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Medial Clavicle Osseous Dimensions with Implication on Plate Fixation

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Abstract

Significantly displaced medial clavicle fractures are associated with high rates of painful nonunion. Operative fixation can be challenging due to limited medial bone stock and adjacent vital vascular structures. Twenty-one consecutive chest computer topography (CT) scans were analyzed to measure anterior-posterior and superior-inferior dimensions of the medial clavicle. Correlation between height and clavicular dimensions were assessed by Pearson correlation coefficient. Two cases using dual T-locking plates are described. From anterior to posterior, the medial clavicle typically measures 1.44 (SD 0.26 cm) and 2.51 cm (SD 0.38 cm) at its narrowest and widest points, respectively. The mean superior-inferior width was 1.56 cm (SD 0.21 cm) and 2.76 cm (SD 0.39 cm) at its narrowest and widest points, respectively. Inter-observer reliability was 0.986 with combined intra-observer reliability between two time points of 0.984. Surgeons may use CT to reliably evaluate the amount of bone available for screw purchase and pre-operatively determine expected screw lengths. Locking plates using both unicortical locking screws and bicortical screws can be used for fracture fixation. Both patients healed fractures with dual T-locking plates without a short-term hardware complication. Dual T-locking plates may be a consideration for medial clavicle fracture fixation when medial bone purchase is a concern.

Introduction

While clavicle fractures are commonly seen by orthopaedic surgeons, only 2–3% involve the medial third of the clavicle,^{1–4}. Traditionally, the majority of medial clavicle fractures have been treated non-operatively with the exception of open injuries or those compromising neurovascular structures⁵. However, significantly displaced fractures have been associated with high rates of painful nonunion^{1,4,6}. Recent case series have shown success with open reduction internal fixation of displaced medial third clavicle fractures^{7–9}. Several different constructs were used in these series, the most common of which being a single mini-fragment locking plate. As these fractures often leave little area for osseous fixation with close proximity to prominent vascular structures, the purpose of this study was to define the osseous dimensions of the medial clavicle and present two cases of severely displaced medial clavicle fractures treated with dual locking T-plates.

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Conflicts of Interest: None declared.

Materials and Methods

Twenty-one consecutive computer topography (CT) scans of the chest were analyzed on IMPAX software version 6.6.1.3525 (AGFA Healthcare; Mortsel, Belgium). CT slices were 3mm thick. Axial and coronal series were used to measure anterior-posterior and superior-inferior distances, respectively (Figures 1a–b, Figure 2a–b). The widest point of the medial clavicle was measured parallel to the sternoclavicular joint. The narrowest portion was measured perpendicular to the outer cortex in the trajectory of a presumed cortical screw. All measurements were performed twice by two observers (orthopedic residents), on two separate occasions two-weeks apart, resulting in four individual sets of measurements of the same scans. The means and standard deviations of these measurements were calculated. Student's t-tests were used to compare the widths in the axial and coronal planes by male or female sex. Correlation between height and clavicular dimensions were assessed by Pearson correlation coefficient. Intra- and inter-observer agreement was assessed via concordance correlation coefficient, with Bland-Altman plots performed to assess for patterns in the differences between separate measurements. Statistical analysis was performed using MedCalc for Windows, version 15.0 (MedCalc Software, Ostend, Belgium).

Results

Nine men and twelve women with mean age 57.3 years (range 37.5 – 81.1 years) were included. The mean anterior-posterior distance of the medial clavicle ranged from 2.51 cm (SD 0.38 cm, range 3.39 – 1.69 cm) at the widest point to 1.44 cm (SD 0.26 cm, range 1.92 to 0.86 cm) at the narrowest. Coronal images revealed a mean superior-inferior width of 2.76 cm (SD 0.39 cm, range 3.92 to 2.01 cm) at the widest point to 1.56 cm (SD 0.21 cm, range 1.95 to 1.07 cm) at the narrowest. The widest portion of the medial clavicle is in the epiphysis, which quickly tapers to approximately 57% of its width in the diaphysis.

The medial clavicle is significantly wider from superior to inferior at its widest and narrowest dimensions, $p < 0.01$. No difference was seen comparing the width on of the left clavicle versus the right clavicle or male versus female clavicles, and the correlation between height and clavicle dimensions did not reach statistical significance ($p > 0.05$).

Consistency of measurements was shown to be substantial for both intra- and inter-observer reliability, using criteria of Pearson coefficient defined as poor for < 0.9 , moderate 0.90 – 0.95, substantial 0.95–0.99, and almost perfect > 0.99 ¹⁰. When comparing all measurements, inter-observer reliability was 0.986 with combined intra-observer reliability between the two time points of 0.984. Analysis of Bland-Altman plot (graphs not included) for all measured dimensions showed the 95% confidence interval for the absolute difference in measurements ranged from 0.17 – 0.38 cm, and no trends were identified in errors of measurement within individual groups. It was shown, however, that measurement of the narrow portion of the clavicle was much more prone to error, with a poor concordance correlation coefficient of 0.771, whereas measurement of the wide portion of the clavicle had substantial reliability with a coefficient of 0.974.

