Combined Glenoid Anteversion Osteotomy and Tendon Transfers for Brachial Plexus Birth Palsy

Emily Dodwell, MD, MPH, FRCSC, and Sevan Hopyan, MD, PhD, FRCSC

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Introduction

Combined glenoid osteotomy with tendon transfers is a new alternative procedure for patients with severe glenohumeral dysplasia secondary to brachial plexus birth palsy. Traditionally, external rotation osteotomy of the humerus has been used to transpose the existing arc of shoulder motion to a more functional position for patients with severe dysplasia. Here we introduce a surgical alternative, the aim of which is to stably reduce the humeral head within the glenoid and restore active external rotation.

This procedure involves open reduction of the joint, and glenoid neck osteotomy to reduce excess retroversion and improve joint stability (Figs. 1 and 2). Contractures are selectively released, and the teres major and latissimus dorsi tendons are transposed to the proximal part of the humerus to augment external rotation power (Fig. 3). Early (one-year) outcomes of this procedure have indicated that glenohumeral reduction is maintained and active external rotation is improved¹. Although it is too early to assess, we hypothesize that joint reduction and tissue rebalancing may provide a better long-term functional outcome for patients with severe glenohumeral dysplasia secondary to brachial plexus birth palsy.

The shoulder reconstruction is done in thirteen steps:

Step 1: Magnetic resonance imaging (MRI) or computed tomography (CT) for preoperative planning

Step 2: Surgical approach with deltoid elevation

Step 3: Subscapularis slide

Step 4: Harvest of the teres major and latissimus dorsi tendons

Step 5: Posterior approach to the glenohumeral joint

Step 6: Assessment and improvement of abduction contracture

Step 7: Harvest of bone graft

Step 8: Scapular neck osteotomy

Step 9: Posterior opening wedge at the osteotomy site

Step 10: Joint closure and infraspinatus repair

Step 11: Transfer of the teres major and latissimus dorsi

Step 12: Closure and immobilization

Step 13: Postoperative plan

Step 1: MRI or CT for Preoperative Planning

Use axial plane MRI or CT for preoperative planning.

- If possible, use MRI, which gives better detail than CT scanning, to delineate glenoid orientation and surface morphology. The goal of surgery is to improve glenoid version to neutral.
- Measure the degree of glenoid retroversion by marking a line parallel to the scapular midline and one along the glenoid joint surface (Fig. 1).
- Draw a parallel line at least 5 mm medial to the glenoid joint surface (the planned projection of the osteotomy).
- Draw an additional line that represents neutral glenoid version (perpendicular to the line of the scapular spine) starting at the anterior cortex.
- The distance between the planned projection of the osteotomy and the line perpendicular to the scapula at the posterior cortex of the glenoid neck represents the size of opening wedge graft required.

Step 2: Surgical Approach with Deltoid Elevation

Position the patient laterally, and undertake a posterior approach, including lateral elevation of the deltoid origin.

- Following administration of anesthesia, position the patient in a lateral decubitus position, using a beanbag to stabilize the pelvis and lumbar spine.
- Infuse the surgical site subcutaneously with 1:500,000 epinephrine solution to decrease blood extravasation from the surgical site.
- Make an L-shaped incision, with one arm of the “L” along the scapular spine, extending laterally to the posterior corner of the acromion (Fig. 4). Turn the incision distally along the posteromedial aspect of the proximal part of the humerus to a few centimeters beyond the axilla.
- Raise an inferomedial fasciocutaneous flap (Fig. 5).
- Elevate the deltoid origin from the scapular spine laterally; do this subperiosteally in younger juveniles and take slivers of bone in older juveniles and adolescents to facilitate later reattachment and healing.

Step 3: Subscapularis Slide

Elevate the subscapularis from the scapula, provisionally reduce the humeral head, and apply gentle external rotation.

