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ORIGINAL ARTICLE

Glenoid morphology in obstetrical brachial plexus lesion: a three-dimensional computed tomography study

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Background: Obstetric brachial plexus lesion (OBPL) frequently leads to glenohumeral dysplasia, and excessive retroversion of the glenoid is among the best known developmental disturbances. Most analyses of the glenoid are based on 2-dimensional (D) imaging and do not address glenoid inclination or provide information on the glenoid in the sagittal plane. We aim to describe the 3-D deformity of the glenoid in children with OBPL.
Methods: Preoperative computed tomography (CT) scans of the nonaffected and the affected scapula of 24 children (aged 5 to 12 years) with developmental disturbances after OBPL years were analyzed. The dimensions of the scapula and the deformation of the glenoid were visualized in 3-D.
Results: The retroversion of the glenoid fossa was greater in all affected shoulders, and 2-D measurements significantly overestimated retroversion compared with angles measured in 3-D. The inclination of the glenoid fossa was altered, and a distal bony edge loss was observed on 3-D reformations in the sagittal plane. The reliability of the measured angles was excellent, and the κ agreement for the description of the glenoid form was substantial. Furthermore, the dimensions of the scapula were significantly smaller on the affected shoulders.
Conclusion: OBPL is indeed a 3-D disorder. Our measurements revealed excessive retroversion of the glenoid fossa, and the reliability of the 3-D CT measurements was superior to their 2-D counterparts. 3-D CT reformations of the glenoid in the coronal and the sagittal plane added further to 3-D understanding of glenoid morphology in OBPL. These new findings legitimatize a 3-D CT-based description of the glenoid deformities connected with OPBL.
Level of evidence: Basic Science; Anatomy Study; Imaging

Keywords: Glenoid deformity; brachial plexus palsy; glenoid version; glenoid inclination; glenoid form; shoulder

Obstetric brachial plexus lesion (OBPL) is a flaccid paresis of the upper extremity[12] that occurs in 1 to 5 per 1000 births.[1] The etiology is presumed to be traumatic traction of the brachial plexus nerve roots (C5-T1) during childbirth.[25,28] Recent evidence suggests that the natural history of OBPL is favorable in 75%.[1,26]

This project was approved by the Orthopaedic Research Unit, Department of Orthopaedics, Odense University Hospital in 2009.

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When recovery is incomplete, developmental disturbances of the shoulder girdle are commonly seen.[3,20] Decreased growth of the dorsal and ventral sides of the glenoid has been suggested,[33] and the often associated excessive retroversion of the glenoid is among the best known developmental disturbances.[3,20] Morphologic changes of the humeral head[30] and of the glenoid fossa[17,25,35] may appear early in life and are often seen in connection with posterior (dorsal) subluxations of the glenohumeral joint (GHJ). Deformities progress with age and correlate with internal rotation contracture.[34]

Dysplasia is, however, not just an internal-external imbalance, it is a 3-dimensional (D), unbalanced joint, and pathology must therefore be assessed from 3-D data.[5] Failure to incorporate 3-D measurements forces clinicians to base treatment decisions on less reliable 2-D osseous deformation parameters that do not provide a complete understanding of the pathology. Treating glenoid 3-D deformity requires 3-D information on the bony structure,[10] and only a full 3-D correction may help improve functional outcomes.[5]

The deformity is commonly studied using magnetic resonance imaging (MRI) or computed tomography (CT) techniques,[22,28,33] and much of the current literature has focused on measurements of glenoid retroversion using axial plane images.[2,31] The true form of a 3-D joint fossa is difficult to define from a single CT or MRI sequence obtained through the surface.[5] Besides, 2-D transverse images of the glenoid do not address the inclination of the glenoid or provide information on the glenoid in the sagittal plane.[11] Although MRI, to some extent, allows measurements in 3-D, there are several technical limitations, and reproducibility is still not proven.[5,11] In this aspect, CT is superior to MRI because it also allows true bilateral 3-D reformations of the bony structures that constitute the GHJ.

