Brachial Plexus Birth Palsy: The Boston Children’s Hospital Experience

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ABSTRACT

The purpose of this article is to review our institution’s experience with and current approach to the treatment of brachial plexus birth palsy (BPBP). Specific focus is made on the microsurgical treatment of extraforaminal nerve ruptures, the effects of long-standing BPBP on glenohumeral development, and the results of secondary reconstructive surgery for shoulder dysfunction in chronic BPBP.

KEYWORDS: Brachial plexus birth palsy, tendon transfers, glenoid dysplasia

Since 1989, all patients with brachial plexus birth palsy (BPBP) presenting to our institution have been evaluated and treated in the multidisciplinary Hand and Upper Extremity Program of the Department of Orthopaedic Surgery, under the direction of the senior author (PMW). As a part of our continuing efforts to provide accurate information and the best possible clinical care, all patients have been enrolled in a prospective cohort study to monitor natural history and assess the results of surgical treatment. At the time of initial presentation, information was obtained regarding prenatal risk factors, perinatal events, and musculoskeletal and neurological physical examination findings. Upper extremity motor strength and passive and active joint motion were faithfully recorded. Infants with BPBP were examined monthly during the first 6 months of life, followed by serial evaluations every 3 to 6 months. The modified Mallet classification was utilized to categorize global shoulder function.¹ The Toronto Test Score and Hospital for Sick Children’s Active Movement Scale were also utilized to quantitate upper extremity function.²⁻⁴ In cases of chronic BPBP and persistent shoulder dysfunction, magnetic resonance imaging (MRI) or computed tomography (CT) of the shoulder(s) was obtained to assess for glenohumeral dysplasia, instability, or dislocation.⁵ These radiographic studies were obtained preoperatively as well as 1, 2, and 5 years postoperatively.

The purpose of this article is to review the lessons learned from this ongoing prospective investigation and to outline our institution’s current approach to BPBP. In particular, we focus on the microsurgical treatment of extraforaminal neural ruptures, the effects of long-standing BPBP on glenohumeral development, and the results of secondary reconstructive procedures to improve shoulder function.

MICROSURGERY

Historical Review

Although reports of surgical treatment for brachial plexus lesions date back to the beginning of the 20th century, it was not until the advent of modern microsurgical techniques and the work by Narakas, Millessi, Gilbert, Kawabata, and others that microsurgical repair and reconstruction for BPBP became widely accepted.⁶⁻¹³ Currently, microsurgical brachial plexus surgery consists of neuroma resection and nerve grafting and/or nerve transfers. Neurolysis alone of brachial plexus lesions, although performed more frequently in the past, has been shown to offer no improvement...
over natural history in the treatment of nerve root avulsions and questionable benefit in cases of upper trunk ruptures.\textsuperscript{14–16} Ultimately, the nature of the microsurgical reconstruction must be individualized for each patient, based upon the spectrum of anatomic lesions encountered.

Historically, there have been varying recommendations regarding the indications and appropriate timing for brachial plexus exploration and nerve reconstruction. In the setting of multilevel or total plexus nerve root avulsions (e.g., the flail extremity with Horner’s syndrome), most authorities advocate microsurgical intervention before 3 months of age. In these instances, nerve transfers utilizing the contralateral brachial plexus or ipsilateral intercostal, spinal accessory, phrenic, and/or partial ulnar nerves may be the only reconstructive option.\textsuperscript{17–21}

The optimal timing for brachial plexus exploration and microsurgical reconstruction in cases of extraforaminal nerve ruptures, however, is unclear. Most authorities have used persistent elbow flexion weakness in association with an upper trunk lesion as the primary indication for microsurgery. Taylor, Gilbert, and others recommend microsurgery at 3 months of age if there has been no recovery of antigravity biceps function.\textsuperscript{6,8,12,16,22–26} Clarke and Curtis have promoted microsurgery in infants up to 9 months of age with persistent elbow flexion weakness.\textsuperscript{3} Indeed, the range of repairs cited within the literature extends from 1 to 24 months of age.\textsuperscript{3,8,22,23,27–33} Much of the difficulty in determining the optimal timing for microsurgical intervention arises from the limited available data. Most of our current understanding of this issue comes from retrospective case series with limited follow-up, often involving patients undergoing multiple different surgical interventions.

