



Utilization of the bicipital groove axis for confirming alignment of the humerus with transepicondylar and ulnar shaft axes during intramedullary nailing

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Objective: Intramedullary nailing is the preferred surgical treatment of humerus shaft fractures. The purpose of this study was to investigate the relationship between the bicipital groove and specific anatomical landmarks in achieving correct alignment of the humerus during intramedullary nailing, and to describe these anatomical landmarks.

Methods: Thirty (15 right; 15 left) total upper cadaver extremities were used in this study. After the anatomical landmarks were identified and marked, humeral head axis, transepicondylar axis, ulnar shaft axis, bicipital groove axis, and angular measurements of these were obtained.

Results: The mean angle between the bicipital groove axis and transepicondylar axis was $48.17^\circ \pm 12.35^\circ$ (range: 20.10° to 74.6°). The mean angle between the bicipital groove axis and ulna diaphysis axis was $41.82^\circ \pm 11.56^\circ$ (range: 17.91° to 68.27°). The mean angle between the humeral head axis and bicipital groove axis was $20.53^\circ \pm 3.90^\circ$ (range: 11.85° to 31.81°). The mean retroversion angle between the humeral head axis and transepicondylar axis was $27.52^\circ \pm 11.37^\circ$ (range: 4.26° to 49.36°). The mean angle between the humeral head axis and ulna diaphysis axis was $61.73^\circ \pm 12.08^\circ$ (range: 33.97° to 86.37°). The mean torsion angle was $62.58^\circ \pm 11.28^\circ$ (range: 40.74° to 85.74°).

Conclusion: Measurement and utilization of the relationship between the bicipital groove, ulna diaphysis and transepicondylar axes may be used for restoring humeral rotation.

Keywords: Alignment; bicipital groove; humerus; intramedullar nailing.

Humerus shaft fractures are 1-3% of all fractures.^[1,2] Although up to 90% of humerus midshaft fractures are treated conservatively with splints, casts and functional braces, complex fractures may need open reduction and plate fixation or intramedullary nailing.^[3] Intramedullary nailing is the preferred surgical treatment of humer-

us shaft fractures.^[4] Chen et al. reported that intramedullary nails are used more frequently, they require less operative time than traditional plate-and-screw fixation, and show no difference in early postoperative complication rates and one-year mortality.^[4] They offer the advantages of closed reduction, prevention of soft tissue

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stripping and early mobilization, and provide high stability and promote fracture healing.^[5] During the nailing procedure, fracture reduction and correct humeral alignment are of utmost importance. Fluoroscopy may be used to acquire humeral alignment in accordance with the fracture-sides radiologically during surgery, but this method is not appropriate for complex fractures.

Rotational malalignment may become apparent after closed nailing procedures.^[6,7] For correction of malalignment during intramedullary nailing in the lower extremity, landmarks to prevent femoral and tibial alignment are well-documented. However, a quick, easy-to-use and simple intraoperative technique to mark humeral alignment is still unavailable.

Humerus fractures can heal anatomically when humeral alignment is ensured. Many surgeons dealing with the upper extremity use location of the bicipital groove as a guide to determine prosthesis retroversion. This study aimed to investigate the relationship between the bicipital groove and specific anatomical landmarks in obtaining proper alignment of the humerus during intramedullary nailing, and to describe these anatomical landmarks.

