Surgical Strategy for Improving Forearm and Hand Function in Late Obstetric Brachial Plexus Palsy

David Chwei-Chin Chuang, M.D., Hae-Shya Ma, Loren J. Borud, and Hung-Chi Chen, M.D.

Taipei, Taiwan, and Boston, Mass.

For the purpose of treatment, obstetric brachial plexus palsy can be subdivided into two distinct phases: initial obstetric brachial plexus palsy, and late obstetric brachial plexus palsy. In the latter, nerve surgery is no longer practical, and treatment often requires palliative surgery to improve function of the shoulder, elbow, forearm, and hand. Late obstetric brachial plexus palsy in the forearm and hand includes weakness or absence of wrist or metacarpophalangeal or interphalangeal joint extension; weakness or absence of finger flexion; forearm supination, or less commonly pronation contracture; ulnar deviation of the wrist; dislocation of the radial or ulnar head; thumb instability; or sensory disturbance of the hand. Palliative reconstruction for these forearm and hand manifestations is more difficult than for the shoulder or elbow because of the lack of powerful regional muscles for transfer. This report reviews the authors’ experience performing more than 100 surgical procedures in 54 patients over a 9-year period (between 1988 and 1997) with a minimum of 2 years’ follow-up. Surgical treatment is highly individualized, but the optimal age for forearm and hand reconstruction is usually later than for shoulder and elbow reconstruction because of the requirement for a preoperative exercise program. Multiple procedures for forearm and hand function were often performed on any given patient. Frequently, these were done simultaneously with reconstructive procedures for improving shoulder and/or elbow function. Traditional tendon transfer techniques do not provide satisfactory reconstruction for those deformities. Many of the authors’ patients required more complex techniques such as nerve transfer and functioning free-muscle transplantation to augment traditional techniques of tendon and/or bone management. Sensory disturbance of the forearm and hand in late obstetric brachial plexus palsy seems a minor problem and further sensory reconstruction is unnecessary. (Plast. Reconstr. Surg. 109: 1934, 2002.)

Poor function of the forearm and hand occur in a subset of patients with obstetric brachial plexus palsy. Clarke and Curtis1 have classified obstetric brachial plexus palsy into four categories on the basis of levels of spinal nerve or root involvement: (1) Erb palsy, or upper plexus palsy: a palsy involving C5, C6, or the upper trunk, and sometimes C7, resulting primarily in deformities of the shoulder and elbow; (2) intermediate plexus palsy involving C7 and sometimes C8 and T1; (3) Klumpke palsy, involving C8 and T1; and (4) total plexus palsy, involving C5 to C8 and sometimes T1. The latter three groups are associated with functional deficits of the forearm and hand. Most patients with forearm and hand problems have total plexus injury, because intermediate plexus palsy causing deformities is usually easy to reconstruct, and Klumpke palsy appears to be quite rare. In the study by Clarke and Curtis of 3508 cases of obstetric brachial plexus palsy, only 20 (0.6 percent) were Klumpke palsy. Similarly, Gilbert et al.2 found two predominant groups in their series of 1000 cases of obstetric brachial plexus palsy: Erb palsy and complete paralysis. Klumpke palsy was not observed in their large experience.

Some patients who present for treatment in infancy (called initial obstetric brachial plexus palsy) require early nerve reconstruction. However, patients who present later in life with sequelae (called sequelae obstetric brachial plexus palsy or late obstetric brachial plexus palsy) are not suitable for nerve reconstruction, and instead require palliative procedures to improve function. We have previously described a scoring system for functional evaluation of these cases of late obstetric brachial...
plexus palsy. All of our previously described patients had at least some function at the C8 or T1 level, resulting from incomplete avulsion of C8 and T1, or from aberrant reinnervation by C5 or C6 (i.e., C5 or C6 regenerated fibers grow into the avulsed stump of C8 and T1). Poor forearm and hand function present especially difficult problems, and are less successfully treated than the shoulder or elbow. Few articles in the literature have discussed in detail the treatment of forearm and hand function in late obstetric brachial plexus palsy.