**Initial Experience with Microsurgery for Extraforaminal Ruptures**

Based upon the information available in the late 1980s, absence of biceps recovery at the age of 6 months was initially selected as an indication for brachial plexus exploration and microsurgical reconstruction in BPBP patients with extraforaminal rupture injuries at our institution. Neuroma resection, nerve grafting, and/or neurotization of the anterior division of the upper trunk to the lateral cord and musculocutaneous nerve; suprascapular nerve; and posterior division of the upper trunk to the posterior cord were prioritized in cases of upper trunk ruptures. Sural nerve graft was utilized when appropriate according to standardized techniques.\textsuperscript{34–36} As previously stated, multilevel or total plexus avulsion injuries must be treated with more complex nerve transfers.

Patients with chronic BPBP often have shoulder dysfunction in the form of internal rotation contracture and external rotation and abduction weakness. In these patients, latissimus dorsi and teres major tendon transfers to the rotator cuff\textsuperscript{27} or derotational humeral osteotomies\textsuperscript{38–40} were performed later in life in efforts to improve global shoulder function. The status of the glenohumeral joint—as determined by physical examination and CT or MRI—was used as the prime determinant of which secondary reconstructive procedure was performed; the patients with reduced glenohumeral joints and minimal underlying bone deformity were deemed candidates for tendon transfers. Surgical reduction and stabilization of the glenohumeral joint have evolved over time. Our approach to persistent shoulder dysfunction secondary to chronic BPBP is outlined later in this review.

**Prospective Study of Natural History and Outcomes of Microsurgical Repair**

Given the paucity of information regarding the natural history of BPBP and the controversy regarding the appropriate indications for and timing of microsurgical reconstruction, data from the prospective cohort study were evaluated to address these lingering issues. The study objectives were (1) to define the natural history of BPBP in the first 6 months of life, (2) determine the utility of biceps function recovery in predicting long-term upper extremity function, and (3) to assess the results of surgical treatment for persistent upper extremity dysfunction.

From January 1989 to December 1995, 93 patients with BPBP referred at birth or later for persistent neurological deficits were evaluated and followed by the senior author (PMW). Sixty-six patients were evaluated within the first 3 months of life. Patients were evaluated monthly during the first 6 months of life and prospective data were collected on active muscle function, active and passive ranges of motion, and glenohumeral instability. The Narakas classification system was used to characterize extent of neurological involvement in each patient (Table 1).\textsuperscript{6} Shoulder function was categorized using the modified Mallet classification (Fig. 1).\textsuperscript{5} For the purposes of evaluating functional outcomes, patients were divided into groups according the month at which biceps recovery was first noted. All patients were observed beyond 2 years of age.

**Results of Prospective Data Collection**

The results of this prospective investigation provided important insights into the natural history and results of microsurgical reconstruction in infants with BPBP.\textsuperscript{41} These results are summarized in Figure 2. Eight of the 66 patients had biceps function recovery in the first month of life, and all 8 infants were group 1 (C5–C6 involvement, “classic Erb’s palsy”) according the Narakas classification. All eight patients had modified Mallet
classification scores of 5 out of 5 for all parameters of shoulder function without residual neurological deficits, signifying normal function.

Thirteen patients with 14 lesions demonstrated biceps return during the second or third month of life. These patients had deficits correlating to Narakas group 1, 2, or 3, signifying C5-C6, C5-C7, or C5-T1 root involvement, respectively. No patients had evidence of Horner’s syndrome. Average modified Mallet classification scores were 4.1 out of 5 for global abduction, 3.8 out of 5 for external rotation, 4.1 out of 5 for hand-to-neck motion, and 3.9 out of 5 for hand-to-mouth motion. Two patients with three lesions had recovery of normal upper extremity function. Eleven patients had mild residual external rotation, elbow flexion, and forearm supination weakness.

Eleven patients had biceps recovery in the fourth month of life. These patients were Narakas group 3 or 4, signifying total plexus involvement. Average modified Mallet classification scores were 3.7 out of 5 for global abduction, 2.9 out of 5 for external rotation, 3.5 out of 5 for hand-to-neck motion, and 3.4 out of 5 for hand-to-mouth motion. None of these patients had return of normal upper extremity function.

