

TECHNIQUE OF ACCURATE HUMERAL LENGTH RESTORATION FOR HEMIARTHROPLASTY OF THE SHOULDER

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INTRODUCTION

When hemiarthroplasty is required to reconstruct comminuted fractures of the proximal humerus, proper positioning of the humeral component may be difficult to achieve. Subjective judgment in selecting prosthetic height may lead to non-anatomic reconstruction and poor clinical results. Several fracture jigs (Aequalis¹, Tornier SA, Montbonnot, France and Global Advantage Shoulder, DePuy Orthopaedics, Warsaw, IN) are available but may be difficult to use. The purpose of this article is to describe a reliable surgical technique using the pectoralis major tendon insertion as a reference for the determination of the humeral component height during hemiarthroplasty reconstruction for proximal humerus fractures.

PREOPERATIVE PLANNING 2

Pre-operative calibrated radiographs of the both the fractured and the contralateral humerus are essential to determine humeral length, canal diameter, and head size. These must be performed in addition to the standard radiographs of the fractured proximal humerus. To perform these radiographs, the patient should be seated with the arm placed in 45° abduction and 45° external rotation. The patient must be positioned to allow the arm to lie flat on the radiograph cassette, so as to minimize the risk of error. A 100mm long magnification marker is taped to the lateral aspect of the patient's arm in order to quantify the effect of magnification on the radiograph. It is essential that the marker not be placed anterior or posterior to the humerus, as this position change will potentially modify the magnification effect on the humeral length measurement.

The humerus length is then calculated as follows: $L=L'/I'$

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Figure 1: Pre-operative planing. Unaffected humerus length measurement.

*100 (L: actual length, L': humerus length measured, I': length of the long magnification marker).

This measurement forms a basis for the surgical reconstruction technique and is compared with the method using the pectoralis tendon reference described below (Fig. 1).

SURGICAL TECHNIQUE

The patient is placed in a beach-chair position, with the shoulder freely accessible and mobile. An extended deltopectoral approach is required from the coracoid to the superior border of the pectoralis major tendon insertion. The biceps tendon is released from the bicipital groove and followed proximally to define the rotator interval. It may then be tenotomized at its origin on the superior glenoid labrum. The joint is opened, and stay-sutures are placed separately through the greater and lesser tuberosities. The anterior humeral circumflex vessels are identified and ligated. The axillary nerve is identified and protected throughout the procedure. The subscapularis tendon is then mobilized on its superficial and deep surfaces. The humerus is dislocated anteriorly, and the humeral head is removed and measured.

With the arm in extension and external rotation, the canal is sounded with cylindrical reamers of progressively increasing diameters. A trial implant is assembled using a stem diameter corresponding to the last reamer used, a 130° neck, and a head corresponding to the fractured head diameter. The trial component is inserted into the canal in the proper orientation, and impacted such that the top of the humeral head is 5 cm above the upper border of the pectoralis major tendon insertion on the humerus. This should be confirmed with the height measured radiographically and marked on pre-operative templating. Twenty degrees of humeral head retroversion is determined using the bicondylar axis of the humerus with the arm in neutral rotation and the elbow flexed 90 degrees. The trial humeral component is then reduced into the glenoid. With the arm in neutral rotation the prosthesis should be assessed for proper centering in the glenoid, as well as for stability. The trial component is then removed and a cement restrictor is placed



Figure 2: Post-operative axillary view.



Figure 3: Post-operative result (true anteroposterior long film X-ray). Reconstructed humeral length measurement.

in the canal. Number 5 Ethibond sutures (Ethicon, Somerville, NJ) are passed through drill holes made in the proximal humerus. Several sutures are also placed through the greater and lesser tuberosities.

The true hemiarthroplasty components are then assembled.

