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Result of modified Outerbridge-Kashiwagi procedure for elbow flexion contractures in brachial plexus birth injury

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Abstract

We report the results of ten consecutive patients who had correction of an elbow flexion contracture of greater than 30° in brachial plexus birth injury using a modified Outerbridge-Kashiwagi procedure. All patients had minimum 23-month follow-up. Pre- and post-operative elbow range of motion and DASH scores were recorded in all patients. The operative technique for the procedure and post-operative course is discussed. Surgery was supplemented by botulinum toxin injection into the biceps brachii muscle in most cases. The average age at surgery was 14 years 10 months. The initial plexus lesion was global in eight patients and upper in two. Pre-operative flexion contractures averaged 51° (range 35 to 60) and post-operative averaged 21° (range 15 to 30). Of these patients, one had no change in active flexion, four had loss of active flexion, and five had gain of active flexion. All ten patients were satisfied with their results and stated that they would recommend the procedure to other patients.

Level of evidence: IV

Keywords

Brachial plexus birth injury, obstetric brachial plexus injury, elbow flexion contracture

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Introduction

Brachial plexus birth injury (BPBI) often leads to elbow flexion contractures. Many of these are minor and require attention in therapy along with splinting or casting to correct or prevent them from worsening. Occasionally, these elbow flexion contractures will worsen with growth and development of the child. There are many theories as to what causes these contractures, including muscle imbalance, impaired muscle growth of the elbow flexor muscles, and co-contraction of agonist/antagonist muscles. It has been postulated that the muscle imbalance between stronger elbow flexors and forearm supinators compared with weaker or absent elbow extensors and forearm pronators may be a cause of elbow flexion contractures (Waters, 2005). Overactivity of the long head of the biceps brachii muscle on electromyography has been found, compared with the contralateral unaffected limb in BPBI patients (Sheffler et al., 2012b). Another hypothesis is that innervation of the elbow flexors returns before that of the extensors resulting in flexor dominance (Ballinger and Hoffer, 1994).

Conservative treatment has been effective for milder contractures. Long arm elbow extension orthotics (Haerle and Gilbert, 2004; Price and Grossman, 1995) and static progressive hinged elbow splints (Davila and Johnston-Jones, 2006) have been used

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for flexion contractures less than 30°. Serial casting has been useful for more severe elbow flexion contractures, to reduce the contracture to 30° before transitioning to splints (Ho et al., 2010; Zander and Healey, 1992). However, the success of serial casting and splinting are dependent on compliance with long-term night splinting and is effective only in motivated patients. Recurrence of the contracture is inevitable if splinting is discontinued (Ho et al., 2010). In one large series, the magnitude of the contracture decreased by 31% when casting was performed, but increased by 4.4% per year afterwards (Sheffler et al., 2012a).

Surgical solutions for the problem of elbow flexion contractures in BPBI have been limited. Gradual distraction using a unilateral hinged elbow external fixator has been used successfully (Vekris et al., 2010). Another described surgical technique is anterior release of the elbow, for flexion contractures greater than 35° (Garcia-Lopez et al., 2012). This includes fractional lengthening of the anterior brachialis muscle and tenotomies of the distal biceps tendon, with division of the lacertus fibrosus and joint capsule, if needed. In a series of ten patients, there was a mean gain in extension of 28°. However, these techniques do not address the underlying bony deformity in the elbow.

With prolonged loss of motion in the elbow, first the soft tissues become contracted, then with growth the bones making up the elbow joint become permanently deformed. This deformation includes bony overgrowth, which results in elongation, widening, and flattening of the olecranon. Figure 1(a) is a MRI illustrating an overgrown olecranon too wide to fit into a shallow fossa. The fossa becomes shallow and too small to accommodate the overgrown olecranon, thus creating a bony block to full extension (Figure 1(b)).

Here we describe and review our experience with a modified Outerbridge-Kashiwagi (O-K) procedure that can permanently and significantly improve the elbow contracture that impairs function and alter appearance for adolescents left with significant elbow flexion contractures, defined as those greater than 30°. The operation narrows and shortens the olecranon, and deepens and contours the olecranon fossa to more closely approximate the normal human anatomy. This is often combined with a soft tissue release in the anterior elbow. Isolated anterior soft tissue release was initially performed, but this yielded only limited results, with 10° to 15° improvement in the flexion contracture. All patients had previous serial splinting and/or casting but had recurrence of the elbow flexion contracture and refused further serial casting.