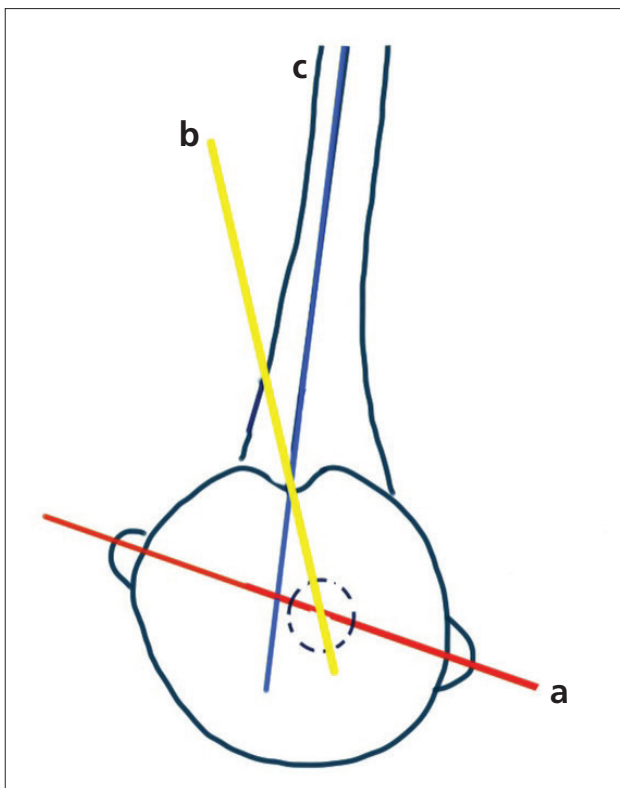


Fig. 1. Drawing of superior view of humerus and ulna showing (a) transepicondylar axis, (b) bicipital groove axis, (c) ulna diaphysis axis. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Materials and methods

Thirty (15 right; 15 left) formaldehyde fixed randomly chosen total upper cadaver extremities from Dokuz Eylül University Medical Faculty Anatomy Department Izmir, Turkey were used in this study. All specimens were free of arthritic changes or deformity and trauma. All muscles and soft tissues were removed, but joint ligaments were left intact. The glenohumeral joint capsules were opened and humerus proximal side anatomic structures were exposed. After anatomical landmarks were identified and marked with colored needles, angular measurements of defined axes were obtained.

These axes were; the humeral head axis (a line through the external center of the head and the center of the humeral shaft), the transepicondylar axis (between the centers of the medial and lateral epicondyles), the ulnar shaft axis (between the centers of the proximal and distal ulna diaphysis), the bicipital groove axis (a line

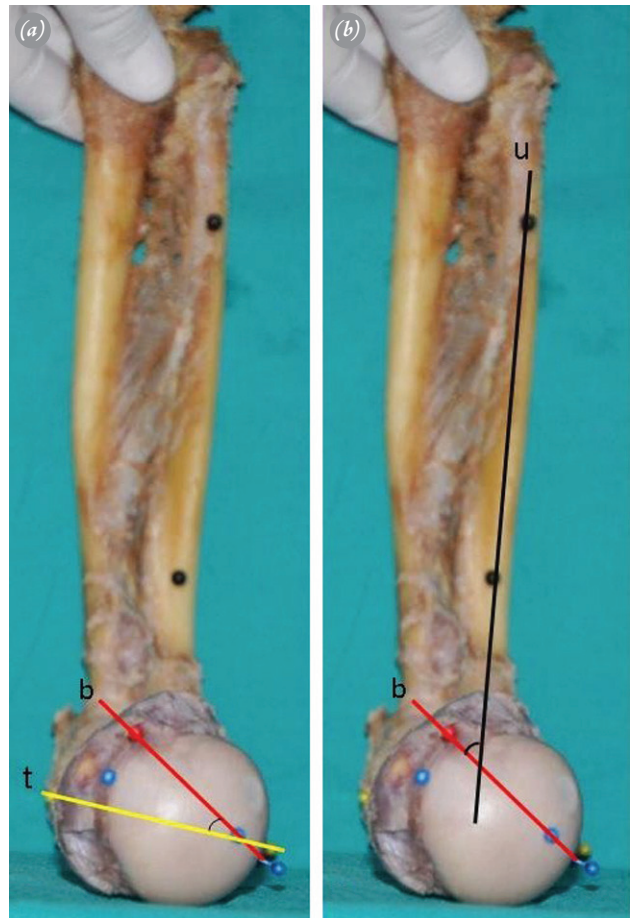


Fig. 2. (a) Angle between bicipital groove axis and transepicondylar axis. (b) Angle between bicipital groove axis and ulna diaphysis axis. (b: Bicipital groove axis; t: Transepicondylar axis; u: Ulna diaphysis axis). [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

