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Original article

The relationship between the glenoid track and the range of shoulder motion: A cadaver study

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ABSTRACT

Introduction: The concept of the glenoid track has been proposed to evaluate the risk of dislocation. The glenoid track width was demonstrated to be 84% of the glenoid width in cadaveric shoulders and 83% in live shoulders.
Hypothesis: The glenoid track width seems to be affected by the range of motion.
Purpose: The purpose of this study was to determine the relationship between the glenoid track and the range of shoulder motion.
Methods: Ten fresh-frozen cadaveric shoulders were used. The specimen was fixed to a shoulder-positioning device. The anterior rim of the glenoid was marked on the humeral head using a Kirschner wire with the arm in 60° of abduction. This marking was repeated with the arm in (1) horizontal flexion/extension and (2) internal/external rotations (0° to max). The distances from the Kirschner wire markings to the footprint of the rotator cuff tendon were measured.
Results: The greater the angle of the horizontal extension or external rotation, the smaller the glenoid track width, whereas the greater the angle of the horizontal flexion or internal rotation, the greater the glenoid track width. There was a negative relationship between them. The horizontal flexion/extension motion was demonstrated to affect the glenoid track width more than the internal/external rotation motion.
Conclusion: The glenoid track width decreased with the increase of horizontal extension. We should consider the range of horizontal extension angle when applying the glenoid track concept in clinical practice.
Type of study: Laboratory study.

1. Introduction

The large glenoid or humeral osseous defect has been reported to cause postoperative instability in patients with anterior shoulder instability [1,2]. Surgeons need to be aware of the critical size of the glenoid and humeral osseous defects, which need to be treated when performing surgeries. Biomechanical studies have identified the size of the osseous defect, which affects stability. Regarding the glenoid defect, 20% or 25% of the glenoid width has been demonstrated to be a critical size of the glenoid defect [2–4], although there are some recent reports [5,6] recommending that a glenoid bone loss even smaller than 20% be treated. Regarding a Hill–Sachs lesion, it has been reported that a large one which engaged with the glenoid rim was called an "engaging Hill–Sachs lesion", which needed to be treated [2]. A new concept, glenoid track, was proposed by Yamamoto et al. [7] to evaluate the risk of dislocation. Recently, this new concept has garnered attention [8–10]. The glenoid track width was demonstrated to be 84% of the glenoid width in cadaveric shoulders [7] and 83% in live shoulders [11]. However, these values of 84% and 83% were mean values of the specimens and subjects, and the glenoid track width seems to be affected by the range of motion because the glenoid track was defined as a zone of contact of the glenoid on the humeral head. The glenoid track width in a patient with wide range of motion should be different from that in a patient with limited range of motion. The mean value of 83% [11], which is commonly used to calculate the glenoid track width, has been determined without taking the range of motion into consideration. The relationship between the glenoid track and the range of shoulder motion has not been clarified yet. There have been no studies demonstrating which motion affects the glenoid track most. The purpose of this study was to determine the relationship between the glenoid track and the range of shoulder

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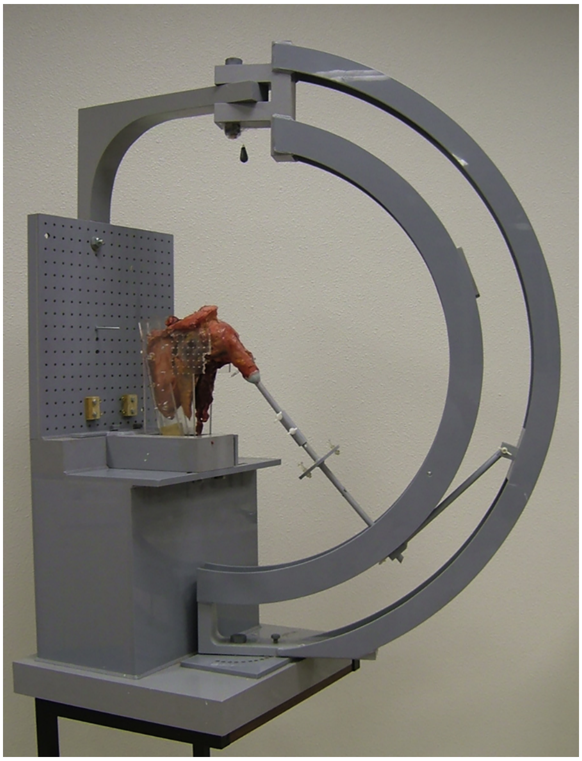

Fig. 1. Custom-designed shoulder-positioning device.

motion and to clarify which motion would affect the glenoid track most using cadaveric shoulders. Our hypothesis was that the horizontal flexion/extension motion would be demonstrated to affect the glenoid track width. The present study was approved by the Institutional Review Board of our hospital (#2012-1-417).