Patients and methods

Patients

Ten consecutive adolescent patients with BPBI and elbow flexion contractures greater than 30° were included in the study. There were five males and five females. The average age at surgery was 14 years 10 months, ranging from 12 years 3 months to 18 years of age. The initial plexus lesion was global in eight patients and upper plexus (C5,6) palsy in two. All patients had at least MRC grade 4/5 strength in their biceps and triceps. Each had pre- and post-operative active elbow flexion and extension measured using a goniometer. All elbows had pre-operative radiographs demonstrating a reduced radial head. All patients had pre- and post-operative DASH scores recorded, the latter at their last follow-up appointment. At final follow-up, each patient answered a brief questionnaire consisting of whether they were satisfied with their result and whether they would recommend it to another patient. This questionnaire included three questions: (1) What type of benefit were you seeing from the surgery?; (2) What benefit/improvement did you see from the surgery?; (3) Would you recommend the surgery to someone else?

Surgical technique

A roll is placed under the affected limb's scapula and the upper extremity is prepped to the shoulder. The first stage of the procedure is performed with the arm adducted across the torso to expose the posterior distal arm. No tourniquet is used. A 7 cm longitudinal incision is made over the distal posterior arm, utilizing a triceps splitting approach. The posterior elbow joint is exposed and the triceps is split in the midline and partially peeled off the olecranon with the cautery knife. A chevron cut is made in the olecranon to shorten by a centimeter and narrow the widened, elongated olecranon. A freer elevator is slipped under the olecranon to protect the trochlear groove. Approximately 25% of the articular surface of the olecranon is excised. Figure 2 illustrates the areas of the olecranon that are removed. Bone wax is placed over the denuded surfaces of the 'new' olecranon and then the elbow is fully extended.

If the 'new' olecranon abuts the dysplastic olecranon fossa, then a distal humeral ostectomy is performed using either 12 mm Moreland Trephine (Figure 3(a)) or a trephine for the anterior cruciate ligament tibial tunnel. The hole is centred on the tip of the new olecranon with the elbow in full extension; this point is marked, the elbow flexed, and the

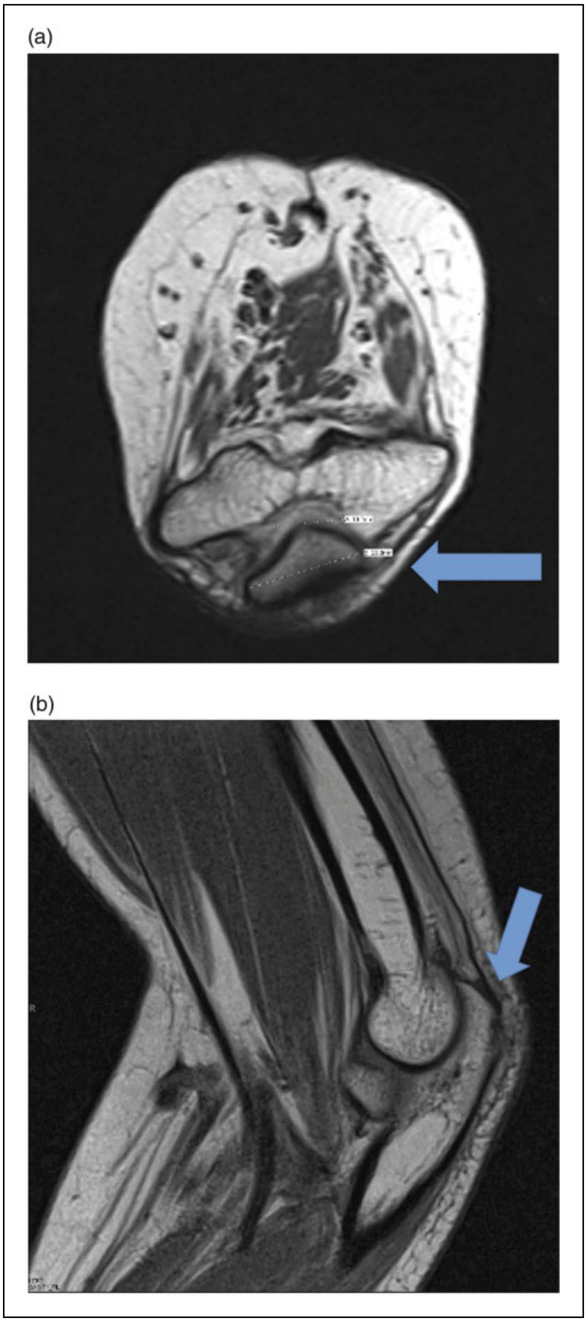

Figure 1. MRI of the elbow illustrating bony abnormalities in patients with BPBI. (a) Axial view shows overgrown olecranon too wide to fit into a shallow olecranon fossa of the humerus. (b) Sagittal view shows how the olecranon fossa of the humerus becomes shallow and too small to accommodate the overgrown olecranon, resulting in a bony block to full extension.

