The Relationship Between the Coracoid and Glenoid After Brachial Plexus Birth Palsy

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Abstract: The purpose of this study was to determine the changes in glenoid and coracoid anatomy after brachial plexus birth palsy. Fifty-seven children underwent bilateral shoulder magnetic resonance imaging. The uninvolved coracoid angle averaged 32.5 ± 6.1 degrees (range 21.3–46.0) compared with 21.7 ± 6.9 degrees (range 6.1–41.0) on the involved shoulder. The uninvolved coracoid physeal angle averaged 42.7 ± 7.6 degrees (range 26.0–57.0) compared with 61.7 ± 11.6 degrees (range 38.8–89.9) on the involved shoulder. The uninvolved glenoid physeal angle averaged 78.4 ± 5.2 degrees (range 66.9–89.9) compared with 50.4 ± 14.7 degrees (range 17.9–76.7) on the involved shoulder. The uninvolved interphyseal angle averaged 59.6 ± 7.2 degrees (range 42.0–76.1) compared with 65.5 ± 11.6 degrees (range 45.0–88.0) on the involved shoulder. The uninvolved coracoid scapular distance averaged 1.6 ± 0.28 cm (range 1.0–2.5) compared with 1.2 ± 0.37 cm (range 0.37–1.9) on the involved shoulder. These results highlight the contiguous relationship between the coracoid and glenoid physis during development and indicate that retroversion of both the glenoid and coracoid physis occurs after brachial plexus palsy.

Key Words: glenohumeral deformity, brachial plexus birth palsy, shoulder, coracoid

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An upper trunk lesion is the most common type of brachial plexus birth palsy. Infants with delayed recovery usually fail to regain full shoulder movement, as rotator cuff and deltoid innervation is incomplete. The incomplete recovery leads to muscle imbalance with strong internal rotators and weak external rotators, which results in an internal rotation contracture that is detrimental to glenohumeral joint development.[1–4] The constant position of internal rotation leads to early glenohumeral joint deformity by 6 months of age and advanced deformity by 2 years, which is characterized by increased glenoid retroversion and posterior humeral head subluxation.[3–6] In contrast to changes in the glenohumeral joint, alterations in the coracoid's position have not been studied.[4,5,7,8] Coracoid overgrowth and elongation have been reported and surgical procedures described to address its misdirection.[9–11] These procedures, however, have not been justified, and clear indications remain elusive. The purpose of this study was to determine whether changes occur in glenoid and coracoid anatomy after brachial plexus birth palsy.

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METHODS

Patients

Fifty-seven children between the ages of 11 and 111 months (average 45.4 months) were included in this study. All children had the diagnosis of residual brachial plexus palsy. All children underwent bilateral shoulder magnetic resonance imaging (MRI). All imaging was performed on a 1.5 Tesla LX platform MRI unit (GE Medical Systems, Milwaukee, WI). Cartilage-sensitive axial images with a minimal interslice gap were used. Three-dimensional axial gradient-echo and axial T2 images (2.5-mm section thickness with 0 spacing) were obtained of both shoulders. In addition, fast spin-echo T1- and T2-weighted MR images with fat saturation (3-mm section thickness with 0 spacing gap) were performed in the axial planes of bilateral shoulders. All children were supine, sedated, and monitored by electrocardiography, oxygen saturation measurements, and observation.

Measurements

In an attempt to standardize the cross-sectional slice chosen for measurements, certain criteria were established.[3] An axial image was selected that visualized both the coracoid and glenoid physis for all angular measurements. A separate image that visualized the coracoid tip was chosen for the coracoid-to-scapula distance.

The IMPAX for Orthopedics (Agfa-Gevaert Group, Mortsel, Belgium) software tool was used to measure the radiographic parameters. A scapular line was constructed that connected the medial margin of the scapula and the middle of the glenoid fossa.[12] The coracoid angle was defined as the angle formed between the scapular line and longitudinal to the base of the coracoid (Fig. 1). The coracoid physeal angle was defined as the angle formed between the scapular line and the coracoid physis (Fig. 2). The glenoid physeal angle was defined as the angle formed between the scapular line and the glenoid physis (Fig. 3). The interphyseal angle was defined as the angle formed between the coracoid physis and the glenoid physis (Fig. 4). The coracoid scapular distance was measured