In this article, we present a retrospective review of children with late obstetric brachial plexus palsy who underwent palliative surgery for improvement of forearm and hand function.

**Patients and Methods**

More than 100 operative procedures designed to improve forearm and hand function in patients with late obstetric brachial plexus palsy were performed in 54 patients between 1988 and 1997, with a minimum of 2 years of follow-up in all patients. No patients had prior nerve reconstruction. There were 35 male and 19 female patients. The right limb was affected in 36 cases, and the left limb was affected in 18 cases. The mean age at first procedure for hand or forearm function was 10 years (range, 3.5 to 21 years). Several had undergone procedures for shoulder or elbow reconstruction previously, or simultaneously with forearm and hand reconstruction.

The most common forearm and hand problems in these patients with late obstetric brachial plexus palsy (Table I) were weakness or absence of wrist, metacarpophalangeal joint, or interphalangeal joint extension involving whole or part of four fingers; thumb instability caused by lack of abductor pollicis brevis, abductor pollicis longus and extensor pollicis brevis, or extensor pollicis longus; forearm supination contracture; and weak or absent finger flexion (whole or part fingers). Less common problems encountered included forearm pronation contracture, dislocation of the radial or ulnar head, and sensory disturbance involving the ulnar two digits and the ulnar side of the palm and forearm.

**Table I**

Sequelae Deformity of the Forearm and Hand in Obstetric Brachial Plexus Palsy in This Series*  

<table>
<thead>
<tr>
<th>Deformity</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Weak or absent MPJ extension (EDC)</td>
<td>32</td>
</tr>
<tr>
<td>2. Weak or absent wrist extension</td>
<td>8</td>
</tr>
<tr>
<td>3. Weak or absent IPJ extension (whole or part fingers)</td>
<td>7</td>
</tr>
<tr>
<td>4. Forearm supination contracture</td>
<td>22</td>
</tr>
<tr>
<td>5. Thumb instability</td>
<td>20</td>
</tr>
<tr>
<td>6. Ulnar deviation of the wrist</td>
<td>10</td>
</tr>
<tr>
<td>7. Weak or absent finger flexion (whole or part fingers)</td>
<td>8</td>
</tr>
<tr>
<td>8. Forearm pronation contracture</td>
<td>3</td>
</tr>
<tr>
<td>9. Dislocation of proximal radial head</td>
<td>3</td>
</tr>
<tr>
<td>10. Dislocation of distal ulnar head</td>
<td>2</td>
</tr>
</tbody>
</table>

* One patient may have two or more sequelae deformities involving the forearm and hand. MPJ, metacarpophalangeal joint; EDC, extensor digitorum communis; IPJ, interphalangeal joint.

Surgical procedures performed for improving forearm and hand function in these patients are summarized in Table II. The main procedures included flexor tendon transfer for wrist, metacarpophalangeal, or interphalangeal extension (26 of 54 patients [48 percent]); rerouting of muscle to augment forearm pronation in cases of supination contracture (20 patients [37 percent]); and rerouting of tendon to augment radial deviation of the wrist in cases of excessive ulnar deviation (10 patients [19 percent]). Functioning free-muscle transplantation was applied for augmentation of extensor digitorum communis and extensor pollicis longus function (six patients), and for augmentation of flexor digitorum profundus (three patients), with a total incidence of about 17 percent (nine of 54 patients). Although thumb instability was quite often encountered, opportunities for opponensplasty were few (only six patients) because of the lack of powerful or sufficient tendon for transfer. The others, which were less often applied, included the following: using wrist extensor tendon transfer for finger flexion, for metacarpophalangeal extension, or for lumbricales replacement; metacarpophalangeal flexion using the A1 lasso procedure; tenodesis of wrist or finger extension; arthrodesis of the wrist or thumb; and reduction of dislocation of the radial or ulnar head. Multiple procedures for forearm and hand function were often performed on any given patient. Frequently, these were carried out simultaneously with reconstructive procedures for improving shoulder and/or elbow function.