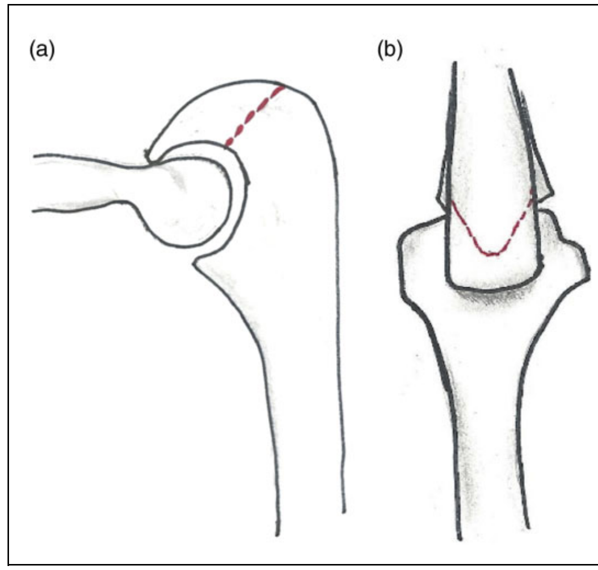

Figure 2. Drawing showing olecranon osteotomy in (a) sagittal plane; and (b) coronal plane.

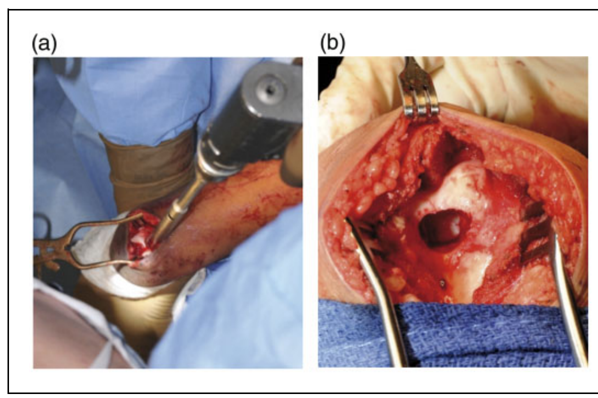

Figure 3. (a) Distal humeral ostectomy with Moreland trephine; and (b) after completion.

ostectomy completed (Figure 3(b)). A round burr is used to extend the distal ostectomy in the medial and lateral areas.

If the tip of the new olecranon does not engage the shallow, dysplastic olecranon fossa, then the wound is packed, and the arm extended over two parallel armboards. A lazy 'S' incision is made over the anterior elbow, proximal medial to distal lateral. The lacertus fibrosus is usually the first tight structure to be encountered and this is transected in an oblique fashion. Care is taken to identify and protect the lateral and medial antebrachial cutaneous nerves. The biceps brachii is lengthened within its intramuscular component. The median nerve is explored and an external neurolysis performed from the proximal part of the wound to the pronator tunnel. Care is taken to identify and protect the brachial artery and vein. With the nerve and vessels protected, the fascia over the brachialis is released in one or two areas. This is mobilized, and an anterior elbow capsulotomy is performed. The collateral ligaments are left intact to avoid destabilizing the elbow. Occasionally, the fascia overlying the flexor or extensor wad is released if tight.

Once the anterior releases have been done, then the 'new' olecranon will engage the hypoplastic olecranon fossa and the distal humeral ostectomies can be performed as described above. When the olecranon and distal humeral ostectomies and the anterior releases are completed, the only remaining tight structures in full extension will be the median nerve and/or brachial vessels. At this point, the wound is irrigated and 100 units of botox injected into the biceps brachii if this is a healthy muscle. This helps with postoperative casting in extension and also with initial rehabilitation. Fibrin glue is injected around the median nerve to prevent adhesions around it. The triceps tendon is repaired; care is taken not to overtighten this repair. The wounds are closed and a well-padded plaster cast is applied with gravity extension of the elbow.

Post-operative protocol

The cast is changed 2 weeks post-operative to a long arm dropout cast and changed weekly for 3 weeks. A gentle stretch is applied during the casting and the patient allowed to gain extension with the dropout cast. It cannot be over-emphasized that the serial casting must avoid any painful stretching during the process. Two to four casts are utilized with the end-point being a plateau in terminal extension. Painful therapy should be avoided as this will result in myositis and stiffness of the elbow, which was seen in two earlier patients prior to the start of this study. Patients are taught a home exercise programme that includes active range of motion exercises, contract/release stretching, and isotonic strengthening. Mean duration of follow-up was 38.3 months (range 23 to 70). All patients had posterior release with olecranon reshaping and distal humeral ostectomy. Nine patients had anterior release. Of these, all had lengthening of the biceps brachii, seven had release of the lacertus fibrosus, eight had release of the brachialis fascia, eight had joint capsulotomy, eight had median nerve neurolysis, and nine botox injections.

