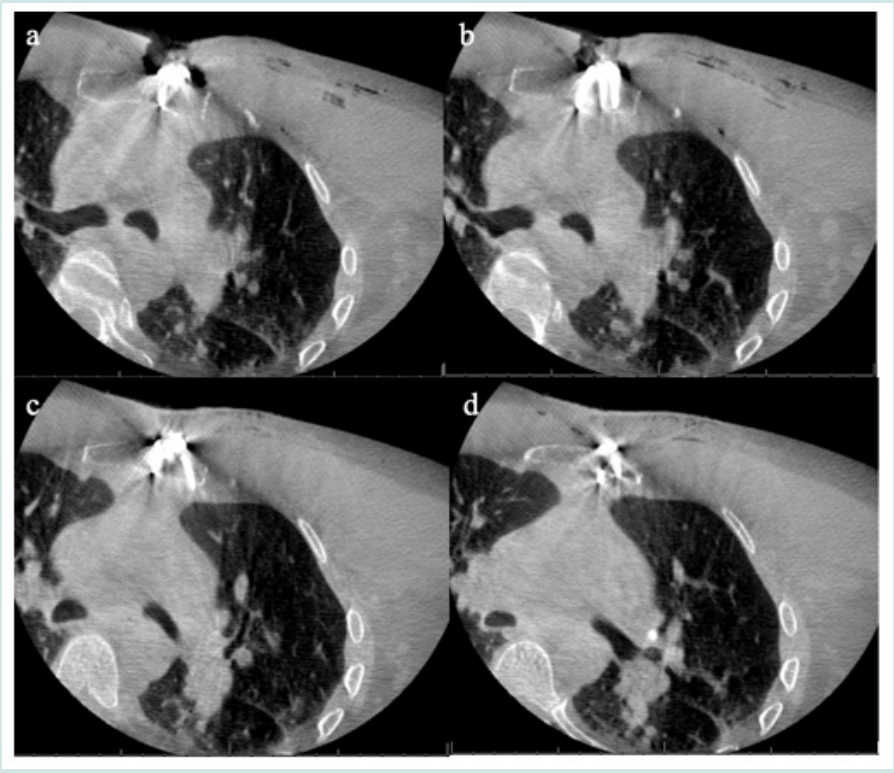

Figure 4: Intraoperative O-arm axial cranial to caudal axial cuts (a-e) assessing posterior length of sternal screws aimed towards the mediastinum.

The patient was discharged home the same day on oral analgesics and instructed to avoid active and passive range of motion at this time. He returned to clinic at the one week postoperatively with radiographs obtained showing stable post-operative alignment. The patient was seen two weeks post-operatively after he reached across his body with his nonoperative arm (to do his seatbelt) he felt something shift at the medial clavicle. Clavicle radiographs did not show any obvious change in fracture or hardware, but a CT of the clavicle demonstrated the medial plate has pulled off the sternum somewhat compared to intraoperative imaging (Figure 5). A decision was made to keep the previously scheduled hardware removal at six weeks from his initial surgery due to overall stability.

At six weeks postoperatively, the patient underwent hardware removal. He was discharged the same day on oral analgesics and given a sling for comfort. His activities were allowed to progress after the two-week visit with strengthening allowed after radiographs showed fracture consolidation at the three-month mark. At that time, the patient had painless active shoulder range of motion of forward flexion 140°, Abduction 100°, internal rotation to L1 spinous process, and adducted external rotation of 35°. At four months, repeat radiographs demonstrated healing without evidence of failure of his coracoclavicular ligament reconstruction or medial clavicle with good strength and without any reported functional deficits (Figure 6). The patient has since been lost to follow-up.

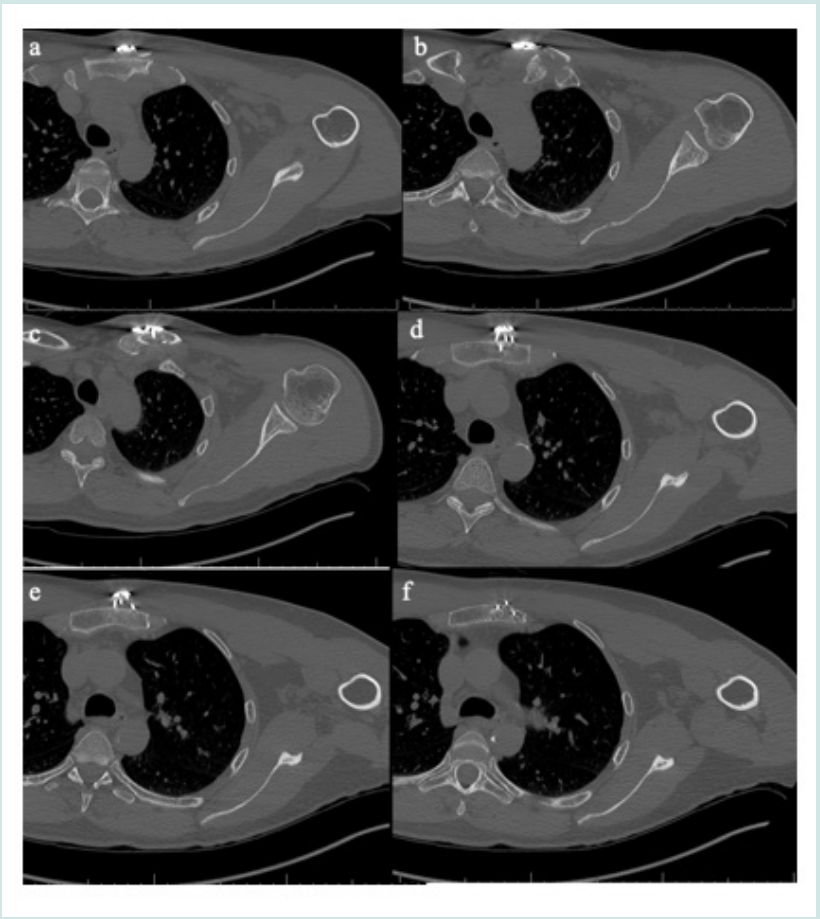

Figure 5: Cranial to caudal axial CT cuts (a-e) of the left clavicle two weeks post-operatively demonstrating anterior displacement of the medial plate off of the sternum.