- Identify the inferolateral border of the scapula deep to the superior aspect of the teres major.
- Pass an elevator between the anterior aspect of the scapula and the subscapularis (Fig. 6). Ideally, suprapariosteal elevation is performed, although extensive scarring might permit only subperiosteal elevation.
- Elevate the supraspinatus muscle belly bluntly off of the anterior aspect of the scapula in an inferior-to-superolateral direction.
- With a thumb holding the humeral head reduced in the glenoid fossa, gently and progressively externally rotate the shoulder 70° to 90° with the shoulder adducted (Fig. 7). This will complete the muscular slide.

Step 4: Harvest of the Teres Major and Latissimus Dorsi Tendons

Incise the insertions of the teres major and latissimus dorsi from the proximal part of the humerus and perform a tenolysis.

- With the shoulder internally rotated, approach the teres major and latissimus dorsi tendons at the lateral aspect of the long head of the triceps.
- Protect the axillary and radial nerves and accompanying vessels.
- Harvest the two tendons from their periosteal insertions (Fig. 8).
- Identify and protect the teres major and thoracodorsal nerves and vessels.
- Release adhesions between the tendons and surrounding soft tissues to the level of the inferior aspect of the scapula to ensure optimal excursion of the muscles.

Step 5: Posterior Approach to the Glenohumeral Joint

Open the posterior glenohumeral joint and assess overhead elevation.

- Approach the posterior aspect of the capsule through the interval between the infraspinatus and the teres minor.
- Release the insertion of the infraspinatus from the rotator cuff and reflect it medially, sparing some superior fibers to protect the suprascapular neurovascular bundle.
- Incise the joint capsule in line with the glenoid joint surface.
- Inspect the humeral head and provisionally reduce it.
- Reassess the overhead scapulohumeral angle. If scapulohumeral motion is reduced, then lengthen the proximal tendon of the long head of the triceps by striping it.

Step 6: Assessment and Improvement of Abduction Contracture

Improve abduction contracture if it is marked.

- With the joint reduced, the abduction contracture may worsen. If a marked Putti sign (scapular rotation with a prominent superomedial corner at the base of the neck) is present, then perform a supraspinatus slide.

- Elevate the trapezius from the medial aspect of the scapular spine to reveal the supraspinatus.
- Elevate the supraspinatus laterally from its fossa, stopping short of the spinoglenoid notch.
- The joint is held reduced and stretched in adduction.
- Resect the superior angle of the scapula if a marked Putti sign persists.

Step 7: Harvest of Bone Graft

Harvest tricortical graft from the scapular spine or posterior aspect of the acromion.

- On the basis of measurements taken from the preoperative MRI (Fig. 1), harvest a triangular wedge of bone from the medial aspect of the scapular spine or from the posterior aspect of the acromion. This is structural graft, so the cortical portion of the graft must be intact to open the scapular neck osteotomy site and withstand compressive forces on this strut.
- Trim the bone graft to the appropriate size.

Step 8: Scapular Neck Osteotomy

Undertake a posterior opening wedge osteotomy of the scapular neck.

- Despite the presence of both abnormal glenoid shape and abnormal glenoid version, the intention is to perform only redirection of the glenoid, without reshaping or bending the articular surface.
- Clear the periosteum over the scapular neck from the labrum laterally to just medial to the spinoglenoid notch.
- Protect the suprascapular neurovascular bundle in the spinoglenoid notch by keeping the dissection subperiosteal.
- Extend the osteotomy from the spinoglenoid notch to the inferior aspect of the scapular neck, staying at least 5 mm medial to the glenoid rim to ensure protection of the glenoid blood supply and to avoid osteonecrosis.
- Use the corner of a sharp osteotome to score the posterior cortex in line with the intended osteotomy.
- Advance the osteotome deeper (Fig. 9), aiming slightly lateral, toward the base of the coracoid.
- Stop the osteotomy just short of the anterior cortex of the superior portion of the scapular neck to retain an intact anterior hinge. Inferior-

ly, the neck is thin and the osteotomy will typically breach the anterior cortex.

- Intermittently during the osteotomy, inspect the glenoid articular surface visually to ensure that the trajectory of the osteotome will not enter the joint.
- If the anterior cortex has been disrupted, bone graft stability can still be achieved, if the anterior periosteum or soft tissues are not excessively disrupted, with careful maintenance of external rotation during closure. Fixation with a plate or screw would be a challenge given the narrow width of the glenoid fragment, but it might also be considered.