This study was therefore designed to provide a full 3-D description of the glenoid deformity in OBPL using CT as well as a description provided by CT of the developmental disturbances of the entire scapula. We also assessed differences in glenoid morphology between the affected ipsilateral and the nonaffected contralateral shoulders. Finally, the interrater and intrarater reliability of 2-D and 3-D measurements was assessed. We hypothesized that the dysplasia of the glenoid fossa in OBPL is 3-D and that 3-D CT is superior to 2-D CT in providing a more accurate description of the glenoid morphology in OBPL.

Materials and methods

Between October 2003 and May 2008, 31 children underwent CT evaluation for developmental disturbances after OBPL at our institution. Five were excluded because of inadequate quality of the CT scanning, and 2 were excluded because they were younger than 5 years old. The remaining 24 children (13 boys, 11 girls) were enrolled in the study. They were a mean age of 8 years, 4 months (interquartile range, 5 years, 4 months–12 years, 3 months). The right shoulder was affected in 17 children and the left shoulder was affected in the remaining 7. None of the children in the study had undergone surgery before inclusion.

A multidisciplinary team clinically examined all of the children. The severity of the lesion in each child was assessed using the Mallet score, which has been developed to assess the ability of the affected upper extremity to perform functional activities of daily living, denoting 1 to 3 points for each of the 5 activities tested.[20] The Mallet score was only properly documented in 17 of 24 children.

CT imaging examinations

The imaging examination protocol for children with OBPL included bilateral CT scanning of the shoulders. Scans were performed in a GE 4 Slice LightSpeed CT scanner (GE Healthcare, Waukesha, WI, USA). The images were acquired at 140 kV, 200 mA, and a rotation speed of 0.5 seconds. The images were obtained in 2.5-mm contiguous slices from 1 cm above the acromion to 1 cm below the inferior angle of the scapula. The CT scanning was performed with the child placed supine and with the hands under the thighs, whenever possible. The effective radiation dose was estimated to be 2.4 mSv. Radiation of our current CT protocol (U = 120 kVp, I = 99 mA, t_rot = 0.5s, pitch = 0.531:1) is estimated to be less than 2 mSv.

All data were retrieved from the image archiving and communication system and transferred to local workstations. Multiplanar image reformations were created using a software algorithm (AW Volume Share 2, GE Healthcare, Brøndby, Denmark) when processing the images. The images were digitally manipulated, and all other bony structures were removed, except for the entire scapular body. Two-D axial (Fig. 1) and coronal slices and 3-D reformations were used in the evaluation process.

Morphologic measurements

Scapular length was measured at the midglenoid level as the horizontal distance between the medial side of the scapula and the glenoid fossa.[33] The height of the scapula was measured as the distance between the tips of the superior and inferior angles. All measurements were done on the nonaffected and the affected scapula to enable comparison.

The dimensions of the glenoid were assessed from the Saller line[8] (Fig. 2). The orientation of the glenoid fossa relative to the scapula

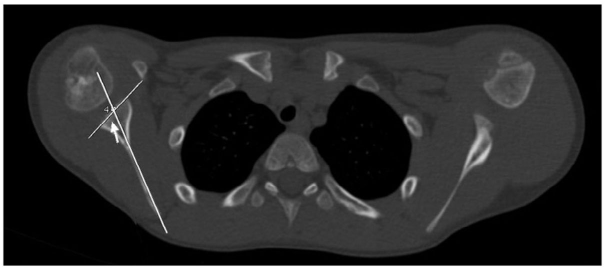

Figure 1 Two-dimensional axial presentation of glenoid retroversion. Two lines were drawn, one passing through the anterior and posterior margins of the glenoid and a second intersecting line from the medial margin of the scapula through the center of the glenoid. The posteromedial angle was measured, and 90° was subtracted to determine the 2-dimensional version. The *arrow* points to the inclination angle.