**Surgical Techniques**

Augmentation of wrist and metacarpophalangeal extension. Powerful wrist or finger flexors and/or pronator teres (with C8 and T1 intact) can be useful donor muscles to augment finger or thumb extension. Most late obstetric bra-
Brachial plexus palsy patients have some useful wrist extension but lack metacarpophalangeal joint extension because of poor extensor digitorum communis, extensor pollicis longus, or abductor pollicis longus function (Fig. 2, left). In our series, 26 of 54 patients (48 percent) underwent flexor-to-extensor transfer. Traditional techniques of tendon transfer pioneered for radial nerve palsy are applicable. Careful preoperative examination of the donor volar muscle is essential for success of the procedure. A minimum M4 muscle strength (i.e., sustained resistance to an examiner’s one-finger resistance) is required for suitable donor muscle. In selecting the route of transfer, preoperative wrist deviation should be considered. For example, in ulnar deviation of the wrist with weak wrist extension, the flexor carpi ulnaris (instead of the pronator teres) to extensor carpi radialis longus is planned for reconstruction to augment wrist extension. The extensor carpi radialis longus should be cut at the tenomuscular junction, and then the distal tendon portion passing under and circling the radius bone is sutured to the transferred flexor carpi ulnaris at the forearm back under tension for correcting both wrist drop and wrist ulnar deviation.

In 17 patients (31 percent), the forearm flexors were weak (C8 and T1 were injured incompletely). There are five methods used for augmenting extensor digitorum communis function to correct metacarpophalangeal joint drop.

1. Musculocutaneous nerve transfer (Fig. 3) (five patients): The intact musculocutaneous nerve is isolated between the biceps and coracobrachialis muscles in the upper arm and axilla and divided distally. The distal stump is reinnervated by approximating it to the deep central branch of three intercostal nerves (usually T3 to T5). The proximal nerve stump is then used as a nerve neurotizer to innervate a free gracilis myo-
FIG. 1. (Left) A 6-year-old boy with late obstetric brachial plexus palsy with deficits of finger metacarpophalangeal joint extension and only 30 degrees of forearm pronation of the right hand. (Right) Four years after flexor carpi radialis–to–extensor digitorum communis transfer and rerouting of biceps for forearm pronation, he achieved improved finger extension and 90 degrees of forearm pronation.

FIG. 2. (Left) A 6-year-old boy with late obstetric brachial plexus palsy with deficits of finger metacarpophalangeal joint extension and only 30 degrees of forearm pronation of the right hand. (Right) Four years after flexor carpi radialis–to–extensor digitorum communis transfer and rerouting of biceps for forearm pronation, he achieved improved finger extension and 90 degrees of forearm pronation.
cutaneous flap for extensor digitorum communis replacement. The proximal gracilis is fixed to the upper third of the humerus in the space between the deltoid insertion posteriorly and the biceps muscle anteriorly. The distal gracilis tendon was approximated to the extensor digitorum communis tendon by means of an end-to-side weave. Postoperative splinting maintains elbow flexion and wrist and finger extension for a 6-week period. Electric stimulation of the transferred muscle can begin as early as 3 weeks after surgery.

2. Extensor carpi radialis longus–to–extensor digitorum communis transfer (one patient): In the pure but rare instance of Klumpke palsy, finger flexion and metacarpophalangeal and interphalangeal extension are frequently absent or weak. Usually, only the flexor carpi radialis and extensor carpi radialis longus are preserved. Extensor carpi radialis longus–to–extensor digitorum communis transfer, using the concept of one muscle for two functions, can be quite effective. The four extensor digitorum communis tendons are moved superficially to the extensor retinaculum and sutured together. The extensor carpi radialis longus is detached from its insertion and sutured to the conjoined extensor digitorum communis in an end-to-side weaving fashion. Postoperative splinting for 6 weeks is required.

