Optimizing the radiographic technique in clavicular fractures

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The purpose of this study was to assess the accuracy and utility of the posteroanterior (PA) 15° caudad view of the clavicle to assess shortening of clavicular fractures. The first stage involved taking radiographs of an adult skeleton, centered on the clavicle, with the standard anterosuperior 15° cephalad view and the PA 15° caudad view. Additional images were taken in the 15° caudad view with a series of oblique rotational views and oblique images in the vertical plane. Metal markers were placed on the clavicle at 10-mm intervals. Clavicular length and the interval between markers were measured on the radiographs. The second stage involved obtaining the PA 15° caudad radiograph in 50 patients with clavicular fractures. The noninjured clavicle also underwent radiography. The lengths of the noninjured clavicle and of the fragments of the fractured clavicle were recorded. The length of the skeletal clavicle in the standard anterosuperior image was 149 mm, with up to 19 mm of variation on oblique views. The length in the PA 15° caudad image was 130 mm, with a maximum of 4 mm of variation on the oblique views up to 30°. The true length of the skeletal clavicle was 124 mm. Forty-five fractures were diaphyseal, and five were outer-third fractures. There was less than 5 mm of measured difference in the length of injured and noninjured clavicles in 38 of 45 patients with diaphyseal fractures (84%). We have identified a more accurate technique for the assessment of fractures of the clavicle in evaluating length and clavicular alignment. The PA 15° caudad clavicle radiograph technique is well tolerated by patients. (J Shoulder Elbow Surg 2003;12:170-2.)

Current clear indications for the operative treatment of clavicular fractures include compound injuries, associated neurovascular injury, and fragments causing overlying skin ischemia. There may be other situations in which early surgery is appropriate. Robinson[7] found a 5.8% incidence of nonunion in displaced diaphyseal fractures of the clavicle and noted that further prospective study was required to assess the role of surgical treatment of these fractures.

It may also be appropriate to operate on those with significant shortening or displacement. Chan et al[1] reported on 4 patients with shoulder symptoms attributed to malunion of the clavicle who were successfully treated by corrective osteotomy. Nordqvist et al,[4] however, found permanent shortening to be common after clavicular fracture but that this had no clinical significance. The critical amount of acceptable shortening has not been determined. One of the main problems in accurately measuring shortening is radiographic technique. The unusual sigmoid shape of the clavicle, difficult patient positioning, variable film focus distance, and resultant magnification discrepancies all combine to reduce accurate reproduction of the clavicle.[6]

For imaging clavicular shaft fractures, Craig[2] recommends an anterosuperior (AP) view and a 45° cephalad tilt view. In 1926 Quesana[5] recommended two views at right angles to each other, a 45° superior view and a 45° inferior view. Many centers use an AP 15° cephalad tilt radiograph as the standard view.[2,3] We have compared the accuracy of this view with that of the posteroanterior (PA) 15° caudad tilt radiograph in a human skeletal model and evaluated the clinical utility and accuracy of the PA 15° caudad view in a series of patients.

MATERIALS AND METHOD

We used an articulated adult human skeleton to assess different radiographic views of the left clavicle. Metallic markers were placed at 10-mm intervals on the anterior border of the clavicle. Radiographs of the AP 15° cephalad tilt and the PA 15° caudad tilt views were taken, with additional rotational views. In the horizontal plane additional views were taken in 10°, 20°, and 30° of medial and lateral angulation of the beam. In the vertical plane additional views were taken with the beam angled 15° cephalad and caudad to the two index views. These views were taken to assess the magnification discrepancies of the index views and the magnitude of error from imprecise radiographic technique. The x-ray beam was focused on the center of the clavicle in all radiographs. The PA 15° caudad

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Figure 1 Patient positioning for the PA 15°caudad radiograph of the clavicle.

radiograph was used to image 50 consecutive patients with clavicular fractures who were examined in the orthopaedic fracture clinic. The contralateral clavicle was imaged for comparison by the same technique. In each case the contralateral clavicle was normal. The length of each fracture fragment and the length of the contralateral clavicle were measured in each case. Measurements were made by the 2 authors, an orthopaedic surgeon and a radiology registrar. The total length of the fracture fragments was compared with the length of the contralateral clavicle. Magnification error was assessed by comparing the humeral head diameter on each side. The PA 15° caudad radiograph was taken with the affected arm in a sling and the x-ray cassette placed adjacent and parallel to the clavicle (Figure 1). The patient either stands or sits, slightly angled to place the clavicle parallel to the film. Five patients could not achieve this position because of other injuries (eg, lower limb fracture), so an AP 15° cephalad tilt radiograph was obtained and the patients were excluded from the study. All patients were managed nonoperatively with a sling.

