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**Introduction:**

The most common sequelae of brachial plexus birth palsy (BPBP) is an internal rotation contracture (IRC) of the shoulder[1]. The causes of this contracture are multifactorial, beginning with external rotation weakness, followed by capsular contracture and likely diminished growth of the subscapularis[1]. The consequent dysplasia of the glenohumeral joint is notable for increased glenoid retroversion, formation of a pseudo-glenoid with posterior displacement of a flattened humeral head relative to the scapula[2]. More recent research demonstrates that decreased retroversion of the humeral shaft commonly occurs and further contributes to the internal posture of the arm[3].

There is less understanding regarding the consequences of brachial plexus injury on the development of the proximal part of the forequarter, specifically the clavicle and the orientation of the scapula to the thorax. As the clinical measure of external rotation is essentially an aggregate of the angular measurements of skeletal segments between the forearm and thorax, alterations in any of the component segments will impact this measure. All other measures being equal, a scapula that is oriented internally on the thorax will result in decreased external rotation, thus increasing the severity of any resultant IRC (Figure 1).

The purpose of this study was to better understand contributing components to the most common sequelae of brachial plexus birth palsy (BPBP), internal rotation contracture (IRC) of the shoulder. We hypothesized that in a cohort of children receiving treatment for IRC, there would be side-to-side differences in clavicular length and resting posture of the scapula, correlating with IRC severity and each other.

**Methods & Materials:**

Twenty-four children that underwent bilateral shoulder and elbow MRI during treatment for IRC were included in this retrospective analysis. Measures of scapulothoracic angle (STA), clavicle length (CL), glenoid retroversion (GRV), and humeral retroversion (HRV) were made on involved and uninvolved sides. Inter-observer and intra-observer reliability was assessed. Paired t-tests were performed to compare STA, CL, GRV, and HRV between involved and uninvolved sides, with p-value<0.05 considered statistically significant. Spearman correlation coefficients were applied to assess associations between age (at MRI), IRC severity, ratio of CL (involved/uninvolved), and difference in STA.

**Results & Discussion:**

The IRC averaged -19° (median -17.5, range -60° to 0°). Measurement of differences between involved and uninvolved sides demonstrated statistically significant differences in all measures, including a shorter CL (67.2mm vs 79.2mm, p=0.00048) and more acute STA (38° vs 43°, p=0.0004). GRV (27.5° vs 6.1°, p<0.0001) and HRV (4.2° vs 20.0°, p<0.0001) also differed. Spearman correlations did not reveal strong relationships between STA, CL, and other variables measured, including IRC severity and glenoid deformity type. IRC severity correlated with decrease in GRV (p = 0.040) and HRV (p = 0.035). Notably, age did not significantly correlate with IRC severity (p=0.6), or difference in CL (p=0.1), STA (p=0.2), GRV (p=0.9), and HRV (p=0.3). The involved clavicle was 94.5% (range 70.5% to 107.1%) length of the

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[1] Nikolaou S, Peterson E, Kim A, Wylie C, Cornwall R. Impaired growth of denervated muscle contributes to contracture formation following neonatal brachial plexus injury. *J Bone Joint Surg Am*. 2011;93(5):461-470. doi:10.2106/JBJS.J.00943

[2] Pearl ML, Woolwine S, van de Bunt F, Merton G, Burchette R. Geometry of the proximal humeral articular surface in young children: a study to define normal and analyze the dysplasia due to brachial plexus birth palsy. *J Shoulder Elbow Surg*. 2013;22(9):1274-1284. doi:10.1016/j.jse.2012.12.031

[3] van de Bunt F, Pearl ML, Lee EK, Peng L, Didomenico P. Analysis of normal and dysplastic glenohumeral morphology at magnetic resonance imaging in children with neonatal brachial plexus palsy. *Pediatr Radiol*. 2017;47(10):1337-1344. doi:10.1007/s00247-017-3882-1

uninvolved side. The STA of the involved side was 89.3% (range 80.6% to 100%) of the uninvolved side. In quantifying anatomic changes associated with IRC resultant from BPBP, we can identify further areas for optimal intervention to address limited motion and cosmesis, particularly in patients who fail traditional treatment which does not address or account for differences in clavicle length.