3. Plication (six patients) or tenodesis (one patient) of extensor digitorum communis and/or abductor pollicis longus: In patients with no regional tendon donors, this can be an alternative procedure. In our six patients treated with this method, segmental shortening with resection and tendon repair is preferred over side-to-side plication, which is prone to loosening. One patient received tenodesis of extensor digitorum communis and abductor pollicis longus, in which tendons were inserted into the radius bone under tension.

4. Wrist fusion with augmentation of metacarpophalangeal extension (three patients): Three older late obstetric brachial plexus palsy patients (over the age of 15) were treated with wrist arthrodesis. This was combined with flexor carpi radialis–to–extensor digitorum communis transfer (two patients) or plication of extensor digitorum communis (one patient).

5. The method of Doi et al. (one patient): This method includes functioning free-muscle transplantation for extensor digitorum communis replacement, powered by the spinal accessory nerve (one patient).

Correction of Forearm Supination Contracture

Forearm supination contracture (37 percent) varies in severity in late obstetric brachial plexus palsy. In mild cases in which the interosseous membrane is not yet fixed, rerouting of the biceps as described by Zancolli is sufficient [16 of our patients (30 percent)] (Figs. 1 and 2 and 6 through 8). However, when severe supination contracture of 90 degrees or more associated with a fixed interosseous membrane is present, additional procedures are required. In four patients in our series, in addition to the classic biceps rerouting, detaching the supinator insertion over the
radius and rerouting it (passing under the radius bone) to act as a pronator, extensive separation of the interosseous membrane including the distal radioulnar joint, and rotational osteotomy of the radius or humerus are required simultaneously to correct severe supination contracture.

Correction of Ulnar Deviation of the Wrist

Ulnar deviation of the wrist in commonly seen in late obstetric brachial plexus palsy patients because of muscle imbalance, usually related to excessive tension of the flexor carpi ulnaris, extensor carpi ulnaris, or extensor digitorum communis. In our series, this was
FIG. 5. (Left) A 10-year-old boy with left late obstetric brachial plexus palsy had inability to flex the fingers and sensation disturbance over the ulnar aspect of the forearm and hand. There was no regional tendon available for transfer. (Center and right) Two and a half years after right contralateral C7 transfer with two sural nerve grafts, and a gracilis functioning free-muscle transplantation for flexor digitorum profundus replacement in a two-stage procedure. He achieved finger flexion and can hold an object with the help of an interphalangeal joint extension dynamic splint.

FIG. 6. (Left) A 4-year-old boy with late obstetric brachial plexus palsy had severe intrinsic palsy of the right hand with deficits of the proximal interphalangeal extension and a supination contracture of the forearm. (Right) One year after central advancement of the extensor mechanism distally with insertion into the middle phalanx, plication of the extensor digitorum communis, and rerouting of the biceps for forearm pronation, improved hand function was achieved.
seen in 10 patients (19 percent). Several procedures were used to address this problem, designed mostly to improve cosmesis. Release of the wrist ulnar skin contracture by Z-plasty plus flexor carpi ulnaris transfer to extensor carpi radialis longus (two patients), or extensor carpi ulnaris transfer to extensor carpi radialis longus (three patients), or extensor carpi ulnaris to abductor pollicis longus (two patients) was performed. Rerouting of the extensor carpi radialis longus or abductor pollicis longus by division of the tendon at the tenomuscular junction and passing the distal end around the radial bone and suturing it to the transferred tendon was performed.