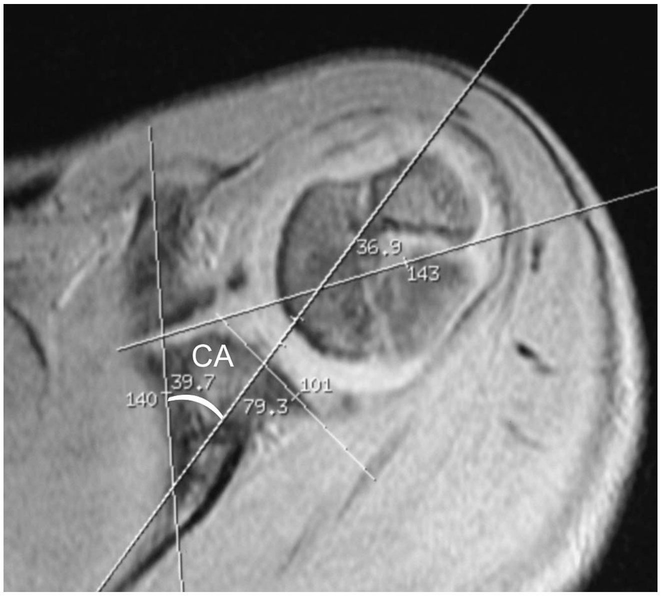

FIGURE 1. The coracoid angle (CA) was defined as the angle formed between the scapular line and longitudinal to the base of the coracoid. In this uninvolved shoulder, the CA measures 39.7 degrees.

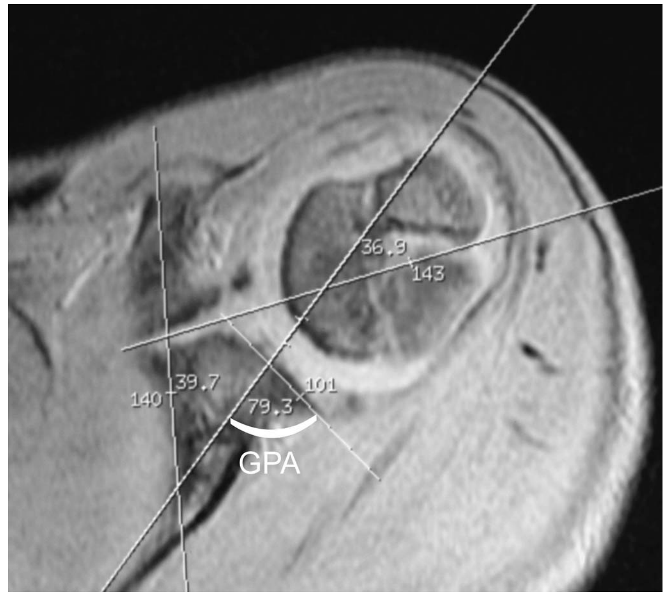

FIGURE 3. The glenoid physeal angle (GPA) was defined as the angle formed between the scapular line and the glenoid physis. In this uninvolved shoulder, the GPA measures 79.3 degrees.

as the perpendicular length between the lateral margin of the coracoid tip and the scapular line (Fig. 5).

Statistics

The SPSS for Windows 10.1 (SPSS Inc, Chicago, IL) statistical program was used to analyze the data. Descriptive statistics were calculated for each variable, including average, range, and standard deviation. Subsequent analysis consisted of Pearson product correlation coefficients and paired *t* tests. All probability testing was completed in the null form and significance was established at the $P = 0.5$ level.

RESULTS

In all children, the coracoid physis and glenoid physis were contiguous. The coracoid physis was located in the anterosuperior aspect of the scapula, directly adjacent to the glenoid physis. The coracoid process was visualized as an osteocartilaginous structure with a primary rectangular

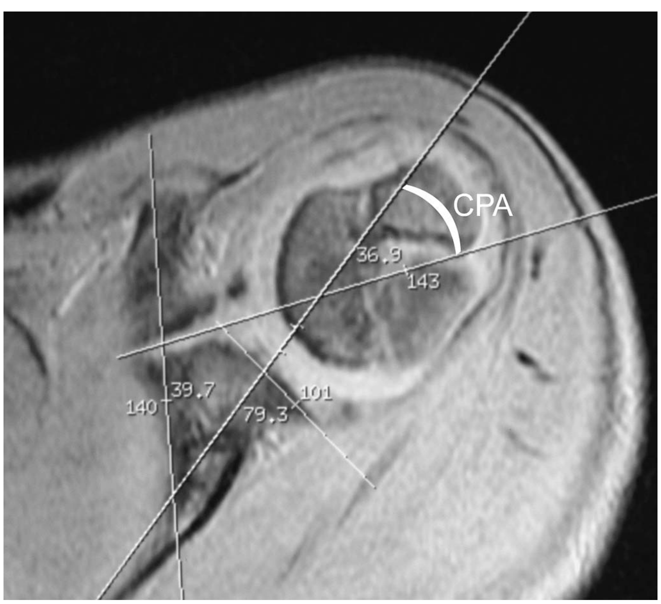

FIGURE 2. The coracoid physeal angle (CPA) was defined as the angle formed between the scapular line and coracoid physis. In this uninvolved shoulder, the CPA measures 36.9 degrees.

