THE ROTARY INFLUENCE OF ARTICULAR CONTOURS DURING PASSIVE GLENOHUMERAL ABDUCTION

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ABSTRACT

Automatic external rotation at the glenohumeral joint is an essential component of active as well as passive elevation of the arm through abduction. Recent studies have demonstrated this automatic rotation to be present during passive abduction using cadaveric glenohumeral joints even in the absence of extra-articular influences like the coraco-acromial arch and glenohumeral muscles. In the present study, simulated abduction in disarticulated cadaveric joints was shown to be associated with automatic external rotation suggesting a role in this mechanism for the articular contours.

Keywords: *Joint, Glenohumeral, Abduction, Automatic, Rotation, Contours*

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INTRODUCTION

Automatic external rotation has been known to be an essential component of full elevation of the arm through abduction. It has been demonstrated during passive elevation of the intact arm and more recently, in the absence of extra-articular factors such as the coraco-acromial arch and glenohumeral muscles which are widely held to play significant roles in influencing external rotation. The present study investigates the possibility of automatic external rotation being influenced during abduction by the nature of the glenohumeral articular contours .

MATERIAL AND METHODS

Ten intact glenohumeral joints were isolated from formalin preserved cadavers ranging in age between 55 and 70 years. From each scapulo humeral articulation all muscles and capsule were cleared and the glenoid labrum was also removed as it is considered to be only a weak supporting structure in the natural state[1,2] and hardening through fixation with formalin in the specimens studied could influence response to simulate abduction in an unnatural manner. To exclude any influence on the results by the irregular shape and weight distribution in the shaft of the humerus, the humeral heads were sawn off at the junction with the respective shafts carefully noting the relative orientation between head and shaft (Fig 1). A uniform metal rod was then affixed to the head in the original orientation of the shaft. In the present method of study the combined weight of the metal shaft and humeral head was used to allow interaction between articular contours during simulated glenohumeral abduction.

The scapula of each glenohumeral articulation was supported in a clamp with the blade vertical, medial border horizontal and the glenoid facing directly upwards to receive the humeral head (Fig 2). Simulated abduction and relevant measurements were done using the following setup. A wooden L-shaped frame was pivoted through a scale on its longer limb from a vertical board such that the amount of swing could be read by a needle against the scale. With the scapula held parallel to the vertical board, the humeral head from the same articulation was aligned with the pivot while the metal shaft passed through a hole in the short limb of the L-frame which

Fig 1 - Humeral head (H) sawn off at anatomical neck has metal rod (M) fixed to it in the same orientation as the original shaft (Sh). Light weight deflector (D) fixed to metal rod is for transmitting rotary movements to pointers (P_1, P_2) on scale (refer Fig 3)

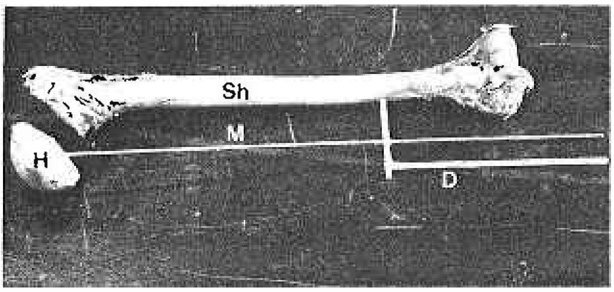
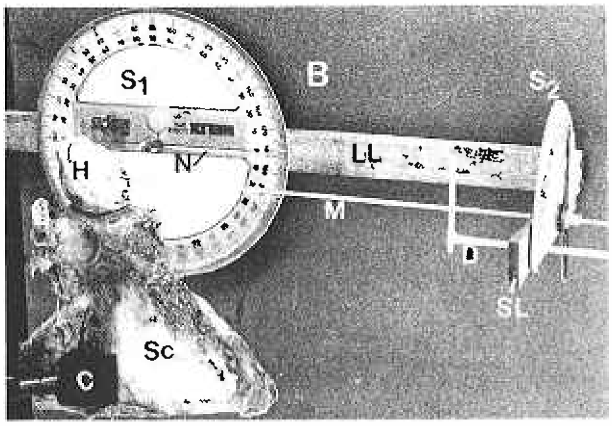


Fig 2 - Set up used for simulating abduction without manual contact on articulation. Scapula (Sc) is supported vertically on clamp (C) parallel to board (B) with glenoid pointing upwards and receiving head of humerus (H) which is aligned with centre of scale (S_1 where needle (N) measures angular displacement of long limb (LL) of wooden L-frame. Metal shaft (M) passes through shorter limb (SL) and scale (S_2) so that any rotation transmitted through deflector (D) is recorded by one of two pointers (P_1, P_2) (Refer Fig 3) on the scale ie either internal or external rotation.



also carried a scale for reading rotation. A light L-shaped, deflector was fixed to the metal shaft so that its long limb, lying parallel to the shaft could lie between two recording needles belonging to the scale on the short limb of the L-frame (Fig 3).