Cases

Patient 1

A fifty-four year old male with a segmental right clavicle fracture after a roll-over all-terrain vehicle accident. He was seen in clinic one week following the injury and found to have a minimally displaced distal clavicle fracture and a proximal clavicle fracture with significant anterior displacement (Figure 3a–b). The medial clavicle injury caused the majority of discomfort and created a sizeable deformity. He was neurovascularly intact and without any associated injuries. Discussion of operative versus non-operative treatment was discussed, with the patient opting for open reduction internal fixation of the medial clavicle fracture with possible fixation of the lateral fracture dependent on the stability on intra-operative fluoroscopy.

Patient 2

A fifty-six year old male who sustained a nondisplaced scapular body fracture and medial third clavicle fracture after falling ten feet off of a roof onto his left shoulder (Figure 4a–b). Initially treated non-operatively by an outside surgeon, persistent pain at his clavicle fracture caused him to pursue surgical treatment of the injury two weeks after the injury.

Surgical Technique

Each patient was positioned supine with an interscapular bump allowing the chest and ipsilateral arm to be prepped in the usual sterile fashion. An incision was made in line with the medial third of the clavicle allowing direct exposure of the fracture. The sternoclavicular joint was preserved and reduction performed with bone clamps. With a small medial fracture segment, a two-plate construct was chosen. Two 2.7mm or 2.4mm Synthes (West Chester, PA, USA) T-locking plates, spanned the fracture superiorly and anteriorly. Unicortical locking screws were placed in the medial fragment and bicortical locking and nonlocking screws used distally. Medial locking screws ranged from 14 to 20mm in length and cortical diaphyseal screws ranged from 14 to 16mm in length. Post-operatively, the patients were placed in a shoulder sling and swathe and were made non-weight bearing on the injured side.

Follow-Up

Patient 1 was followed in clinic for six months at which time he denied having pain (Figure 5). His range of motion of at the ipsilateral shoulder was 140 degrees of forward elevation, 180 degrees in abduction, 60 degrees external rotation, and internal rotation to T12. Disabilities of Arm, Hand, and Shoulder (DASH) outcome score was 24.2 out of 100 indicating the minimal amount of disability and on visual analogue scale reported no pain at rest and normal activities with 2 out of 10 pain with heavy activities, but was completely satisfied with the operation. Patient 2 was seen in clinic six weeks post-operatively before being lost to follow up. At that time, he was doing well with incomplete union of the fracture, but no evidence of hardware loosening and minimal swelling over the medial clavicle (Figure 6).

Discussion

Displaced medial clavicle fractures are rare injuries that are increasingly being treated with open reduction internal fixation given the potential for painful nonunion. The close proximity of critical vascular structures, little bone stock with which to work, and thin overlying soft tissue make this a difficult fracture for fixation. Major vessels including the innominate, brachiocephalic, internal mammary arteries and veins are in close proximity to the medial clavicle. Merriman et al noted major vasculature as close as 2 to 3mm on CT scan while Sinha et al report that the subclavian vein occasionally abutted the medial clavicle^{11,12}. Clearly proper surgical technique is needed to address fractures in this area. Low et al reported on five medial clavicle fractures treated with open reduction internal fixation utilizing a plate placed superiorly on the clavicle⁷. All five went on to union with good functional results and only one reoperation for hardware removal. Similarly, a superior T-locking plate or reconstruction plate was used for ten patients by Oe et al with good results⁸. Screws crossed the sternoclavicular joint for improved fixation. They had one post-operative infection. The largest series of twenty-seven patients by Sidhu et al report excellent outcomes utilizing various plates for nineteen patients and transosseous sutures for eight patients.

This study is the first to report on the osseous dimensions of the medial clavicle with implications on fracture fixation. While this study provides only a limited case series with short-term follow up to demonstrate the utility of understanding the osseous dimensions of the medial clavicle, it does follow these patients to a united fracture without complaints of hardware irritation.

Adjacent to the sternoclavicular joint, the clavicle is at its widest and can easily accommodate 20mm and greater unicortical locking screws in the anterior to posterior or superior to inferior directions. Moving distally, the bone narrows considerably but may be appropriate for cortical screws with proper respect for the nearby vascular structures. The substantial intra- and inter-observer reliability on CT axial and coronal images allows surgeons to be confident in using the CT for pre-operative planning. Surgeons may evaluate the amount of bone available for screw purchase and expected screw lengths, particularly medially. The two patients presented in this study have plates applied superiorly and anteriorly to best capture the minimal bone stock medially providing a stabile construct to promote union. Prominence of the plates was not an issue and one patient reports an excellent outcome. Therefore, dual T-locking plates may be a consideration for medial clavicle fracture fixation when medial bone purchase is a concern.

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Figure 1.
A and 1B- Axial CT images with anterior (A) to posterior (B) medial clavicle measurements.

Figure 2.
A and 2B- Coronal CT images with superior (A) to inferior (B) medial clavicle measurements.

Figure 3.
A and 3B- Patient 1 radiograph (A) and axial CT image (B) of medial and lateral clavicle fractures.

Figure 4.
A and 4B- Patient 2 radiograph (A) and axial CT image (B) of medial clavicle fracture.

Figure 5.
Patient 1 follow up radiograph with healed fracture and hardware in place.

Figure 6.
Patient 2 follow up radiograph with healing fracture and maintained alignment without evidence of hardware loosening.