Appendix: Derivation of the Glenohumeral Abduction Contracture Measurements with Use of MRI

Measurements were made on coronal and axial thoracic MRIs showing both shoulders with the patient positioned with arms at the side. All angles were measured bilaterally. Three lines were drawn on coronal MRIs: along the humeral shaft, parallel to the thoracic spine midline, and along the scapular spine (the spinoglenoid notch to the medial border of the scapular body at the medial end of the scapular spine). The brachiothoracic angle ($\angle$BT) was measured between the humeral shaft and the line parallel to the thoracic spine midline (Fig. 2-A), and the scapulohumeral angle ($\angle$SH) was measured between the humeral shaft and scapular spine (Fig. 2-B). Two lines were drawn on axial MRIs: along the sagittal midline of the thoracic vertebrae and along the scapular body. The scapular protraction angle ($\angle$SP) between these two lines was measured and subtracted from 90° (Fig. 2-C).

The scapular tilt angle ($\angle$ST), which is the position of the scapula relative to the thoracic spine accounting for scapular protraction (maximum passive adduction), was calculated from the following equation:

$$\angle ST = arcsin * (sin(90 - \angle SH) * cos(\angle SP))$$

The glenohumeral abduction ($\angle$GHA) angle, which is the position of the scapula relative to the humeral shaft accounting for scapular protraction, was calculated from the following equation:

$$\angle GHA = arctan * (tan(90 - \angle SH + \angle BT) * sin(90 - \angle SP))$$

Glenohumeral abduction contracture (GHC) was calculated as the difference in glenohumeral abduction angle between the affected and unaffected sides, accounting for the position of the humeral shaft, with the following equation:

$$GHC = (\angle GHAaffected - \angle GHAunaffected) + \angle BT$$