2. Materials and methods

2.1. Preparation of specimens

Ten fresh-frozen cadaveric shoulders (mean, 86 years old; 2 males and 8 females) were used. The cadaveric shoulders were thawed overnight at room temperature. The exclusion criteria were those with full-thickness rotator cuff tears, fractures, contracture, severe osteoarthritis, or other diseases of the shoulder detectable by direct inspection or on radiograms. Each specimen had been disarticulated at the scapulothoracic joint proximally and amputated at the mid-part of the humerus distal to the deltoid attachment distally. The skin, subcutaneous tissue, and all of the muscles were removed preserving the rotator cuff. The testing condition and experimental setting were followed by Yamamoto et al.'s study [7]. The infraspinatus and teres minor tendons were released from the greater tuberosity with the posterior capsule. The remnant posterior capsule was vertically sectioned down to 6:00 position, leaving the posterior half of the joint open, which enabled us to evaluate the contact between the humeral head and the glenoid. The antero-superior soft tissue structures such as the supraspinatus, the subscapularis, the labrum, and the anterior half of the capsule including the superior, middle, and inferior glenohumeral ligaments were all preserved.

A pair of acrylic plates was fixed to the scapular body by means of the Kirschner wires (1.8 mm in diameter). An intramedullary rod (10 mm in diameter) was inserted into the proximal humeral shaft and fixed in place with resin. The specimen was then attached to a custom-designed shoulder-positioning device (Fig. 1). The device allowed the humerus to be placed in a given plane of elevation (such as the scapular or coronal plane), a given angle of glenohumeral elevation (0° to 100°), a given angle of humeral external and internal rotation, and a given angle of horizontal flexion and extension. The coronal plane was defined as a plane, which was 30° horizontally extended relative to the scapular plane [12].

A 22-N force [13] was applied to the humeral head against the glenoid fossa through the cables attached to the Kirschner wires. A screw was inserted perpendicular to the humeral shaft, 10° internally rotated from the plane including the humeral axis and the bicipital groove. The screw was used as a reference to indicate the anterior/posterior direction of the humerus [14]. Abduction angles were 60° relative to the scapula, simulating 90° of abduction of the arm relative to the trunk [15]. Neutral rotation was defined relative to the trunk, which was equivalent to 30° of external rotation relative to the scapular plane. In this paper, the range of shoulder motion was expressed as the arm relative to the scapula. The position of the humerus relative to the scapula was determined using a goniometer attached to the shoulder-positioning device. The specimen was kept moist with a spray of saline solution applied every 10 minutes during the test.

2.2. Arm positions and marking the glenoid rim

The anterior rim of the glenoid was marked on the humeral head using a Kirschner wire with the arm in 60° of abduction. This marking was repeated with the arm in:

- horizontal flexion/extension keeping maximum external rotation;
- internal/external rotations (0° to max) keeping maximum horizontal extension.

The distances from the Kirschner wire markings to the medial border of the footprint of the rotator cuff tendon were measured. During the test, a set of torque for external rotation and horizontal extension was applied to the humerus with pulleys and weights. According to the previously-reported studies [7,16], a torque of 250 N-mm for external rotation and a torque of 600 N-mm for horizontal extension. With these torques applied, we kept the arm in maximum external rotation (39° ± 21°) and maximum horizontal extension (25° ± 17°). After each arm positioning was set, the location of the anterior glenoid rim was marked on the humeral head by creating small holes with use of a Kirschner wire (1.0 mm in diameter). The holes were aligned 2 to 3 mm apart. The Kirschner wire was inserted from outside of the joint, through the joint capsule and the labrum, into the humeral head. After marking the location of the glenoid in two test positions, the holes for different angles were painted in different colors using acrylic color paints in order to distinguish them easily.

2.3. Measurement of the distances

Measurement of the distances from the medial margin of the contact area to the medial margin of the cuff attachment site on the greater tuberosity was done. The distances were measured by a digital caliper (Digital caliper PC-15JN, MITSUTOYO, Kawasaki, Japan). First, the articular center of the humeral head (point C) was defined. Then, the most medial point (point M) was determined on the medial margin of the contact area such that the distance from the articular center (point C) to the most medial point (point M) would be the shortest. Thus, the distance from point M to the medial margin of the footprint (point F) on the line CM was measured in this position. The distance from point M to point F was defined as the width of the glenoid track. After the experiments, the glenoid

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