Results

Table 1 shows the pre- and post-operative extension, flexion, and arcs of motion. The pre-operative flexion contracture averaged 50.5° (range 35 to 60). Post-operative flexion contracture averaged 20.7° (range 15 to 30). The difference was statistically significant ($p < 0.001$). Average pre-operative active elbow flexion was 131.5° (range 120 to 155). Average post-operative active elbow flexion was 129.7° (range 97 to 145). Of these patients, one had no change in active flexion, four had loss of active flexion, and five had gain of active flexion. All patients had increased total arc of elbow motion, except for one patient who had a global BPBI with the most severe weakness of elbow flexion in this cohort. He had a much more severe proximal deficit and weakness. Power in both biceps and triceps was MRC grade 4/5 with co-contraction of both muscles. Hence function in his upper extremity was much more limited than other patients in this series. Despite losing some of his flexion arc he was very happy to have resolution of his elbow flexion contracture. All ten patients were satisfied with their results and stated that they would recommend the procedure to other patients. No patients had an elbow instability.

Of the ten patients with recorded DASH scores, the mean pre-operative score was 39.2 (range 14.7 to

Table 1. Pre- and post-operative elbow extension, flexion, and arc of motion of all patients.

Pre-operative measurements			Post-operative measurements		
Extension (°)	Flexion (°)	Arc of motion (°)	Extension (°)	Flexion (°)	Arc of motion (°)
−60	150	90	−25	144	119
−60	120	60	−27	120	93
−52	130	78	−17	127	110
−35	120	85	−15	140	125
−45	120	75	−15	135	120
−53	155	102	−20	97	77
−50	135	85	−15	145	130
−45	130	85	−20	125	105
−60	135	75	−30	140	110
−45	120	75	−23	124	101

63.8), and the mean post-operative score was 21.5 (range 4.3 to 72.4). One patient had a paradoxical increase in DASH score, despite gaining 35° of extension, losing only 3° of active flexion, and reporting satisfaction with the operation, and a willingness to recommend it to others. Specific comments from patients who benefited from this surgery included the following: improved ability to drive a car, shoot a basketball, do push-ups, carry things, zipper up pants.

Results from the questionnaire were as follows: (1) Nine patients desired both functional and aesthetic improvement, while one desired functional improvement only; (2) Eight patients felt that they had a functional and aesthetic improvement, while two felt that they had a functional improvement only; (3) All ten patients would recommend the surgery to someone else.

Discussion

Elbow flexion contractures following BPBI are common, with a reported incidence of 48% reported in a large series of 319 patients (Sheffler et al., 2012a). Unfortunately a contracture >30° affects the functional elbow range of motion, reported to be from 30° to 130° (Morrey et al., 1981). This can profoundly affect the ability of children with BPBI to take care of themselves. Conservative treatment with casting and splints is effective in a select group of motivated patients. However, prevention of recurrent flexion contracture requires lifelong adherence to a nighttime splinting regimen (Ho et al., 2010).

Reported surgical solutions are few (Garcia-Lopez et al., 2012; Vekris et al., 2010), and do not address the underlying bony deformity in the elbow. Garcia-Lopez et al. described an anterior-only release of the elbow with lengthening of the tendons of the distal biceps and anterior brachialis in a series of ten patients, with a mean gain in extension of 28°. Vekris et al. described closed treatment with a unilateral hinged elbow external fixator with short term follow-up. The original O-K procedure as described in 1978 (Kashiwagi, 1978) was designed to address mild to moderate elbow osteoarthritis through a mini-open midline posterior approach with a triceps split. By creating a hole through the olecranon fossa in the distal humerus, the anterior part of the ulnohumeral joint can be accessed for removal of osteophytes and loose bodies. The O-K procedure has been shown in a number of studies to reduce pain and increase range of motion for elbow osteoarthritis (Cha et al., 2014; Forster et al., 2001; Vingerhoeds et al., 2004).

The procedure we have described here follows a similar mini-open midline posterior surgical approach that allows custom narrowing and shaping of the widened olecranon, as well as a distal humeral ostectomy to accommodate full extension of the elbow. Conservative treatment with splinting and casting and other described surgical techniques do not address the underlying bony deformity, and the underlying bony block to extension is still present. By following a sequential surgical approach where the posterior bony deformity is addressed, with an anterior soft tissue release if required, a full release of the elbow addressing all anatomical structures is performed. Care has to be taken to preserve the collateral ligaments with an anterior release to prevent elbow instability. Future analysis requires longer term follow-up and a determination of why some gain or lose active flexion. Limitations of the study are a small cohort of ten patients. Nevertheless, surgery of this sort is uncommon for a rare condition (BPBI). In addition, longer term follow-up of patients would be ideal.

In conclusion, we have described a new technique for treating elbow flexion contractures in BPBI. This modified O-K procedure has resulted in statistically significant improvements in the elbow flexion contracture, with high patient satisfaction rates.

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