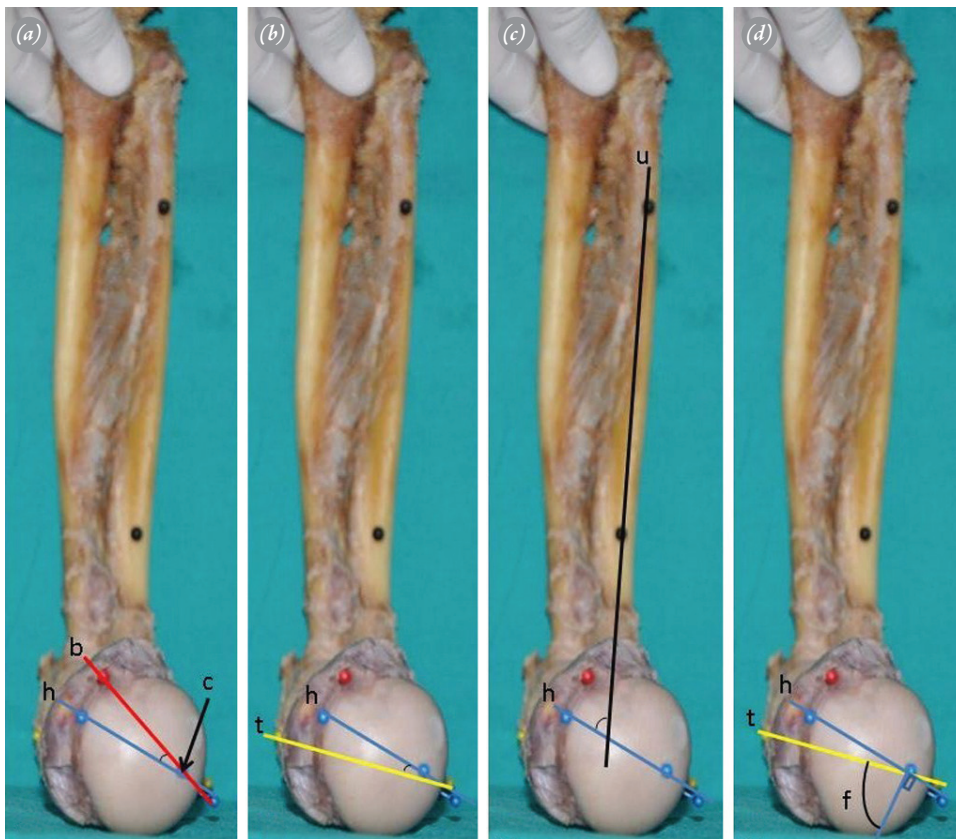


Fig. 3. (a) Angle between humeral head axis and bicipital groove axis. (b) Angle between humeral head axis and transepicondylar axis. (c) Angle between humeral head axis and ulna diaphysis axis. (d) f: Torsion angle ($= 90^\circ -$ angle of the retroversion) (c: Center of the head axis; h: Humeral head axis; b: Bicipital groove axis; t: Transepicondylar axis; u: Ulna diaphysis axis). [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

through the center of the humeral head and the center of the base of the superior bicipital groove) (Fig. 1). All forearms of these upper extremities were placed in forearm supination and 90° elbow flexion in axial axis. This position was chosen in order to see the humeral head and forearm simultaneously to perform the measurements. In this position, centralized humeral head photographs were taken with a digital camera (Nikon® d3100) positioned 1.5 m away from the tip of the humeral head. The camera was mounted on a stable tripod to achieve measurement standardization in the sagittal axis, when the humerus proximal end, humerus distal end (lateral and medial epicondyles) and long axis of the ulna can be seen together (Figs. 2 and 3). The digital camera and forearm were positioned parallel in the same plane to avoid incorrect measurements. All photographs were taken at the same magnification. All angular parameters were evaluated with Image Tool programs (UTHSAA Image tool version 3.0 for Windows®). Linear calculations were measured with a Vernier composing stick sensitive to 0.1 mm. All measurements were performed

by an experienced anatomist (A.K).

