# Dorsal Carpal Wedge Osteotomy in the Arthrogrypotic Wrist

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**Purpose** To assess the outcome of patients who underwent dorsal carpal wedge osteotomy (DCWO) for the treatment of wrist flexion deformities causing functional limitations resulting from arthrogryposis.

**Methods** We performed a retrospective chart review of consecutive patients treated with DCWO between 1996 and 2009 by a single surgeon. Follow-up of greater than 1 year (mean, 45 mo; range, 12–108 mo) was available in 12 patients (20 wrists).

**Results** All 12 patients' parents reported subjective improvement in position and appearance, and in performing activities of daily living. Wrist extension was significantly increased (mean, 43°), wrist flexion was significantly decreased (mean, 34° from neutral), and there was no significant change in wrist motion arc. We saw significantly greater improvement in wrist extension in children operated on at 7 years of age or greater and in patients treated concomitantly with an extensor carpi ulnaris tendon transfer. Complications included 1 infection.

**Conclusions** The excessively flexed wrist in children with arthrogryposis can safely and effectively be improved with DCWO, which in turn facilitates independence in activities of daily living and school-related tasks as reported by parents. For patients older than 7 years of age at the time of surgery, and for patients treated with concomitant extensor carpi ulnaris transfer at the time of DCWO, we found greater recovery of wrist extension. *(J Hand Surg 2013;38A:265–270. Copyright © 2013 by the American Society for Surgery of the Hand. All rights reserved.)*

**Type of study/level of evidence** Therapeutic IV.

**Key words** Amyoplasia, arthrogryposis, carpal osteotomy, wrist deformity.

CHILDREN AFFECTED WITH THE amyoplasia type of arthrogryposis have upper extremities that are usually internally rotated at the shoulders, extended at the elbows, and flexed and ulnarly deviated at the wrist. In addition, this sporadic condition is characterized by atrophy and weakness of muscles of the affected extremities. Motion of the upper extremity in children affected by arthrogryposis can be limited, resulting in functional impairment. Most children with amyoplasia have normal intelligence. However, because of their upper extremity contractures and abnormal limb position, they often have difficulty performing activities of daily living as well as school-related tasks such as handwriting.[1]

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The goal of treatment of upper limb involvement in amyoplasia is to improve position and maximize function. Upper limb deformities that interfere with function and persist despite conservative treatment may be treated surgically. A variety of surgical procedures have been described to address deformities associated with the shoulder and elbow.[2–7]

One technique described to surgically correct wrist flexion deformity in amyoplasia is the dorsal carpal wedge osteotomy (DCWO).[8] The DCWO is a closing wedge osteotomy through the midcarpus. The midcarpus is at the apex of the deformity, which is the most appropriate site for correction. In addition, in amyoplasia, the midcarpus is often the site of carpal coalitions. Because DCWO does not violate the radiocarpal joint of the wrist, motion there is preserved. Dorsal carpal wedge osteotomy has been used to reposition the wrist to a more functional alignment of greater wrist extension. However, to date, little is known about the clinical outcomes of this procedure or the appropriate age for it.

The purpose of this study was to assess the outcomes of patients who had undergone DCWO for the treatment of wrist flexion deformities resulting from amyoplasia. In addition, we examined the effects of age, sex, concomitant extensor carpi ulnaris (ECU) transfer, and ambulatory status on surgical outcomes, as measured by range of motion.

## MATERIALS AND METHOD

We obtained institutional review board approval before conducting this study. This study was a retrospective chart review of consecutive patients treated with DCWO for wrist flexion deformity resulting from amyoplasia between 1996 and 2009, by a single surgeon at the University of Minnesota, Shriners Hospital–Twin Cities, and Gillette Children's Specialty Healthcare Hospitals.

We reviewed the medical records for clinical data. Data collected included demographic data, nonsurgical intervention before surgery (occupational therapy, splinting, and casting), preoperative and postoperative (at the time of the latest clinic visit) range of motion, and concomitant procedures performed on the affected extremity. We questioned all patients and their parents regarding independence in activities of daily living (ADLs) and handwriting function. We recorded information available in the chart related to the ability to perform ADLs and writing. Passive wrist range of motion obtained included flexion, extension, supination, and pronation. The range of motion reported is that of the most recent follow-up visit at the time of the chart review; we used a standard goniometer to obtain these measurements. We reviewed the occupational therapist clinic notes to gather information related to ADL and writing ability.

We reviewed 26 wrists in 16 patients. We excluded 4 patients because of follow-up of less than 1 year. The remaining 12 patients (20 wrists: 11 right and 9 left) formed the cohort of this study. Nine patients were girls and 3 were boys, with an average age of 8 years at the time of surgery (range, 5–15 y). Two patients had only upper extremity involvement. Ten had both upper and lower extremity involvement. Seven patients walked independently without ambulatory aids, 2 patients walked with aids, and 3 were wheelchair-dependent. Mean follow-up time from the date of surgery to the most recent clinic visit for the 12 patients reported here was 45 months (range, 12–108 mo). We calculated range of motion in 12 patients (20 wrists) for whom complete data was available.

### Surgical technique

Surgical indications for DCWO included excessive wrist flexion contracture deformity that limited upper extremity function and failed to improve despite nonoperative intervention such as occupational therapy intervention and splinting.