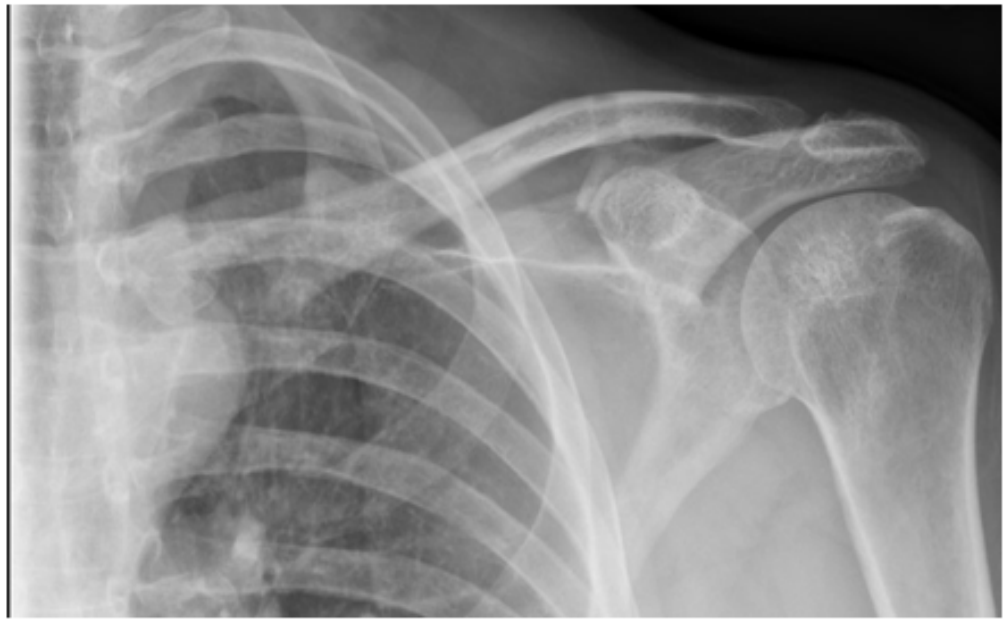

Figure 6: AP radiograph of the left clavicle four months from initial surgery without evidence of failure of his coracoclavicular ligament reconstruction or medial clavicle.

Discussion

There remains a lack of consensus on the optimal method for surgical fixation of medial clavicle in the literature include. Numerous methods of fixation have been discussed in the literature with good outcomes in small sample sizes [12,13,14,15-17,6,7]. Plate and screw fixation has the potential to provide a safer alternative to pin and wire fixation which have cited complications involving structures within the mediastinum [18]. However, there have been reports of nonunion in patients with medial clavicle fractures treated with small fragment reconstruction plates due to implant migration and risk to mediastinal structures remain [12]. Fixation constructs that spanned the SC joint provided a potential solution by providing increased stability and allowing fixation across comminuted periarticular fragments. To improve the strength of fixation of medial clavicle fractures, several techniques of surgical fixation of medial clavicle fractures that cross the sternoclavicular joint have been reported [14, 6-8]. These case series have reported promising functional outcomes with rare but significant complications including penetration of a drill or screw into the mediastinum, sternum fracture following unadvised postoperative use, and nonunion [7]. There is also a lack of consensus regarding the time until plate removal. Several studies have recommended time to plate removal ranging from 3-18 months, but our study has demonstrated a good functional outcome with plate removal at 6 weeks [6,16].

Standard radiographs are unable to capture true orthogonal images of the medial clavicle [10]. Therefore, plain films are inadequate in the evaluation screws placed in the medial clavicle and sternum. CT scan is the gold standard for evaluation of this anatomic location, but would require transporting the patient to the radiology department for assessment of screw placement with a potential return to the operating room if they are malposition. O-arm is an intraoperative imaging modality that has been utilized extensively in spine surgery to obtain real-time 3-dimensional feedback in the operating room [19]. It provides a similar level of imaging quality as a CT scanner at lower doses of radiation than a standard CT while avoiding breaking a sterile environment to go to the imaging department and a potential return to the operating room. This case highlights that the use of intraoperative O-arm provides a powerful tool for assessment of intraoperative plate and screw positioning in the treatment of medial clavicle fractures. The use of the O-arm also allows the surgeon to better assess fracture and SC joint reduction as compared to standard C-arm intraoperative imaging. We propose continued use of intraoperative O-arm SC joint plating of medial clavicle fractures [20-22].

Conclusion

This case report highlights the utility of intraoperative CT for treatment of a comminuted medial clavicle fracture with anterior SC joint dislocation. These rare injuries can be challenging to treat operatively due to the proximity of major vessels and difficulty with intraoperative radiographic assessment. Intraoperative CT scan is a useful tool to assess fracture reduction, plating, and screw length in treatment of medial clavicle fractures.

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Conflicts of interest

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