Fifteen patients were followed up who demonstrated biceps recovery during the fifth month of life. According to the classification system of Narakas, these patients had group 3 or 4 neurological lesions. Average Mallet classification scores for shoulder function were 3.5 out of 5 for shoulder abduction, 2.7 out of 5 for external rotation, 3.2 out of 5 for hand-to-neck motion, and 3.1 out of 5 for hand-to-mouth motion. All 15 patients had scapular winging. None had normal upper extremity functional recovery.

### Table 1 Narakas Classification

<table>
<thead>
<tr>
<th>Narakas Classification</th>
<th>Neurological Involvement</th>
<th>Functional Deficits</th>
</tr>
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<tr>
<td>Group 1</td>
<td>C5–C6</td>
<td>Shoulder abduction, external rotation, elbow flexion, forearm supination</td>
</tr>
<tr>
<td>Group 2</td>
<td>C5–C7</td>
<td>As above, plus wrist and digital extension</td>
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<tr>
<td>Group 3</td>
<td>C5–T1</td>
<td>Flail extremity</td>
</tr>
<tr>
<td>Group 4</td>
<td>C5–T1</td>
<td>Flail extremity with Horner’s syndrome</td>
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**Figure 1** The modified Mallet classification of shoulder function. Patients are asked to perform actively five different shoulder movements: abduction, external rotation, placing the hand behind the neck, placing the hand as high as possible on the spine, and placing the hand to the mouth. Each shoulder movement is subsequently graded on a scale of I (no movement) to V (normal motion symmetric to the contralateral, unaffected side). (Adapted from Mallet J. Primaute du traitement de l’épaule—méthode d’expression des résultats. Rev Chir Orthop Réparatrice Appar Mot 1972;65:166–168.)
Thirteen patients with biceps recovery during the sixth month of life were similarly assessed. These patients were also Narakas group 3 and 4. Average modified Mallet classification scores were 2.9 out of 5 for global shoulder abduction, 2.1 out of 5 for external rotation, 2.5 out of 5 for hand-to-neck motion, and 2.3 out of 5 for hand-to-mouth motion. All 13 patients had scapular winging and 3 had Horner’s syndromes.

When the 39 patients who demonstrated biceps recovery between the fourth and sixth months of life were assessed in aggregate, several observations were made. All patients were in group 3 or 4 of the classification system of Narakas. Average modified Mallet classification system scores were 3.4 out of 5 for global abduction, 2.6 out of 5 for external rotation, 3.1 out of 5 for hand-to-neck motion, and 2.9 out of 5 for hand-to-mouth motion. Twenty-seven of the 39 patients had scapular winging and none demonstrated recovery of normal upper extremity function.

The results of six patients who underwent microsurgical reconstruction of the brachial plexus for absent biceps recovery at 6 months of life were also assessed. Three of these patients had flail upper extremities, and five of the six had Horner’s syndromes. At average 3.8-year follow-up, average modified Mallet classification system scores were 3.5 out of 5 for global abduction, 2.7 out of 5 for external rotation, 3.0 out of 5 for hand-to-neck, and 3.0 out of 5 for hand-to-mouth. Four had persistent scapular winging. None of these patients had return of normal upper extremity function. The functional outcomes of these patients were significantly better than those for the 15 patients who had biceps recovery in the fifth month of life. These results, however, were not significantly better than those of patients who had spontaneous biceps recovery in the fourth month of life.

Further statistical evaluation revealed that although normal upper extremity function was seen only in patients with biceps recovery within the first 2 months of life, global shoulder function decreased significantly with delayed recovery of biceps function after 2 months. All patients with biceps recovery in the fourth through sixth months of life had limitations with external rotation and scapular winging. Patients undergoing microsurgical reconstruction had improved outcomes compared with those demonstrating spontaneous biceps recovery at 5 months of age, but none had return of normal function.

