# Morphological changes to the glenohumeral joint due to preganglionic and postganglionic neonatal brachial plexus injury

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INTRODUCTION: Neonatal brachial plexus injury (NBPI) is a common nerve injury occurring during childbirth affecting 0.4 to 4 per 1000 newborns [1], with most frequent injury to the C5-C6 level. Sequelae include both postural changes, including an internally rotated and adducted arm, and osseous changes, including glenoid retroversion, humeral head flattening, and glenohumeral subluxation. The extent of postural deformity depends in part on location of the injury along the nerve, whether preganglionic or postganglionic [2]; however, the influence of injury location on osseous morphology is unclear. This study investigated the morphological changes to both the glenoid and humeral head in a rat model of NBPI.

METHODS: This study was approved by the NC State IACUC. We used an existing rat model of NBPI [3] to examine osseous changes in two experimental groups: preganglionic NBPI (N=8) and postganglionic NBPI (N=8, scapular measures previously reported [4]). Neurectomy was performed at postnatal day 3-5 on a single limb; the contralateral limb served as a control. The preganglionic surgery was achieved through supraclavicular incision whereas an incision through pectoralis major was performed to inflict the postganglionic injury. Rats were sacrificed at 8 weeks. Glenoid and humeral head morphology were obtained from micro-computed tomography scans (36-µm voxel size, SCANCO µCT 80) post-processed in Mimics (Materialise). Glenoid inclination angle, glenoid version, and humeral head thickness and width were measured. Affected and unaffected shoulders were compared with paired two-sample t-tests. Differences between preganglionic and postganglionic groups were assessed with two-sample t-test ($\alpha$=0.05).

RESULTS: Morphological changes to the glenoid and humeral head due to preganglionic and postganglionic injuries were observed. Glenoid version angles on the affected limb (means: preganglionic = 1.21°; postganglionic = 0.233°) tended to be retroverted relative to the unaffected limb (means: preganglionic = 3.95°; postganglionic = 7.72°) for both preganglionic ($p$ = 0.19) and postganglionic ($p$ = 0.09) groups (Figure 1A). However, there were no significant differences between the two groups ($p$ = 0.463). The glenoid inclination angle was significantly higher in the affected limb (mean = -56.1°) compared to the unaffected limb (mean = -38.4°) for the postganglionic group ($p$ = 0.0212), but no differences were observed for the preganglionic ($p$ = 0.964) group. Glenoid inclination angle was significantly more negative (declined) for postganglionic compared to preganglionic injury ($p$ = 0.0329). Humeral head thickness and width (Figure 1B) were both smaller in the affected (means: preganglionic: thickness = 4.27 mm, width = 4.71 mm; postganglionic: thickness = 4.22 mm, width = 4.53 mm) than the unaffected shoulder (means: preganglionic: thickness = 4.53 mm, width = 4.96 mm ; postganglionic mean, thickness = 4.58 mm & width = 4.73 mm) for the preganglionic ($p$ = 0.05 & 0.0457) group and tended to be smaller in the postganglionic group ($p$ = 0.1835 & 0.226). However, there was no significant difference between groups for either thickness ($p$ = 0.923) or width ($p$ = 0.560).

DISCUSSION: We observed marked morphological differences in the glenoid between the two NBPI variants and characterized the extent of glenohumeral deformity in an established rat model. Both preganglionic and postganglionic injuries exhibited altered humeral head size and tendency towards retroversion relative to the unaffected limb, but only glenoid inclination was significantly more affected in postganglionic injury compared to preganglionic injury. Tendency for glenoid retroversion observed here in both preganglionic and postganglionic groups has been previously reported in postganglionic in rat models [3] and in humans [5]. While the glenoid cavity did not decline in the preganglionic group, declination was severe in the postganglionic affected glenoid [3]. This suggests that declination is a key marker of nerve injury location in this animal model. Prior work has suggested that muscle longitudinal growth may be restricted in the postganglionic case but not the preganglionic case [2], which may contribute to altered loading and thus osseous deformities; the increased declination may reflect this altered loading scenario [6]. Humeral head was smaller on the affected shoulder especially in the preganglionic group, a finding seen clinically in humans [7] and reported for rats, but only for postganglionic injuries [3]. Sham control and unaffected animals will be examined in ongoing analyses.

SIGNIFICANCE/CLINICAL RELEVANCE: The study provides important insight into the differential effects of nerve injury location in NBPI and its effects on osseous deformities at the shoulder. Osseous deformity in preganglionic injury has not been previously quantified. This work provides new evidence critical for understanding the underlying contributions to deformity and loss of function at the shoulder in NBPI necessary for developing improved treatment to limit development of deformity.

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ACKNOWLEDGMENTS: The study was funded by NIH R21HD088893 (JHC, KRS).

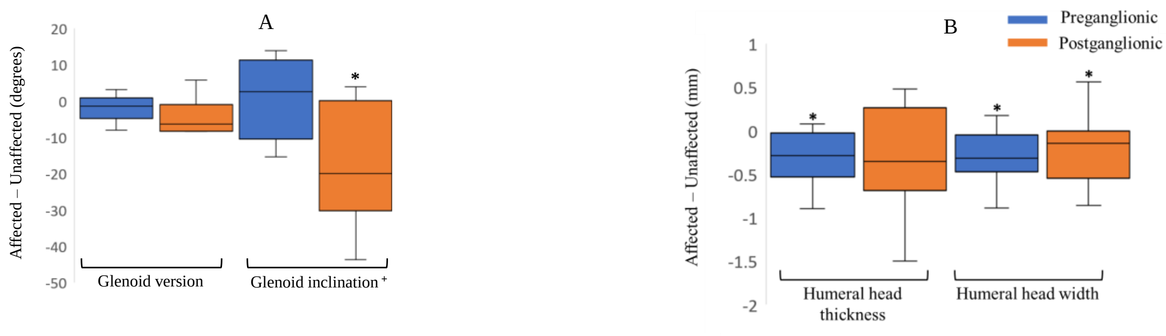


Fig 1: A) Glenoid morphology, B) Humeral morphology.
* indicates significance relative to the unaffected limb ($p$<0.05). + indicates significant differences between preganglionic (blue) and postganglionic (orange) groups.