The measured parameters were:

1. Angle between the bicipital groove axis and transepicondylar axis.
2. Angle between the bicipital groove axis and ulna diaphysis axis.
3. Angle between the humeral head axis and bicipital groove axis.
4. Angle between the humeral head axis and transepicondylar axis (retroversion angle).
5. Angle between the humeral head axis and ulna diaphysis axis.
6. Torsion angle

All parameters were analyzed statistically with SPSS 15.0 for Windows®.

Results

In our study the mean angle between the bicipital groove axis and transepicondylar axis was $48.17^\circ \pm 12.35^\circ$

Table 1. Measured parameters and results.

Axis	Mean angle (°)	Range (°)
Bicipital groove axis-transepicondylar axis	48.17±12.35	20.10–74.6
Bicipital groove axis-ulna diaphysis axis	41.82±11.56	17.91–68.27
Humeral head axis-bicipital groove axis	20.53±3.90	11.85–31.81
Humeral head axis-transepicondylar axis	27.52±11.37	4.26–49.36
Humeral head axis-ulna diaphysis axis	61.73±12.08	33.97–86.37
Torsion angle	62.58±11.28	40.74–85.74

(range: 20.10° to 74.6°). The mean angle between bicipital groove axis and ulna diaphysis axis was 41.82°±11.56° (range: 17.91° to 68.27°). The mean angle between humeral head axis and bicipital groove axis was 20.53°±3.90° (range: 11.85° to 31.81°). The mean retroversion angle between the humeral head axis and transepicondylar axis was 27.52°±11.37° (range: 4.26° to 49.36°). The mean angle between the humeral head axis and ulna diaphysis axis was 61.73°±12.08° (range: 33.97° to 86.37°). The mean torsion angle was 62.58°±11.28° (range: 40.74° to 85.74°) (Table 1).

Discussion

For open reduction of the humerus, rotational alignment can be provided anatomically, but in intramedullary nailing, where closed reduction is possible, there is no well-described anatomical landmark for restoration of humeral alignment. In this study, we described two landmarks to restore humeral alignment: the angle between the transepicondylar and bicipital groove axes, and the angle between the ulna diaphysis and bicipital groove axes. In the literature, the bicipital groove has been used for shoulder arthroplasty surgery. Kummer et al. found a mean bicipital groove angle of 55.5° with a range 5° to 97°. [8] Balg et al. reported a mean bicipital groove angle of 55.8° (range: 22° to 89.5°). [9] Our results are similar to previous studies. We found a mean bicipital groove angle of 48.17°±12.35° (range: 20.10° to 74.6°).

During humerus intramedullary nailing, correcting humeral alignment may be challenging. In this study, landmarks to measure humeral alignment intraoperatively were described, and the bicipital groove proposed as a landmark for placement of a humeral prosthesis. We introduced a new angle, that between the axes of the ulna diaphysis and bicipital groove, which may help surgeons to ensure humeral alignment. Obtaining the transepicondylar axis may be difficult, especially in traumatic patients. Palpation of epicondyles may be difficult in cases of traumatic edema or in obese patients. In such conditions, use of the ulnar shaft axis may be a good alternative. In the course of humeral nailing, surgeons

may easily use the forearm axis, provided by the ulna diaphysis axis, to achieve humeral alignment. We found that the mean angle between the bicipital groove and ulna diaphysis axes was 41.82°±11.56° (range: 17.91° to 68.27°). During the intramedullary nailing procedure, surgeons can double-check humeral alignment using the transepicondylar and ulnar shaft axes.

