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ORIGINAL ARTICLE

Clinical measurements for inferior, posterior, and superior glenohumeral joint contracture evaluation in children with brachial plexus birth palsy: intraobserver and interobserver reliability

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Background: Glenohumeral (GH) contractures appear in most patients with incomplete motor recovery as a result of progressive development of periarticular muscle contractures. The objectives of this study were to describe a method to measure the passive range of motion of the glenohumeral joint (GHJ) in patients with brachial plexus birth palsy (BPBP) and to evaluate its intraobserver and interobserver reproducibility.
Methods: Three orthopedic surgeons measured the passive GHJ mobility of 25 patients older than 4 years with unilateral BPBP. Measurements were performed twice on both shoulders. They comprised the spinohumeral abduction angle (SHABD), spinohumeral adduction angle (SHADD), GH cross-body adduction (CBADD), and GH internal rotation in abduction (IRABD). Anterior GH contracture was not evaluated.
Results: Passive shoulder measurements obtained from the uninvolved and involved shoulders were as follows: SHABD, 42° and 18°, respectively; SHADD, 14° and –1°, respectively; CBADD, 71° and 41°, respectively; and IRABD, 54° and 37°, respectively. Contracture of the lower portion of the involved GHJ was observed in 18 of 25 patients (72%); the upper portion, in 16 of 25 (64%); and the posterior portion, in 22 of 25 (88%). Interobserver variation (intraclass correlation coefficient) was 0.91 (excellent) for SHABD, 0.63 (good) for SHADD, 0.86 (excellent) for CBADD, and 0.67 (good) for IRABD. Intraobserver variation (intraclass correlation coefficient) was 0.94 (excellent) for SHABD, 0.87 (excellent) for SHADD, 0.92 (excellent) for CBADD, and 0.89 (excellent) for IRABD.
Conclusions: Clinical measurements of passive GHJ range-of-motion analyzed in this study showed excellent or good intraobserver and interobserver variability. Our study showed that BPBP resulted in a multidirectional GH contracture in most patients. We have described a simple and reliable way to evaluate passive GH motion, providing reliable anatomic landmarks.
Level of evidence: Basic Science Study; Kinesiology

Keywords: Brachial plexus birth palsy; shoulder contracture; glenohumeral angle; brachial plexus; intraobserver reliability; interobserver reliability

The local ethics committee approved the protocol of the clinical trial in advance of any data collection (Institutional Review Board No. 154/2017).

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Brachial plexus birth palsy (BPBP) occurs in approximately 0.4-4.6 of every 1000 live births.[4,11] Natural history studies of this condition have shown that 20%-30% of children with BPBP will have residual neurologic deficits at 3 years of age.[12] Glenohumeral (GH) contractures appear in most patients even with almost complete motor recovery[14,18] as a result of progressive development of periarticular muscle contractures.[3,6,7] While extensive literature is available on shoulder internal rotation contracture, little has been written on adduction, abduction, and external glenohumeral joint (GHJ) contracture.[3,6,9,16]

The objectives of this study were to describe a method to measure the passive range of motion of the GHJ in patients with BPBP to evaluate upper, posterior, and inferior contractures and to report the values of these measurements, as well as to evaluate the method's intraobserver and interobserver reproducibility.

Materials and methods

This is a prospective, transverse, observational study. Patients provided written informed consent before participation in accordance with the Declaration of Helsinki guiding biomedical research involving human subjects.