**Current Microsurgical Recommendations**

The results of the preceding prospective cohort study are consistent with previous reports. Based upon these data, several conclusions can be made: (1) patients with recovery of biceps function within the first 2 to 3 months of life can expect normal or near-normal upper extremity functional outcomes; (2) patients with return of biceps function after 3 months of age do not obtain complete neurological recovery or normal upper extremity function; (3) patients with more extensive brachial plexus involvement (e.g., greater involvement of the C8 and T1 cervical nerve roots) and a Horner’s syndrome have poorer prognoses; (4) patients without recovery of
biceps function within the first 6 months of life benefit from microsurgical repair or reconstruction of the brachial plexus, although full return of upper extremity function is not expected.

On the basis of the available literature and the findings of this prospective cohort study, we currently recommend microsurgical repair or reconstruction for (1) infants with flail upper extremities and Horner’s syndromes (i.e., multilevel or total plexus nerve root avulsions) at or before 3 months of age and (2) infants with extraforaminal ruptures and no return of biceps function by 5 to 6 months of age.

**Future Directions**

Despite the results of this and other previously published reports on the natural history and results of microsurgical repair and/or reconstruction in infants with BPBP, several questions remain. At present, the optimal timing for microsurgery in the cases of extraforaminal ruptures remains controversial, and there is still no consensus on the specific indications for microsurgical reconstruction in these patients. Current recommendations for the timing of microsurgical repair range between the ages of 3 and 9 months, and the range of repairs cited within the literature extends to 24 months of age. Clearly, there is need to define the indications and optimal timing for microsurgery. Considerations include the desire to avoid unnecessary procedures and the concern that microsurgical reconstruction performed too early or too late may ultimately result in inferior upper extremity function and patients’ outcomes. In addition, given the relative efficacy of secondary reconstruction (i.e., tendon transfers or humeral osteotomies) in improving upper extremity function, more work needs to be done weighing the results of these late procedures against those of early microsurgery.

To date, no prospective study has been performed assessing the results of microsurgery as a function of age at which surgery is performed. A multicenter prospective study is currently under way to address these issues. The rationale for this study is presented by the authors in an accompanying article in this issue of *Seminars in Plastic Surgery*.

**SHOULDER RECONSTRUCTION**

**Historical Review**

Although initial nonoperative management consisting of stretching, splinting, botulinum toxin injections, and even electrical stimulation is often utilized to maintain shoulder motion, there is frequently persistent shoulder dysfunction due to external rotation and abduction weakness. Ensuing soft tissue contracture, typically involving internal rotation of the shoulder, further complicates the clinical situation. Although scapulothoracic motion can assist with lateral abduction and internal rotation to a limited degree, external rotation is poorly compensated for. This typically leads to difficulty with placing the hand in space for functional tasks or play.

Historically, several procedures for improving global shoulder function in BPBP patients have been described. Soft tissue contractures may be addressed through musculotendinous lengthenings of the pectoralis major, subscapularis, and coracobrachialis. Ten- don transfers of the latisimus dorsi and teres major to the rotator cuff have been utilized to improve both shoulder abduction and external rotation. Dero- tational humeral osteotomies have been employed in older children with significant joint deformity to place the upper extremity in a more functional position. Frank glenohumeral dislocations have been addressed with closed or open reduction and glenohumeral capsularorrhaphy, often in combination with the preceding procedures. More recently, arthroscopic release of the subscapularis tendon and anterior glenohumeral ligaments has been advocated to address secondary contractures. The wide spectrum of secondary reconstructive procedures about the shoulder reflects the diversity of clinical presentation and highlights the importance of individualized surgical treatment.

**The Boston Children’s Hospital Experience**

The results of shoulder reconstruction for chronic BPBP in patients treated at our institution have been previously published in several peer-reviewed articles. Most recently, we have reported the results of 48 children with BPBP and persistent internal rotation contracture and external rotation and abduction weakness treated with reconstructive shoulder surgery from 1989 to 1998. Average age at the time of surgery was 4.9 years. None of the patients had undergone prior shoulder procedures.