The humeral canal is irrigated and dried thoroughly to remove excess blood and debris. Cement is placed into the canal to the level of the cement restrictor, and the humeral component is impacted into position at the appropriate depth (the top of the humeral head 5 cm above the upper part of the pectoralis major tendon) with the appropriate retroversion. When the cement is hardened the humerus is reduced into the glenoid and the tuberosities are reconstructed, using the No. 5 Fiberwire sutures (Arthrex, Naples, FL) placed through the humeral shaft and through the hole in the prosthesis. The humeral head is morcellized and the cancellous bone is grafted in the interval between both tuberosities and the prosthesis (Fig. 2, Fig. 3).

DISCUSSION

BIOMECHANICAL CONSIDERATIONS

Poor functional results are associated with non-anatomical reconstruction, either in length or retroversion of the proximal humerus³⁻⁶. The tendency to shorten the humerus may lead to shortening of the muscular fibers of the deltoid. This permanent contracture of the deltoid and associated muscles compromises active anterior elevation of the shoulder by decreasing their lever arm. Humeral lengthening has even worse consequences, such as pain and limited range of motion, due to the superior humeral migration and abnormal joint compression forces, which may lead to anterosuperior impingement.⁷ Components placed in excessive retroversion, especially greater than 30-40°, can lead to a poor reconstruction of the tuberosities with over-tensioning of the posterosuperior cuff.^{4, 7} This can cause pullout of the sutures and posterior migration of the greater tuberosity with fracture nonunion or malunion. The bicipital groove, usually cited as a reliable reference

during reconstruction, is an imprecise landmark. The course of the bicipital groove is 'S' shaped and is axially oriented in its lower part. Positioning the proximal humeral prosthesis in relation to the lower bicipital groove can increase the retroversion by 20°. 8-10

ANATOMICAL STUDY 11

A cadaver study was performed to determine a reliable bony or tendinous landmark which could be used as a reference point during proximal humeral reconstruction. The pectoralis major tendon was selected, as it is well-defined, easily identified, and consistent in location.

Twenty-six human cadaveric upper extremities were dissected, and the insertion of the pectoralis major tendon was exposed. A three-dimensional (3D) digitizer was used to map the surface of the proximal humerus and the humeral insertion of the pectoralis major tendon. A 3D-computer model was then created to calculate the distance between the upper part of the pectoralis tendon and the highest point of the humeral head.

Despite examining a wide range of specimens with respect to age, sex and diameter of the articular surface, this distance remained fairly constant (mean 51.9±5.9 mm, range 42.4-59.7 mm). Therefore, the mean distance between the upper border of the pectoralis major tendon and the highest point on the humeral head may represent a simple parameter to estimate and restore humeral length.

PRELIMINARY CLINICAL RESULTS

This new operative technique was been applied to 6 clinical cases. The patients included 5 females and 1 male, with a mean age of 70 years. All patients were right hand dominant, and in only one patient was the non-dominant arm fractured. Pre-operative and post-operative humeral length measurements were performed using the technique described above (Fig. 1). Post-operative radiographs included a true anteroposterior radiograph with the arm in external rotation, an axillary view, and a calibrated radiograph of the affected humerus (Fig. 2, Fig. 3). The post-operative humeral length measures are reported in Table 1. The pectoralis major tendon improved the positioning

Fractured Humerus length (mm)	Contralateral humerus length (mm)	Length difference (mm)
316.19	319.05	-2.86
300	306.6	-6.6
298.18	295.33	2.85
299.06	303.77	-4.72
334.29	326.61	7.68
327.52	324.77	2.75
	Average (absolute values)	4.58

Table 1: Postoperative humeral lengths.

of the prosthesis with regard to the humeral length. Using this landmark, prosthetic positioning was relatively precise, with humeral length restored to within 3 mm of the unaffected side.

CONCLUSION

Anatomic placement of a proximal humeral prosthesis used for reconstruction of a complex proximal humerus fracture is a challenging. Priority should be given to the precise positioning of the prosthesis with regards to height and version. On the basis of this anatomic study, we propose that the pectoralis major tendon be used as a reliable landmark to determine the prosthetic component height, regardless of component selected by the surgeon.

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