When correct alignment of the humerus cannot be obtained during surgery, a possible consequence is malunion in the internal or external rotation position, which begets functional disability and rigidity. The acceptable range of rotational malalignment in humeral shaft fractures is considered to be 20°. [10] Intramedullary nailing alignment depends on the position of the arm. During the locking stage of intramedullary nailing, internal or external rotation of the arm can cause malalignment of the humerus. Although this may decrease the shoulder's range of motion, the functional scores of the shoulder were reported not to be significantly affected. [11] This may be because of the wide movement capacity of the shoulder. There are studies in the literature reporting that excessive malrotation of the humerus may improve the incidence of shoulder dislocation. [12,13] Li et al. found that the humeral head was internally rotated about 20° or more in 27.2% of intramedullary nailing patients, and concluded that the degree of malrotation correlates with the decrease in range of motion in patients who had undergone intramedullary nailing surgery. [14]

Many studies have proposed the bicipital groove as a landmark for placement of shoulder prostheses, so it has been widely studied and its anatomical features are well-documented. [9,15,16] The relationship of the bicipital groove with humeral retroversion may be used for orientation of the humeral head in the adjustment of prosthetic retroversion. The bicipital groove has a slight helioid shape. The groove runs from proximal-lateral in a distal medial direction. Balg et al. suggested that bicipital groove orientation was different at anatomical neck level from surgical neck level. They found that the groove at the surgical neck is more retroverted, by a mean of 9.3°, than at the anatomical neck level, while the surgical neck

is more axially.^[9] In our study we guided superior bicipital groove for the measurements.

Determining retroversion angle is also important in shoulder arthroplasty. Many cadaveric measurements made for calculating humeral head retroversion angle are contained in the literature, and different angles have been reported. Kummer et al. found the mean retroversion value as 28.3° (range: 4° to 64°).^[8] Doyle et al. reported the average retroversion angle as 26.8° (range: -2° to 52°).^[16] Hempfing et al. found that the mean retroversion angle of the humeral head was 23° (range: 2° to 52°).^[17] In our study, the mean retroversion angle was 27.52±11.37° (range: 4.26° to 49.36°).

Utilization of the bicipital groove as a point of reference for prediction of the rotational status of the humerus in humeral alignment by comparing the contralateral bicipital groove has been reported in the literature.^[18] Edelson measured 336 dry bone humeral specimens and found significant differences in retroversion angles between the right and left humerus (average 5.8° and 2.8° more in right side in men and women respectively).^[19] Kronberg et al. also reported significant differences in humeral head retroversion between dominant and non-dominant sides.^[13] Hence, to use the other side's bicipital groove for humeral alignment may not produce correct values.

The limitations of this study include the relatively small number of specimens, the lack of radiological measurements, and the lack of intraobserver and interobserver correlations. This study was created as a descriptive anatomical study and our specimens were small in number. Also, we did not use computerized tomography for the measurements. Computerized tomography scans with 3D modelling could give more precise results. We used digital images and image tool programs, which have been validated previously in the literature.^[20] In addition, the distal bicipital groove could prove to be a better landmark. However, with our methodology, photographs of the distal bicipital groove from the superior of the humeral head could have posed a problem, so we chose the superior part of the bicipital groove as a landmark. While the distal third of the bicipital groove is often the only portion of the groove remaining in patients with a comminuted proximal humeral fracture, we thought that intramedullary nailing is generally used for humeral shaft fractures, so we used the superior part of the bicipital groove in this present study.

The authors believe that measuring and utilizing the relationship between the bicipital groove, ulna diaphysis and transepicondylar axes is a simple and reliable method for restoring humeral rotation. Surgeons performing

humerus intramedullary nailing surgery may use these axes to determine humeral alignment and the risk of malrotation may be reduced.

Conflicts of Interest: No conflicts declared.

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