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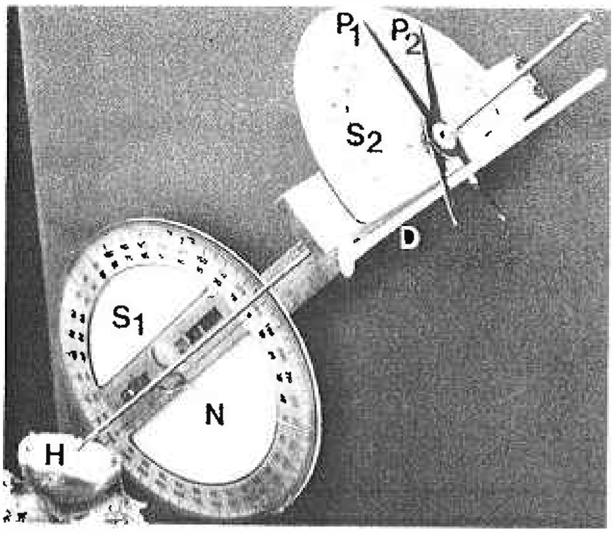
Fig 3 - In this example a simulated abduction of about 50° is accompanied by external rotation as recorded by pointed (P_2) against scale (S_2) in response to movement by the deflector (D). Both pointers while being light have sufficient friction at the pivot to hold the readings.



This arrangement allows measured amounts abduction to be simulated, without any direct manual contact with the articulation, by elevating the L-frame from the horizontal position. Any simultaneous rotation of the shaft in either direction would be recorded on the short limb by one or the other of the two needles respectively.

Each of the ten sets of articulation was mounted in turn on the rigging and subjected to about eighty degrees of abduction. Further elevation was avoided because the sharp edges of the cut humeral head were then in contact with the glenoid. Any accompanying rotation was measured to the nearest five degrees. To exclude any significant rotation being influenced by the shape of the head alone, simulated abduction was repeated in all the articulations by replacing the glenoid with a flat perspex surface placed horizontally.

RESULTS

Being essentially a qualitative study on the possible capacity for interacting articular surfaces to impose a torque, observations were confined mostly to rotary movements of the shaft. Table I shows the extent of rotation against respective specimens. With glenoid in place all except one specimen showed consistent external rotation ranging between 20° and 40° and averaging 29.5°. Specimen no. 9 showed an initial internal rotation of 20° followed by 10° of external rotation (ie from zero reading).

In general the humeral head showed a simple rolling movement in the initial stages of abduction. Rotary movement was observed in the latter stages of abduction when the humeral head was noted to be in contact with the upper portion of the glenoid. It was however not possible in this study to determine exactly at which stage of abduction the rotation commenced. On the perspex surface no rotation was observed in all except specimens 3 and 4 which both showed 5° of external rotation.

DISCUSSION

Automatic external rotation at the glenohumeral joint which is essential for full elevation through abduction[3-7] has been shown to occur during passive elevation of the intact arm[5] under the influence of extra-articular influences such as the coraco-acromial arch[5] and glenohumeral muscles[4,8-10] and also in the absence of these factors[11] implying therefore a possible role for articular factors in the mechanism of rotation. It is known that among other factors 'the nature of movements that occur

Table I - Rotation at Glenohumeral Joint in Response to 80° of Simulated Abduction

Specimen No	Rotation During Abduction on Glenoid	Rotation During Abduction on Flat Perspex
1	30°E	0°
2	40°E	0°
3	20°E	5°E
4	25°E	5°E
5	40°E	0°
6	35°E	0°
7	25°E	0°
8	30°E	0°
9	20°I and 10°E	0°
10	20°E	0°

E = External rotation;
I = Internal rotation.

at any joint depends on the form of the articular surfaces....'[12]. With respect to automatic rotation, contribution from articular surfaces has been better studied in the knee joint where various aspects of contours of both femur and tibia have been emphasized by different authors[13, 14]. The glenohumeral articulation however, described most frequently as having a simple ball and socket arrangement[1, 5] has less obvious contour features that may suggest a role in the mechanism of automatic rotation.

Findings in the present study indicate a significant role for the glenohumeral articular contours in influencing external rotation. The hemispherical humeral head with its spheroidal or ovoid[16] articular surface appears to be less influential as demonstrated by absent or minimal rotation being recorded against the flat perspex surface. The glenoid on the other hand has a less regular contour, often described as pear shaped, being more pointed towards its upper end, and also featuring a notch along its anterior border. In the present study external rotation was most notable during the later stages of simulated abduction when the head had rolled towards the superior aspect of the glenoid. This finding is in agreement with other studies[17] which have shown the humeral head to have moved upwards on the glenoid during abduction.

The use of the combined weight of the humeral head and the metal shaft may be justifiable in this study as the generation of significant forces at the joint has been previously demonstrated during abduction[3]. Notably this force has been shown to be concentrated in the upper glenoid during most of abduction[18].

CONCLUSION

Automatic external rotation during glenohumeral abduction can be influenced by interaction between the articular contours. The upper part of the glenoid appears to play a relatively more significant role in influencing the rotation. Further study is necessary to elicit the significant features in the glenoid contours relevant to the phenomenon.

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