Correction of Interphalangeal Joint Extension

Intrinsic weakness in Klumpke palsy or total plexus palsy is a frustrating challenge for the reconstructive surgeon. Several techniques were used:

1. Boutonnière correction: In patients with the ability to extend the metacarpophalangeal joint but an inability to extend the proximal interphalangeal joint, loosening

Fig. 7. (Above) A 13-year-old boy with late obstetric brachial plexus palsy had severe supination contracture (50 degrees) of the left forearm, volar dislocation of the proximal radial head, volar dislocation of the distal ulnar head, and sensory disturbance of the ulnar half of the hand. (Below) After rerouting the biceps for pronation, pulling back and fixing the radial head in place with one tail of the distal biceps tendon, and performing the Sauve-Kapandji procedure to correct distal ulnar head dislocation, he has significant improvement of his forearm pronation (from −30 degrees to 70 degrees), with a stable radial head and ulnar head in place.
rather than rupture of the central attachment of the extensor mechanism to the middle phalanx is usually the main problem. In those patients whose extensor digitorum communis was functional, distal advancement of the central extensor mechanism to the base of the middle phalanx was performed (five patients) (Fig. 6). The technique is similar to that previously described by Urbaniak and Hayes

2. Lumbricales reconstruction by flexor digitorum superficialis transfer (one patient), or by extensor carpi radialis longus transfer with tendon graft (one patient), indicated in claw fingers with weak interphalangeal extension while the metacarpophalangeal joint is passively flexed.

3. Use of interphalangeal-extension dynamic splint (three patients), as seen in Figure 5.

**Augmentation of Finger Flexion**

In Klumpke palsy or total plexus palsy, weakness or partial absence of finger flexion is uncommonly noted. When powerful wrist extensors are available, traditional extensor-to-flexor transfer is used as in treatment of high median and/or ulnar nerve palsy. However, this was possible in only three patients in our series because of the high incidence of wrist extensor weakness. In cases where wrist extensor donors are unavailable, functioning free-muscle transplantation for flexor digitorum profundus replacement using intercostal donor nerves (two patients) as a donor nerve is preferred. We had one patient, who previously had intercostal nerve transfer to innervate a free-muscle graft for elbow flexion before, receive a contralateral C7 transfer (Fig. 5) followed by functioning free-muscle transplantation in a two-stage procedure for finger flexion. The contralateral C7 was elongated with two sural nerve grafts, which were embedded into the biceps muscle. One year later, a gracilis free-muscle transplantation for flexor digitorum profundus replacement in the second stage was performed.

**Opponensplasty**

Forearm flexor transfer (four patients) was more often used than extensor transfer (two patients) for thumb opponensplasty in our group of patients.

**Correction of Forearm Pronation Contracture**

This problem was much less common than the supination deformity, and was present in only three of our patients. It is only performed

---

**Fig. 8.** (Left) A 4-year-old girl with left late obstetric brachial plexus palsy had volar dislocation of the proximal radial head with supination contracture. (Right) Two years after reduction of the radial head with one biceps sling, there is no more volar dislocation of the radial head, and pronation is also improved.
when the patient requests acquisition of some supination for hand-to-mouth movement. Detaching the pronator teres over the radius and rerouting it (passing under the radius bone) was performed, making the pronator teres act as a supinator.

**Correction of Dislocation of the Proximal Radial Head**

In volar dislocation of the proximal radial head, a long sling including part of the muscle was elevated from the distal biceps tendon (two patients), based on the distal tendinous insertion (radial tuberosity), and pulled back. After reduction of the dislocated radial head while the forearm was pronated, two temporary Kirschner pins were used to fix the proximal radius to the ulna bone. The sling was pulled under tension and fixed to the posterior distal triceps tendon. The temporary Kirschner pins were left for a 4-week period of immobilization (Figs. 7 and 8).

**Correction of Dislocation of the Distal Ulnar Head**

In one patient with chronic palmar dislocation of the distal ulnar head (Fig. 7, above, right), forearm rotation was readily restored after distal radioulnar joint arthrodesis by resecting a segment of the ulna just proximal to the fusion mass (Sauve-Kapandji procedure). For complete dislocation of the radius and ulna in the elbow, no surgical treatment is advocated. Intervention in cases of complete dislocation of both bones usually leads to greater elbow stiffness.