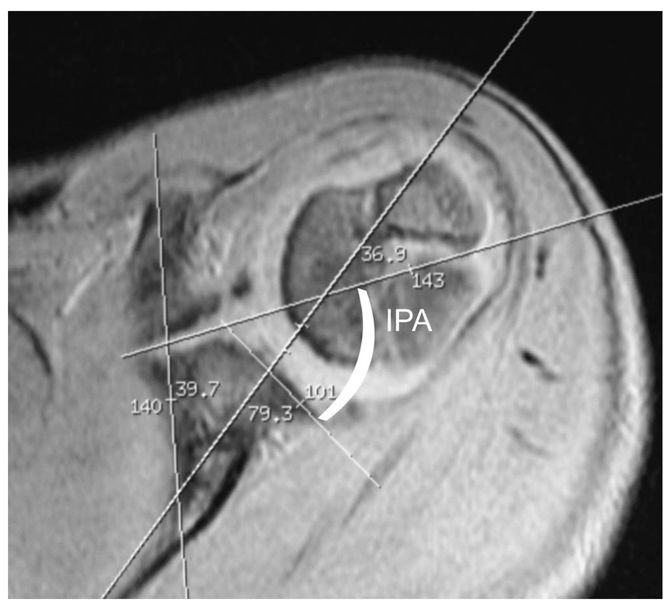

FIGURE 4. The interphyseal angle (IPA) was defined as the angle formed between the coracoid physis and the glenoid physis.

FIGURE 5. The coracoid scapular distance (CSD) was measured as the perpendicular length between the lateral margin of the coracoid tip and the scapular line. In this uninvolved shoulder, the CSD measures 1.9 cm.

ossification center interposed between a physis and cartilaginous tip. The coracoid tip and base were visualized in all children.

Uninvolved Shoulder

The coracoid angle averaged 32.5 ± 6.1 degrees (range 21.3–46.0). The coracoid physeal angle averaged 42.7 ± 7.6 degrees (range 26.0–57.0). The glenoid physeal angle averaged 78.4 ± 5.2 degrees (range 66.9–89.9). The interphyseal angle averaged 59.6 ± 7.2 degrees (range 42.0–76.1). The coracoid scapular distance averaged 1.6 ± 0.28 cm (range 1.0–2.5). There was a significant positive correlation between age and coracoid scapular distance (r = 0.722, $P < 0.001$). There was a significant negative correlation between the coracoid physeal angle and the glenoid physeal angle ($r = -0.474$, $P < 0.001$).

Involved Shoulder

The coracoid angle averaged 21.7 ± 6.9 degrees (range 6.1–41.0) (Fig. 6). The coracoid physeal angle averaged 61.7 ± 11.6 degrees (range 38.8–89.9) (Fig. 7). The glenoid physeal angle averaged 50.4 ± 14.7 degrees (range 17.9–76.7) (Fig. 8). The interphyseal angle averaged 65.5 ± 11.6 degrees (range 45.0–88.0). The coracoid scapular distance averaged 1.2 ± 0.37 cm (range 0.37–1.9) (Fig. 9). There was a significant correlation between age and coracoid scapular distance ($r = 0.455$, $P < 0.001$), age and glenoid physeal angle ($r = 0.33$, $P = 0.12$) and age and interphyseal angle ($r = -0.308$, $P = 0.02$). There was a significant correlation between the glenoid physeal angle and the coracoid physeal angle (r = 0.582, $P < 0.001$) and the glenoid physeal angle and the coracoid scapular distance ($r = 0.722$, $P < 0.001$). There was a significant correlation between the coracoid physeal angle