RESULTS

The length of the clavicle on the articulated skeleton was 124 mm. The length of the skeletal clavicle was 149 mm (15% magnification) on the AP 15° cephalad radiograph and 130 mm (5% magnification) on the PA 15°caudad radiograph. The maximum measured difference between the index PA 15° caudad radiograph and the oblique radiographs was 4 mm (Table I).

In the clinical series 45 fractures were diaphyseal and 5 were outer-third fractures. There was less than 5 mm of measured difference in the length of injured and noninjured clavicles in 38 of 45 patients with diaphyseal fractures (84%). Most fractures had less than 10 mm of measured shortening (Table II). Eleven patients had more than 25° angulation at the fracture site, and nine fractures were comminuted. All ambulatory patients tolerated the positioning for the PA 15° caudad radiograph well. Magnification discrepancies were noted in 5 of 50 patients, by comparing the humeral head diameters. In 5 patients the margins of the clavicle or the fracture were difficult to discern. The different appearance of the radiographs can be appreciated in Figures 2 and 3.

Table I Measured length of skeletal clavicle with different radiographic views

Radiographic view	AP series (mm)	PA series (mm)
Standard	149	130
Oblique		
Horizontal medial angulation 10°	145	131
Horizontal medial angulation 20°	143	134
Horizontal medial angulation 30°	139	128
Horizontal lateral angulation 10°	147	131
Horizontal lateral angulation 20°	142	134
Horizontal lateral angulation 30°	130	128
Vertical angulation 15° cephalad to standard view	143	130
Vertical angulation 15° caudad to standard view	145	131

Table II Measured shortening of diaphyseal fractures with PA 15° caudad radiographs

Measured shortening on radiographs	No. of patients
<10 mm	32
10-20 mm	9
>20 mm	4

DISCUSSION

For determining the amount of clavicular shortening compatible with a good outcome, a simple, reliable method of imaging the clavicle is required. The PA 15° caudad radiograph more reliably assesses shortening than the AP 15° cephalad view. Magnification of the clavicle is minimized by reducing the film-to-object distance. The small film-to-object distance also allows a wide latitude of technical error with minimal change in film accuracy. Patients tolerate the procedure well, both in the erect position and in the sitting position, and radiographers found the procedure quick and easy to perform.

The youngest patient in this series was 6 years old. We do not have experience with this technique in the younger pediatric age group. Weinberg et al[8]

Figure 2 Fractured clavicle in the AP 15° cephalad projection.

Figure 3 PA 15° caudad projection of same fracture shown in Figure 2.

showed an apical oblique view (20° cephalad, 45° oblique) to be extremely useful in the neonate and younger pediatric age groups.

In this study we assumed the clavicle lengths to be the same, side to side. We have not found any reports in the literature describing asymmetry in clavicular length within the normal population.[4,9] It may be difficult to determine the margins of the fracture accurately when assessing shortening, regardless of the radiographic technique. This is especially true when there is comminution. In our clinical series it was difficult to determine the medial border of the clavicle at the sternoclavicular joint in a small number of patients. We accurately identified the medial (sternoclavicular) border of the clavicle for measurements in our study.

The role of open reduction and internal fixation for shortening of the clavicular fractures has not been clearly defined. Before rational decisions can be made about the acceptable amount of shortening in diaphyseal clavicular fractures, the amount of shortening must be accurately represented with radiographic techniques. Our study demonstrates the inaccuracy of the commonly used AP 15° cephalad clavicle radiograph. We have identified a simple modification of radiographic technique that provides a more accurate measurement of shortening in clavicular fractures. Therefore, we recommend the PA 15° caudad radiograph for imaging fractures of the clavicle.

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