**Results**

**Augmentation of Wrist and Finger Metacarpophalangeal Joint Extension**

The powerful forearm and wrist flexors are very useful for reconstruction, and good results can be expected from their transfer (Figs. 1 and 2). Success of extension is defined when M3 muscle strength is achieved.

Success of finger metacarpophalangeal extension is achieved when the metacarpophalangeal can still be extended while the wrist is in extension. The success rate of the flexor carpi radialis–to–extensor digitorum communis transfer [11 of 12 (92 percent)] was higher than that of flexor carpi ulnaris transfer [five of eight (62.5 percent)]. The palmaris longus–to–extensor pollicis longus transfer for thumb extension was successful in 70 percent of patients, and the pronator teres–to–extensor carpi radialis brevis transfer for wrist extension was successful in 60 percent of cases. The flexor digitorum superficialis (usually the ring finger) transfer for digit or thumb extension was much less reliable, as expected.

When no powerful donors for transfer were available, plication of the extensor tendon (extensor carpi radialis, abductor pollicis longus, or extensor digitorum communis) was performed to augment extension as described above. This was successful in only 50 percent of the patients (three of six), and only worked well temporarily, with ultimate loosening. Tenodesis of the extensor digitorum communis and/or extensor pollicis longus to the radius in one patient led to a wrist and finger extension contracture progressively with growth, which ultimately required release.

Five patients had gracilis free flaps innervated by the divided proximal stump of the musculocutaneous nerve (Fig. 3). All five achieved improved extensor digitorum communis function (M3 muscle strength), from inability to approach the targets to the ability to extend the finger to approach the target (Fig. 4, above, right, and below, left). Use of intercostal nerve transfer to the divided distal musculocutaneous nerve was fortunately successful in restoring elbow flexion, similar to the preoperative status in all five of these patients (Fig. 4, below, right).

**Correcting Forearm Supination Contracture**

Rerouting of the biceps for forearm pronation (Zancolli procedure) was very useful, increasing forearm pronation range of motion from an average of 24.5 degrees (range, 0 to 80 degrees) up to an average of 77.5 degrees (range, 0 to 90 degrees) (Figs. 1, 2, and 6). If the supination deformity is severe (>90 degrees), the biceps rerouting is insufficient when used alone. In these cases, the procedure should be used in addition to detachment of the supinator from the radius, separation of the interosseous membrane, release of the distal radioulnar joint, and rotational osteotomy of the radius or humerus (Fig. 7).

**Correcting Wrist Ulnar Deviation**

Results from tendon transfer to correct wrist ulnar deviation varied, depending on the strength of the transferred tendon, the age of the patient, and the recipient tendon used. A tendon that is too weak (e.g., extensor carpi
ulnaris) or a patient who is too old (>10 years old) are disadvantageous factors for the correction. For the recipient tendon, the abductor pollicis longus seems more effective than the extensor carpi radialis longus for achieving more radial deviation. Release of ulnar wrist tightness and creation of a Z-plasty on the skin are usually necessary.

**Restoration of Interphalangeal Joint Extension**

Distal advancement of the central extensor mechanism was effective in improving interphalangeal extension in all five cases (Fig. 6). Two patients, one with lumbrical reconstruction with extensor carpi radialis longus and tendon graft and another with fourth flexor digitorum superficialis, had improvement in interphalangeal joint extension. If there is no powerful tendon for restoration of interphalangeal joint extension, using an interphalangeal joint extension dynamic splint is advised (Fig. 5).

**Augmentation of Finger Flexion**

Traditional extensor-to-flexor tendon transfer techniques, such as transfer of the brachioradialis, extensor carpi radialis longus, or extensor carpi ulnaris for finger flexion, were usually unreliable in late obstetric brachial plexus palsy because of insufficient strength. This is usually a significant challenge to the reconstructive surgeon. More complex procedures such as nerve transfer and functioning free-muscle transplantation are needed. Two patients, in whom intercostal nerve transfer to innervate the free gracilis muscle transplantation was used, achieved M3 finger flexion muscle strength. One patient (Fig. 5), who had intercostal nerve transfer to innervate a free muscle for elbow flexion previously, received contralateral C7 elongation with free nerve grafts followed by free gracilis muscle transplantation for flexor digitorum profundus replacement and achieved M3 to M4 finger flexion strength. However, he still needs dynamic splinting for finger interphalangeal joint extension.