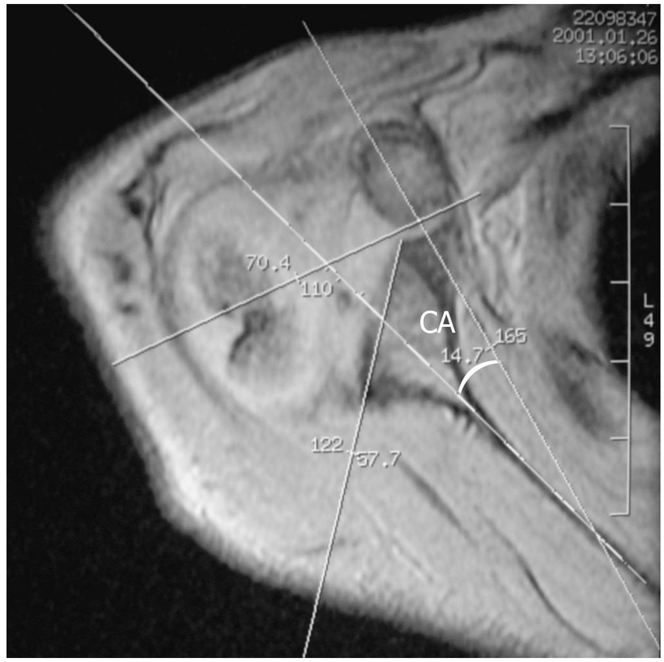

FIGURE 6. Decreased coracoid angle (CA) of involved shoulder that measures 14.7 degrees, indicative of coracoid retroversion.

and the coracoid scapular distance ($r = -0.581$, $P < 0.001$). There was a significant correlation between the interphyseal angle and glenoid physeal angle ($r = -0.572$, $P < 0.001$) and the interphyseal angle and the coracoid scapular distance (r = -0.268, $P < 0.005$).

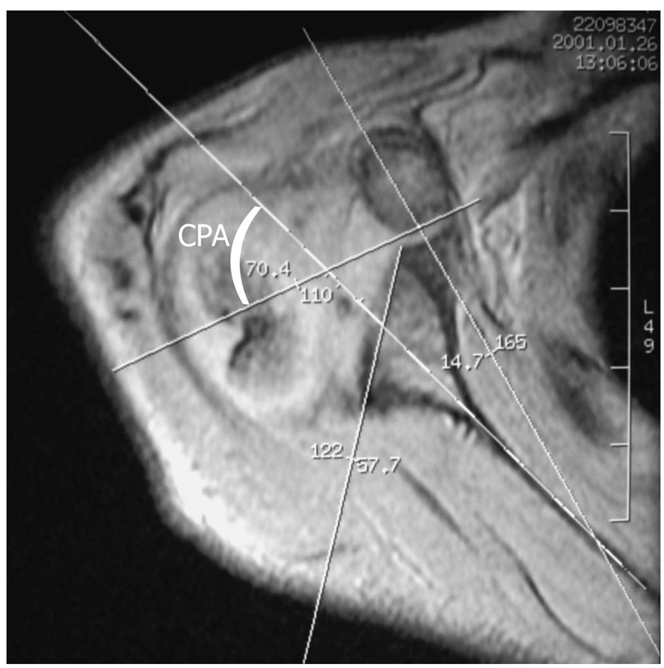

FIGURE 7. Increased coracoid physeal angle (CPA) of involved shoulder that measures 70.4 degrees, indicative of physeal retroversion.

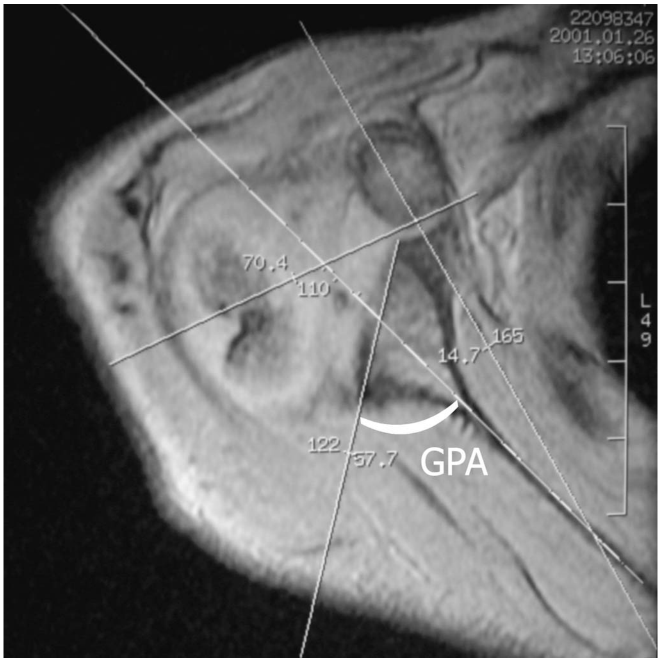

FIGURE 8. Decreased glenoid physeal angle (GPA) of involved shoulder that measures 57.7 degrees, indicative of glenoid retroversion.

