Introduction: When hemiarthroplasty of the shoulder is required to reconstruct comminuted fractures or malunions, proper positioning of the humeral component is difficult. Restoring the anatomy of the proximal humerus in shoulder arthroplasty is a requirement in order to achieve good function and anatomic reconstruction may have a bearing on the longevity of the implant and the incidence of glenoid erosion (1). There is a wide range of proximal humeral anatomy and if the humeral head diameter, version, retroversion and offset from the axis of the humeral shaft (2). The planning for reconstruction is usually based on approximation of anatomy according to the surgeon’s subjective impression. It is our opinion that the implantation of an artificial articular surface that restores the individual’s proximal humeral anatomy is possible as long as precise anatomical landmarks are available and an adaptable prosthesis is used. The pectoralis major tendon is a well defined structure that is visible while performing a deltopectoral approach. Usually this tendon is preserved even in severely comminuted fractures of the proximal humerus or in malunions. Therefore, we hypothesize that this tendon can be used as a reference point to reproducibly determine the proximal humeral anatomy when performing an arthroplasty procedure.

Materials and Methods: Twenty human cadaveric upper extremities (13 male, 7 female, age range 59-98 years) without bony deformities, previous fracture, or surgical intervention were dissected. The insertions of the clavicular and costosternal parts of the pectoralis major tendon on the humeral shaft were exposed. The distal end of the humeral shaft was potted in PMMA and rigidly fixed in a custom-built jig. Two points of the anatomical neck were identified and clearly marked (Figure 1a): (H) was defined as the highest point of the articular surface at the insertion of the supraspinatus tendon and (L) as the corresponding lowest point of the articular surface at the cartilage/calcifer interface. A line, including (H) and (L), was drawn at the anatomical neck and was defined as the circumferenc of the articular surface (CAS). The insertion of the pectoralis major tendon on the humeral shaft was marked by two points: (P1) was defined as the maximal point of insertion of the superficial (clavicular) portion of the tendon and (P2) as the distal point of insertion. Two circumferences of the humeral shaft, upper (UB) and lower (LB), were outlined as perpendicular to the shaft and passing through point (P1) and point (P2) respectively. The vertical distances (HP1), (LP1), (HP2), (LP2), and (P1P2) were measured manually with a ruler. A Microscribe 3D-X digitizer (Immersion Corp., San Jose, CA) was used to digitize all of the points and lines defined above as well as approximately 350 points on the articular surface. These data were imported into Rhinoceros NURBS modeling software (McNeal and Assoc., Seattle, WA). All digitized points were represented graphically and used to define the following additional parameters: using (CAS) and the digitized points (H) and (L) on the articular surface, the plane and the radius of the articular surface (ASR) were defined. After calculation of the centroid of (UB) and (LB) surfaces an axis (s) was used to reconstruct the center of the proximal humeral shaft (Figure 1c). To determine retroversion of the articular surface, a reference axis (β) was drawn through (P1), and perpendicular to (s) (Figure 1c). The following distances and angles were then calculated: (HP1), (LP1), (HP2), (LP2), (P1P2), the inclination angle of the articular surface, as the angle (α) between (s) and an axis perpendicular to the plane of the articular surface (Figure 1c), the retroversion angle showed less variation than the conventional method and may offer a more accurate way to estimate humeral head retroversion. The importance of these observations is that arthroplasty reconstruction of the proximal humerus may be performed with greater accuracy, resulting in improved function and longevity of the prostheses. Restoration of humeral length is important for adequate tension of the deltoid and the rotator cuff muscles. Incorrect placement of the humeral head height has been shown to be associated with poor function (1). The influence of retroversion in shoulder arthroplasty has not yet been clearly established. Nevertheless it has been shown that increased retroversion is associated with a high incidence of nonunion of the tuberosities in hemiarthroplasty for the treatment of complex proximal humeral fractures. Further, glenoid wear could be a consequence of eccentric articular load due to malunion of the tuberosities (3).

Discussion: Based on this cadaveric study we observed that the pectoralis major tendon is a useful landmark to determine humeral head height and retroversion. Despite examining a wide range of specimens with respect to age, sex and diameter of the articular surface, the relationship of the pectoralis major tendon insertion to the top of the humeral head and to the degree of retroversion remained fairly constant. Therefore, the mean distance between the upper border of the pectoralis major tendon and the highest point of the anatomical neck could represent a simple landmark to restore humeral length with reliable precision. Furthermore, the newly defined method to determine the retroversion angle showed less variation than the conventional method and may offer a more accurate way to estimate humeral head retroversion. The importance of these observations is that arthroplasty reconstruction of the proximal humerus may be performed with greater accuracy, resulting in improved function and longevity of the prosthesis. Restoration of humeral length is important for adequate tension of the deltoid and the rotator cuff muscles. Incorrect placement of the humeral head height has been shown to be associated with poor function (1). The influence of retroversion in shoulder arthroplasty has not yet been clearly established. Nevertheless it has been shown that increased retroversion is associated with a high incidence of nonunion of the tuberosities in hemiarthroplasty for the treatment of complex proximal humeral fractures. Further, glenoid wear could be a consequence of eccentric articular load due to malunion of the tuberosities (3).

This study represents the first description of an easily accessible anatomic landmark to aid proximal humeral reconstruction of complex fractures.