Step 9: Posterior Opening Wedge at the Osteotomy Site

Insert the bone graft into the osteotomy site.

- Use a small osteotome to lever open the scapular neck osteotomy site (Fig. 10). Avoid repeating this maneuver, as the anterior cortical hinge may fatigue and break.
- Insert the bone graft and tamp it in place gently so that it acts as a wedge opening the cortex of the posterior aspect of the neck and is stable.
- Probe the anterior cortex of the scapular neck to confirm that the anterior hinge is intact.
- This is typically a stable construct that does not require fixation (Fig. 11).

Step 10: Joint Closure and Infrapinatus Repair

Close the posterior aspect of the capsule and the infrapinatus.

- Hold the glenohumeral joint in external rotation.
- Close the posterior aspect of the capsule without shortening or overlapping in order to minimize loss of internal rotation.
- Repair the infrapinatus to its anatomical position using a nonabsorbable Kessler-type core suture supplemented by additional mattress sutures.

Step 11: Transfer of the Teres Major and Latissimus Dorsi

Transfer the teres major and latissimus dorsi tendons into an osseous trough at the greater tuberosity.

- Place retractors anterolaterally around the humeral head to retract the deltoid.
- Using an osteotome, remove a longitudinal trough of bone measuring approximately 1.5 cm long, 0.5 cm wide, and 1.0 cm deep from the region of the greater tuberosity.
- Suture the teres major into the inferior aspect of this trough (Fig. 12). The latissimus dorsi, given its greater excursion, should be sutured into the superior position.
- Weave nonabsorbable sutures through the tendinous portion of each muscle. A semicircular cutting needle may be helpful in passing these suture ends through bone at the trough site. Supplement core sutures into bone with additional mattress sutures.

Step 12: Closure and Immobilization

Repair the deltoid, close the wound in layers, and apply a shoulder spica cast.

- Repair the deltoid origin to the scapular spine using nonabsorbable sutures through bone (Fig. 13).
- Close the subcutaneous layer and skin.
- Apply a shoulder spica cast with the humerus in maximal external rotation (70° to 90°) and minimal abduction (20° to 30°) to maintain stretch on subscapularis and prevent worsening of an abduction contracture.
- In the presence of an elbow flexion contracture, immobilize the elbow in a cast as straight as possible to maintain stretch during immobilization (Fig. 14).
- Within the first day or two following surgery, patients undergo repeat axial imaging to confirm joint reduction, graft position, and adequate correction of glenoid version (Fig. 15).
- If correction is lost, glenohumeral reduction is the most important parameter to guide the decision regarding revision. Iliac crest autograft or allograft is a suitable option for revision osteotomy.

Step 13: Postoperative Plan

Maintain the spica cast for five to six weeks; then initiate physiotherapy.

- The shoulder spica cast is maintained for five to six weeks.
- Initiate regular supervised physiotherapy immediately on removal of the spica cast.
- Over the first three months following cast removal, the patient undertakes progressive ac-

tive and passive range-of-motion exercises, focusing on stretching in internal rotation to achieve hand-to-belly function and strengthening of the external rotators, flexors, and abductors.

Results

In our series of thirty-two patients with severe glenohumeral dysplasia who underwent combined glenoid osteotomy and tendon transfers, early results suggest that the outcomes of this procedure are similar to those of proximal humeral external rotation osteotomy¹. On average, passive external rotation with the shoulder in neutral increased by 43° (95% confidence interval [CI], 26° to 60°) while passive internal rotation decreased by 22° (95% CI, 12° to 31°). Active external rotation with the shoulder in neutral increased by 82° (95% CI, 66° to 98°), while active internal rotation decreased by 26° (95% CI, 14° to 38°). The aggregate Mallet score improved by 4.0 points (95% CI, 3.0 to 4.9). Glenoid retroversion improved by 26° (95% CI, 20° to 32°). The percentage of the humeral head anterior to the midscapular line improved by 35% (95% CI, 30% to 40%).