Three orthopedic surgeons measured the passive GHJ mobility of 25 patients older than 4 years with unilateral BPBP. Measurements were performed on both the involved side and the uninvolved side. The following month, the same 3 evaluators performed a second set of measurements. A universal goniometer was used for the measurements as described by Gerdhart and Rondinelli.[5]

In all patients, 4 GH motion measurements were obtained (Video S1). For these measurements, 2 examiners were involved. The first examiner placed the upper limb in maximum passive range of motion while the second examiner placed the arms of the goniometer. The measurements were as follows:

1. The spinohumeral abduction angle (SHABD; Fig. 1, *A*) is defined as the angle between the axis of the spine of the scapula and the humerus when the arm is passively taken into maximum abduction with the elbow flexed 90° and the shoulder in external rotation. The lateral arm of the goniometer is aligned along the lateral longitudinal axis of the humerus, with the acromion process and the lateral epicondyle being used as reference landmarks, while the medial arm of the goniometer is aligned along the longitudinal axis of the spine referenced by the index finger of the first examiner. When the humerus is aligned with the spine, a 0° value is considered; a positive value is measured when the angle is greater than this 0° angle, and a negative value is measured when the angle is less than this 0° angle. A decrease in this angle would indicate an inferior GHJ contracture.
2. The spinohumeral adduction angle (SHADD; Fig. 1, *B*) is defined as the angle between the axis of the spine of the scapula and the humerus when the arm is taken into maximum adduction. GHJ extension is needed to avoid abutment of the upper limb with the thorax, and the elbow is held in extension. The lateral arm of the goniometer is aligned along the posterior longitudinal axis of the humerus, with the acromion process and the olecranon being used as reference landmarks, while the medial arm of the goniometer is aligned along the longitudinal axis of the spine referenced by the index finger of the first examiner. An angle between the humerus and the spine of 90° is considered a value of 0°; a positive value occurs when the angle is medial to this 0° angle, and negative value occurs when the angle is lateral to this 0° angle. An increase in this angle would indicate a superior GHJ contracture.
3. GH cross-body adduction (CBADD; Fig. 1, *C*)[15] is defined as the angle between the axis of the spine of the scapula and the humerus when the arm is taken into 90° of abduction and maximum horizontal adduction in the transverse plane. The anterior arm of the goniometer is aligned along the lateral longitudinal axis of the humerus, with the acromion process and the lateral epicondyle being used as reference landmarks, while the posterior arm of the goniometer is aligned along the longitudinal axis of the spine, with the lateral and medial spine prominences being used as reference landmarks. When the humerus is aligned with the spine, a value of 0° is considered; a positive value occurs when the angle is ventral to this 0° angle, and a negative value occurs when the angle is dorsal to this 0° angle. A decrease in this angle would indicate a posterior GHJ contracture.
4. GH internal rotation in abduction (IRABD; Fig. 1, *D*) is defined as the angle between the forearm axis and the horizontal plane after keeping the shoulder in 90° of abduction and the elbow in 90° of flexion while the arm is carried into internal rotation after stabilizing the scapula against the thorax. One arm of the goniometer is aligned parallel to the ground, while the other arm of the goniometer is aligned along the longitudinal axis of the forearm using the tip of the olecranon and the ulnar head as reference landmarks. When the forearm is parallel to the ground, a value of 0° is considered; a negative value occurs when the angle is cranial to this 0° angle, and a positive value occurs when the angle is caudal to this 0° angle. A decrease in this angle would indicate a posterior GHJ contracture.

At the end of the examination, the data were immediately collected by a third person. There were no comparisons or discussions on the data obtained. GHJ contracture was considered when a difference over 10° was observed between the uninvolved and involved shoulders.

Statistical methods

Using a level of significance of 5% and a power of 95%, we calculated that a sample size of 23 measurements would be sufficient to detect a minimum variability of 10% between the evaluators. Paired *t* tests were performed between involved and uninvolved shoulder measurements. $P < .05$ was considered significant.

For analysis of interobserver and intraobserver agreement of the measurements, the intraclass correlation coefficient was used as the quantitative variable. It has been reported that intraclass correlation coefficient values below 0.4 represent low reliability, values between 0.4 and 0.75 represent reliability between regular and good, and values above 0.75 represent excellent reliability.[2,13] Comparisons between evaluators were based on 95% confidence intervals (CIs). We used SPSS software (version 21.0; IBM, Armonk, NY, USA) to analyze the data, adopting a significance level of 5%.