Paired *t* Tests

There was a significant difference between the uninvolved and involved shoulders with regard to coracoid angle ($P < 0.001$), coracoid physeal angle ($P < 0.001$), glenoid physeal angle ($P < 0.001$), interphyseal angle ($P = 0.001$), and coracoid scapular distance ($P < 001$).

FIGURE 9. Decreased coracoid scapular distance (CSD) of involved shoulder that measures 1.32 cm.

DISCUSSION

The coracoid, glenoid, and acromion must develop in an integrated fashion to provide appropriate support for the humeral head and glenohumeral joint.[13] The coracoid and glenoid project from the scapula and are linked by a contiguous physis. The coracoid has a bipolar physis with a physis on both sides of the primary ossification center. The coracoid fuses with the scapula in late adolescence.[13] Little information is available regarding normal development of the coracoid in the growing child. Ogden and Phillips[13] reported that the coracoid primary ossification center appears at about 3 months of age. At 2 years of age, the ossification center expands and the tip and base become apparent.

Waters et al[8] noted that the normal position and orientation of the glenohumeral joint changes after birth. The glenoid is most retroverted during the first 2 years of life (average -6.3 ± 6.5 degrees) and reaches adult glenoid version by the end of the first decade (average -1.7 ± 6.4 degrees).[3] This unique arrangement between the coracoid and glenoid provides support for the shoulder girdle, networks scapulothoracic and glenohumeral motion, and imparts synchrony during shoulder movement. Logically, the contiguous physis must be pivotal during shoulder maturity in the developing child. Direct or indirect alteration of either part of the physis may secondarily affect growth of the adjacent component.

Our results indicate a consistent relationship between the coracoid and the glenoid during normal shoulder development. The maturation of the glenoid and coracoid appear to be linked by the common or shared physis. The shoulder with residual brachial plexus palsy, however, possesses significant abnormalities in the spatial orientation of the glenoid and coracoid. The retroversion of the glenoid is accompanied by similar retroversion of the coracoid physis and its process. The coracoid angulates toward the glenohumeral joint and the coracoid tip approaches the glenohumeral joint. There is a direct correlation between the changes across the glenoid physis and the position of the coracoid. During the development of shoulder dysplasia, the glenoid physeal angle decreases (glenoid retroversion), which correlates with a simultaneous increase in the coracoid physeal angle (coracoid retroversion) and a decrease in the coracoid scapular distance. In addition, the interphyseal angle increases as the glenoid physeal angle decreases, which implies that glenoid retroversion is greater than coracoid retroversion.

The explanation for the changes in the orientation of the coracoid physis and its process remains speculative. Possible reasons include a biologic interaction between the glenoid and coracoid along the shared physis or traction from the surrounding structures that attach to the coracoid. The glenoid changes have been attributed to the Hueter-Volkman law, with eccentric load application during humeral head subluxation.[3] The alteration in physis load across the anterior portion of the glenoid physis may influence the adjacent coracoid physis. Alternatively, abnormal loads may be applied across the coracoid physis, base, or tip during the development of a shoulder internal rotation contracture and glenoid retroversion. The coracoid base may be directly affected by the coracohumeral ligament, which originates from the base and tightens in children with an internal rotation contracture. The coracoid tip serves as an attachment site for the coracobrachialis, pectoralis minor, and biceps brachii (short head) muscles. Humeral head subluxation may result in tension within these muscles and traction across the coracoid, which results in elongation or angulation. Zancolli[11] noted that an internal rotation and adduction contracture combined with posterior humeral head subluxation promoted abnormal glenohumeral joint development and "occasional beaking and forward displacement of the acromion and downward prolongation of the coracoid process." Wickstrom[10] found six patients with "beaking of the coracoid" and attributed this finding to overactivity of the coracobrachialis and the short head of the biceps during forward flexion of the arm.

The clinical implications of coracoid dysplasia are unclear. The retroversion of the coracoid combined with alteration in the subcoracoid space may have a deleterious affect on shoulder function. In addition, the coracoid may impede shoulder reduction or placement of an anterior portal during shoulder arthroscopy. The recognition and delineation of coracoid dysplasia will foster research into its impact on shoulder kinematics and function.

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