What to Watch For

Indications

- Glenohumeral dysplasia greater than or equal to Waters type IV².
- Patients older than four years of age.
- As an alternative to external rotation humeral osteotomy.

Contraindications

- Lack of musculotendinous units available for tendon transfer.
- Patient or family unwilling to comply with postoperative physiotherapy program.

Pitfalls & Challenges

- The axillary, radial, teres major, thoracodorsal, and suprascapular nerves and vessels are at risk and must be protected.
- Care must be taken to maintain the anterior cortex at the osteotomy site.
- Internal or external rotation contracture can occur, which appears partly related to inappropriate tension in the transferred tendons and partly to noncompliance with physical therapy.

Clinical Comments

1. How is the osteotomy directed?

It is important to keep the osteotomy away from subchondral bone and maintain an intact anterior cortical hinge, at least in the thick superior portion of the scapular neck. Aiming the osteotome at the coracoid is a helpful maneuver because that osseous landmark is readily palpable and has a broad base. Stopping the osteotome at the base of the coracoid safeguards the anterior hinge.

2. What can be done if the anterior cortical hinge is lost?

Bone graft stability can still be achieved if anterior periosteum or soft tissues are not excessively disrupted. Stability is improved by a triangle-shaped bone graft and compression of it, which is achieved by external rotation of the reduced shoulder. In exceptionally unstable cases or those with severely deficient bone, anterior translation of the glenoid fragment—analogue to a Chiari hip osteotomy—can be undertaken. Bone graft is then laid against the posterior aspect of the capsule to augment the posteromedial shelf. In this situation, the transferred tendons still achieve functional external rotation.

Emily Dodwell, MD, MPH, FRCSC

Department of Pediatric Orthopedic Surgery, Hospital for Special Surgery, New York, NY 10021. E-mail address: dodwelle@hss.edu

Sevan Hopyan, MD, PhD, FRCSC

Division of Orthopaedic Surgery, Hospital for Sick Children, Room S107, 555 University Avenue, Toronto, ON M5G 1X8, Canada. E-mail address: sevan.hopyan@sickkids.ca

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Fig. 1

Preoperative axial imaging is used to plan the glenoid osteotomy. A line is drawn along the scapula and another, along the glenoid joint surface. A third line is drawn parallel to the joint surface, and a fourth line is drawn starting where the third line meets the anterior glenoid cortex and perpendicular to the line of the scapular spine. The distance between the third and fourth lines along the posterior cortex is the width of the bone graft that must be harvested.

Fig. 2

Glenoid version is neutralized with a glenoid osteotomy and an opening wedge structural graft.

Fig. 3

Schematic showing the opening wedge glenoid osteotomy and a new superolateral position of the teres major and the latissimus dorsi as external rotators.

Fig. 4

Planning of the L-shaped posterior incision.

Fig. 5

Exposure of the deltoid, infraspinatus, teres minor, and teres major.

Fig. 6

An elevator is used to bluntly elevate the subscapularis off of the anterior surface of the scapula.

Fig. 7

The humeral head is provisionally reduced with the thumb, and the subscapularis slide is completed with the arm in adduction and external rotation.

Fig. 8

Harvest of the teres major and latissimus dorsi tendons.

Fig. 9

Glenoid osteotomy.

Fig. 10

Opening of the posterior osteotomy site prior to insertion of the graft.

Fig. 11

The cortical wedge inserted in the osteotomy site.

Fig. 12

Advancement of tendons to a trough in the region of the greater tuberosity. The teres major is repaired to an inferior position on the posterior aspect of the proximal part of the humerus, and the latissimus dorsi is repaired to a superior position.

Fig. 13

The deltoid repaired back to the acromion and scapular spine.

Fig. 14

Shoulder spica cast with the arm in 20° of abduction. When a flexion contracture of the elbow is present, a cast is applied with the arm in extension.

Fig. 15

Preoperative, immediate postoperative, and one-year postoperative axial images showing the glenoid anteversion osteotomy and triangular posterior opening wedge autograft (arrow).

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

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Fig. 7

Fig. 8

Fig. 9

Fig. 10

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Fig. 13

Fig. 14

Fig. 15