**Opponensplasty**

Similar to the finger flexion reconstruction, using wrist flexor transfer (e.g., part of flexor carpi ulnaris with tendon graft) was more reliable than using wrist extensor tendon transfer for opponensplasty. Splint support of the thumb for opposition was sometimes required.

**Correcting Forearm Pronation Contracture**

Rerouting the pronator teres for supination was performed in three patients, with disappointing results. Fortunately, few patients requested such correction.

**Correction of the Dislocated Radial Head**

Two cases of volar dislocation of the proximal radial head were corrected by pulling part of the distal biceps tendon sling back and fixing it (annuloplasty), and all achieved a stable position (Figs. 7 and 8).

**DISCUSSION**

Leffert presented a good review regarding the history, pathogenesis, clinical presentation, musculoskeletal changes, and prognosis of obstetric brachial plexus palsy, although he misused the term “congenital brachial palsy.” Despite significant progress in understanding this disorder, significant controversy about the surgical treatment remains. As Leffert points out, treatment of the paralytic hand resulting from obstetric brachial plexus palsy must be highly individualized. Hentz concludes that palliative treatment of the sequelae of birth palsies is difficult, and the results are rarely totally satisfactory.

Questions related to the management of forearm and hand deformities in late obstetric brachial plexus palsy include, through our experience, the following: What is the optimum age for palliative reconstruction of the forearm and hand? In triple deformities of the shoulder, elbow, and hand, what is the first reconstructive priority? Are traditional techniques of tendon transfer and bone management sufficient for these deformities? Is there any difference in results after reconstruction in younger versus older late obstetric brachial plexus palsy patients? Is it necessary to restore sensory disturbance?

Most authors argue that the best age for reconstruction of the late obstetric brachial plexus palsy deformity is at age 4 or older because of the lack of severe contracture, the ability of the patient to cooperate in rehabilitation, and easier clinical evaluation. Preoperative evaluation of each donor muscle is critically important for a successful transfer. Children should be placed on a preoperative exercise program to strengthen donor muscles. Patients or patients’ parents must be enlisted to manage and encourage the preoperative preparation. In addition, shoulder and elbow muscles always recover earlier and more completely than forearm and hand function in late obstetric brachial plexus palsy. The muscles in the forearm or hand usually demonstrate paralysis (complete palsy with weak motor strength), paralysis (complete palsy with atro-
phy), or sometimes contracture because of muscle imbalance or aberrant reinnervation. Patients with birth palsy, most often Erb palsy with rupture of upper and/or middle trunk, will lead to misdirection of regenerated axons (aberrant reinnervation) and cause significant deformities of the shoulder and elbow. However, the phenomenon of aberrant reinnervation is less significant in the forearm and hand because of less ruptured cases in the lower trunk, but there is more avulsion (Incomplete or complete) of the C8 and T1 roots. Tendon transfer in the forearm and hand cannot be based solely on contracture release and transfer to augment the paretic muscles as seen in the shoulder and elbow. Therefore, although the treatment is highly individualized, shoulder and elbow reconstruction should usually be performed before addressing the forearm and hand. There is usually a lack of powerful muscles in the forearm and hand for transfer in late obstetric brachial plexus palsy. Continuous physical therapy with a rehabilitation program to optimize the residual muscle strength in the forearm and hand is vital for later management. From our experience, the optimum age for forearm and hand reconstruction is during school-age years, 6 to 13 years old; whereas the optimum age for shoulder and elbow reconstruction is during the preschool years, 4 to 6 years old.