Patients underwent either pectoralis major release and latisimus dorsi and teres major tendon transfers to the rotator cuff or derotational humeral osteotomies. All procedures were performed by the senior author (PMW). The choice of surgical procedure was dependent upon the age of the patient and degree of underlying glenohumeral deformity, as determined by preoperative MRI or CT scans. Younger patients with mild to moderate glenohumeral dysplasia were treated with tendon transfers and soft tissue releases (n = 32). Average age was 2.9 years and average clinical and radiographic follow-up was 1.6 years. Older patients with more advanced glenohumeral deformity and/or irreducible dislocations underwent derotational humeral osteotomy (n = 16). Average age in the humeral osteotomy group was 8.4 years and average follow-up was 3.1 years. Figure 3 provides a graphic representation of the number...
of patients receiving each type of surgical treatment according to the degree of glenohumeral deformity.

There was a statistically significant and equivalent improvement in shoulder function as assessed by the aggregate and individual element scores of the modified Mallet classification in patients undergoing both tendon transfers and humeral osteotomies (Tables 2, 3). No patient failed to demonstrate improvements in shoulder function following surgery. Comparatively, patients who underwent tendon transfers demonstrated improved global abduction and hand-to-mouth motion compared with those who underwent humeral osteotomies. Although both tendon transfers and humeral osteotomies uniformly improve shoulder function in patients with chronic BPBP, careful preoperative evaluation— with emphasis on patient’s age and glenohumeral morphology—is critical in selecting the appropriate secondary reconstructive procedure.

Glenohumeral Dysplasia

In addition to the associated functional impairment, long-standing muscular imbalance and soft tissue contracture about the shoulder lead to progressive joint dysplasia and/or instability. These effects on glenohumeral development add yet another layer of complexity to the management of patients with chronic BPBP.

In a previously published investigation from our institution, 42 patients with BPBP and weakness with shoulder external rotation and abduction were analyzed with CT or MRI as part of preoperative planning for potential reconstructive surgery about the shoulder. Mean age was 5.1 years. Preoperative modified Mallet classification of shoulder function averaged 3.0 out of 5 for global abduction, 2.1 out of 5 for external rotation, 2.4 out of 5 for hand-to-neck motion, and 2.4 out of 5 for hand-to-mouth motion, highlighting the degree of functional impairment.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Mallet Classification Scores for Tendon Transfer Patients</th>
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<tr>
<td>Average Mallet Classification Scores</td>
<td>Preoperative</td>
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<tr>
<td>Global abduction</td>
<td>2.9</td>
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<tr>
<td>Global external rotation</td>
<td>2.0</td>
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<tr>
<td>Hand-to-neck</td>
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<tr>
<td>Hand-to-mouth</td>
<td>2.5</td>
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<tr>
<td>Total score</td>
<td>9.5</td>
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</table>

Pre- and postoperative Mallet classification scores of patients undergoing tendon transfers to improve upper extremity function in chronic brachial plexus birth palsy. (Adapted from Waters PM, Peljovich AE. Shoulder reconstruction in patients with chronic brachial plexus birth palsy. Clin Orthop 1999;364:144–152.)

<table>
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<th>Table 3</th>
<th>Mallet Classification Scores for Osteotomy Patients</th>
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<tr>
<td>Average Mallet Classification Scores</td>
<td>Preoperative</td>
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<tr>
<td>Global abduction</td>
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<tr>
<td>Global external rotation</td>
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<td>Total score</td>
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Pre- and postoperative Mallet classification scores of patients undergoing derotational humeral osteotomies to improve upper extremity function in chronic brachial plexus birth palsy. (Adapted from Waters PM, Peljovich AE. Shoulder reconstruction in patients with chronic brachial plexus birth palsy. Clin Orthop 1999;364:144–152.)
The glenoscapular angle (degree of glenoid version) and percentage of the humeral head translated posterior to the line of the scapular spine (posterior subluxation) were quantified in all affected shoulders using standardized radiographic techniques.\textsuperscript{59,60} As expected, average glenoid retroversion of the affected shoulder was markedly increased compared with the contralateral side (25 degrees versus 5 degrees). Sixty-two percent of the 42 patients demonstrated posterior subluxation of the humeral head, with an average of 25% of the head being anterior to the scapular line compared with 49% on the contralateral unaffected side. Subsequent statistical analysis revealed increasing radiographic deformity with increasing age.