The reconstructive priority for the shoulder, elbow, and forearm and hand deformities is highly individualized. However, most of time forearm and hand deformities in late obstetric brachial plexus palsy are the last to be reconstructed unless there exist powerful regional muscles for transfer.

Of the traditional techniques, one that should be condemned is tenodesis. Tenodesis of the extensor carpi radialis, extensor digitorum communis, or extensor pollicis longus to the radius has proven a poor procedure in children with birth palsy, most often Erb palsy with rupture of upper and/or middle trunk. Although it is possible to perform arthrodesis of the wrist joint in growing children without risking injury to the physis, pan-wrist (radioocarpal) arthrodesis is preferred, but is only indicated in older children over the age of 15, or when radiography reveals no further epiphyseal growth in the distal radius or ulna.

Flexor carpi radialis–to–extensor digitorum communis transfer is better than flexor carpi ulnaris–to–extensor digitorum communis transfer. Fourth flexor digitorum superficialis transfer for opponensplasty or for digital extension is much less reliable, as expected. It seems that radial side functional muscles (such as flexor carpi radialis, extensor carpi radialis longus, innervated more by the upper plexus) are stronger than ulnar side muscles in late obstetric brachial plexus palsy, and are more reliable for transfer. The powerful wrist and finger flexors seen on examination prove much more reliable as donors than do extensors. A higher failure rate was encountered when using wrist extensors for opponensplasty or for flexor digitorum profundus reconstruction.

According to our results, traditional tendon transfer techniques, when used alone, do not provide satisfactory reconstruction for deformities of the forearm and hand in late obstetric brachial plexus palsy. Many of our patients required complex techniques such as functioning free-muscle transplantation to augment traditional techniques. Although we had five patients successfully reconstructed with free-muscle transplantation for extensor digitorum communis replacement by using musculocutaneous nerve as a donor nerve, using a normal musculocutaneous nerve as a neurotizer is indeed a high-risk procedure. It required not only that the transferred muscle survive and function, but also that elbow flexion be salvaged by intercostal nerve transfer to the distal musculocutaneous nerve. Patients will be very reluctant to sacrifice the musculocutaneous nerve. Since Doi published his technique of using the spinal accessory nerve to innervate a free muscle for elbow flexion and extensor digitorum communis function and the intercostal nerve to innervate another free muscle for elbow and finger flexion in 1996, we have already abandoned our technique and applied Doi’s technique for extensor digitorum communis replacement because of less risk. Using normal musculocutaneous nerve as a neurotizer, however, can now be seen as one option for difficult hand reconstruction. The other alternative for extensor digitorum communis reconstruction is possibly using dynamic splinting, which is inconvenient. Contralateral C7 transfer with long sural nerve graft embedded into the biceps muscle followed by a func-
tioning free-muscle transplantation as a two-stage procedure is another effective option for extensor digitorum communis reconstruction.

Sensory disturbance of the forearm and hand in late obstetric brachial plexus palsy patients seems a minor problem, and further sensory reconstruction is unnecessary. Most pediatric patients become accustomed to the paralyzed hand, and do not incur any injury from hypesthesia of the hand.

In summary, sequelae deformities of the forearm and hand in late obstetric brachial plexus palsy have less aberrant reinnervation than those of the shoulder or elbow. Palliative reconstruction of these forearm and hand deformities is more difficult than for the shoulder or elbow because the regional muscles are more or less paretic and lack powerful muscles for transfer. Traditional tendon transfer techniques are insufficient. Many patients require more complex techniques to augment traditional techniques, such as functioning free-muscle transplantation, neurotized by extraplexual or contralateral nerve transfer.

David Chiwei-Chin Chuang, M.D.
Department of Plastic and Reconstructive Surgery
Chang Gung Memorial Hospital
199 Tung Hwa North Road
Taipei, Taiwan 105
dear david@pchome.com.tw

REFERENCES

23. Brockman, R., and Weiland, A. J. Small joint arthrode-