These results are consistent with other published reports on glenohumeral development in patient with BPBP.\textsuperscript{61–65} On the basis of these findings, a radiographic classification of glenohumeral deformity was proposed, based in part upon the Severin classification of developmental hip dysplasia (Table 4).\textsuperscript{66}

### Current Surgical Recommendations

Based upon the results of our retrospective case-control study as well as other published reports, it is clear that tendon transfers with or without contracture releases and humeral derotational osteotomies benefit patients with chronic BPBP with shoulder external rotation and abduction weakness and internal rotation contractures. The importance of the underlying glenohumeral anatomy in the decision-making process, however, cannot be overstated.

At present, we believe careful preoperative clinical examination and MRI or CT imaging of the affected shoulder are essential for any patient being considered for secondary shoulder reconstruction. In general, patients fall into one of three broad categories (Table 5). In the patients with a reduced glenohumeral joint and minimal or no glenohumeral deformity (e.g., type I or II), we currently advocate latissimus dorsi and teres major tendon transfers to the rotator cuff to improve shoulder abduction and internal rotation. Musculotendinous lengthenings of the pectoralis major and/or subscapularis may be needed to address concomitant internal rotation contractures in these situations.

Patients with subluxated but reducible glenohumeral joints and moderate glenoid dysplasia may not demonstrate adequate joint remodeling with extraarticular soft tissue procedures alone. In these situations, joint procedures combined with tendon transfers and musculotendinous lengthenings are currently recommended to relocate the humeral head within the developing glenoid fossa to establish joint stability and promote glenohumeral remodeling. These joint procedures include open or arthroscopic glenohumeral reduction and stabilization.

Finally, patients with chronic BPBP with severe joint deformity or irreducible posterior glenohumeral dislocations (e.g., type V or VI) are best managed with humeral derotational osteotomy to position the upper extremity in a more functional position. Humeral osteotomy represents a true salvage procedure, in which no remodeling of the glenohumeral articulation is expected. As previously stated, however, patients undergoing these salvage procedures demonstrate significant improvement in global shoulder function.\textsuperscript{58}

### Future Directions

Although the beneficial role of secondary shoulder reconstruction in improving upper extremity function...
in patients with chronic BPBP is clear, several questions remain unanswered. One of the most important issues to address is the capacity for glenohumeral joint remodeling following reconstructive shoulder procedures for chronic BPBP. Recently, a study of children with shoulder external rotation weakness and internal rotation contracture and preexisting mild to moderate glenohumeral dysplasia has been completed at our institution. All patients underwent extra-articular soft tissue rebalancing in the form of musculotendinous lengthenings in conjunction with latisimus dorsi and teres major tendon transfers to the rotator cuff. Pre- and postoperative clinical and radiographic data were obtained for all patients, with an average follow-up of over 4 years. Preliminary analysis of this cohort of patients demonstrates that although shoulder function improves significantly after these secondary reconstructive procedures, there is limited glenohumeral remodeling after restoration of more normal dynamic forces about the shoulder following extra-articular procedures.

These preliminary findings suggest that joint procedures must be performed to promote any possible glenohumeral remodeling in cases of more advanced shoulder dysplasia. Further investigation is needed to characterize the essential structures that must be addressed to ensure the best possible anatomic result. There have been dramatic advances in the role of arthroscopic techniques in all aspects of shoulder surgery, and the role for arthroscopic treatment of glenohumeral dysplasia and instability in chronic BPBP must be better defined. Finally, although attention has been previously focused on extra-articular soft tissue and humeral procedures to address glenohumeral dysplasia and instability, the role of corrective glenoid osteotomy must be addressed.

CONCLUSIONS

Although many advances in our understanding of the natural history and surgical treatment of BPBP have been made, clearly several issues remain unresolved. We believe that a multicenter prospective study of BPBP patients will provide important insights into these outstanding clinical questions. With the continued collaborative efforts of surgeons and clinical investigators worldwide, it is our hope that many of these remaining questions may be answered, ultimately resulting in improved care for patients with BPBP.

REFERENCES

27. Al-Qattan MM. The outcome of Erb’s palsy when the decision to operate is made at 4 months of age. Plast Reconstr Surg 2000;106:1461–1465
66. Severin E. Contribution to the knowledge of congenital dislocation of the hip joint. Late results of closed reduction and arthographic studies of recent cases. Acta Chir Scand 1941;63(suppl)