The DCWO surgical technique used has been described by Ezaki[2] and Ezaki and Carter.[8] Through a dorsal approach to the wrist, the digital and wrist extensor tendons are isolated and protected. A dorsal capsulotomy is then performed. At the level of the midcarpus, a dorsal wedge osteotomy is made sufficient to correct the wrist flexion deformity to at least a neutral position, taking care that noteworthy finger flexor tightness is not produced by tenodesis. If ulnar deviation correction is required as well, the dorsal carpal wedge can resect more bone on the radial side to provide biplanar deformity correction. This position is held in place with 2 cross K-wires. In addition, tendon transfer of the ECU to the extensor carpi radialis brevis may be performed to correct the ulnar deviation deformity or wrist extension weakness, or both, if the ECU tendon is noted to have sufficient excursion intraoperatively. After the procedure, the patients are placed in a cast for 1 month. If radiographs show healing of the osteotomy, the cast is removed and the K-wires are pulled. Patients are given a wrist splint for protection and begin to participate in occupational therapy activities for wrist range of motion, particularly wrist extension, and hand function. Removable night splints are indicated on a case-by-case basis if needed for further improvement of wrist extension.

Eight patients underwent bilateral DCWO and 4 underwent unilateral DCWO. Of the 8 patients who underwent bilateral DCWO, 6 had the procedure on the same date. In all 20 affected extremities, we performed additional ipsilateral procedures, including ECU centralization tendon transfer and thumb-in-palm deformity correction (Table 1).

### Statistical analysis

We performed paired *t*-tests to compare the preoperative and postoperative ranges of motion. We compared

**TABLE 1. Other Upper Extremity Procedures**

| | Surgery |
|---|---|
| Shoulders | Humeral derotation osteotomy (2) |
| Elbows | Elbow capsular release (4) |
| | Triceps lengthening (4) |
| | Radial head excision (1) |
| | Ulna rotation osteotomy (1) |
| Wrist | ECU transfer (7)* |
| Hands | First web space z-plasty (8)* |
| | Thenar release (2)* |
| | FPL lengthening (2)* |

FPL, flexor pollicis longus.
The number of procedures is indicated in parentheses (no. of limbs).
*These procedures were performed on the same date of the DCWO.

postoperative range of motion for patient groups based on age (≤ 7 vs > 7 y), sex, ambulatory status, and concomitant ECU transfer using the 2-tailed paired *t*-test. The level of significance was set at $P = .050$.

## RESULTS

All 12 patients and parents reported subjective improvement in performing ADLs. All 12 patients and parents indicated that they were pleased with the improved position (Fig. 1) and appearance of the hands. Of the 8 patients with available data, 7 had writing ability similar to their classmates, and 1 reported hand fatigue with prolonged writing. Six patients were fully independent with their ADLs; 2 required some assistance.

### Range of motion

Mean wrist extension lacked 29° from full extension preoperatively (range, 90° from full extension to 0°) and was 15° postoperatively (range, 20° from full extension to 60°) (Fig. 2). Mean improvement of terminal extension was 44° ($P < .001$).

Mean wrist flexion was 86° preoperatively (range, 40° to 110°) and was 51° postoperatively (range, 0° to 90°). Mean loss of wrist flexion was 35° ($P < .001$).

The mean arc of wrist motion was 57° preoperatively (range, 0° to 75°) and 66° postoperatively (range, 0° to 140°). Mean increase in wrist motion was 9°, which was not statistically significant ($P = .130$).

### Age at surgery of 7 years or less versus older than 7 years

Children older than 7 years of age at the time of surgery had significantly greater extension improvement than those 7 years of age or less (Table 2). For children under age 7 years at the time of surgery, a mean of 31° of wrist extension was achieved. For those older than 7 years, the mean improvement was 66°.

The preoperative wrist flexion deformity was significantly worse in older children with an average of 97° of flexion deformity, compared with 79° in the age group 7 years or younger. There was no significant difference in flexion range of motion between these age groups.

### Ambulatory versus nonambulatory

The mean preoperative flexion deformity was greater in the nonambulatory group than the ambulatory group (Table 3). Conversely, the nonambulatory group displayed greater correction of wrist flexion deformity than the ambulatory group (23°). The postoperative arc of motion of the nonambulatory group was more limited than the ambulatory group. All of these findings were statistically significant.

### Tendon transfer versus non–tendon transfer

Patients who had an ECU tendon transfer at the time of DCWO had a greater average improvement in wrist extension than the non–tendon transfer group, to a statistically significant degree (Table 4). The arc of motion of the tendon transfer group improved by 11°, and by 8° in the non–tendon transfer group, which was not statistically significant ($P = .870$).

### Boys versus girls

Boys had more significant preoperative deformity compared with girls (Table 5). Boys had significantly less preoperative extension than girls. The mean wrist extension gain for boys was greater than for girls. All of these differences were significantly different.

### Complications

The 1 complication was a wound infection, which we treated with irrigation, debridement, and antibiotics; it healed without further complications.

## DISCUSSION

In patients with arthrogryposis with severe wrist flexion deformities affecting function, the goal of treatment is to improve position and maximize function. Ezaki[2] and Ezaki and Carter[8] reported that among the procedures recommended for correction of deformity of the arthrogrypotic wrist, DCWO has the advantages of both preserving wrist motion through the radiocarpal joint and repositioning the hand into a more functional position of wrist extension. In arthrogryposis, the midcarpal

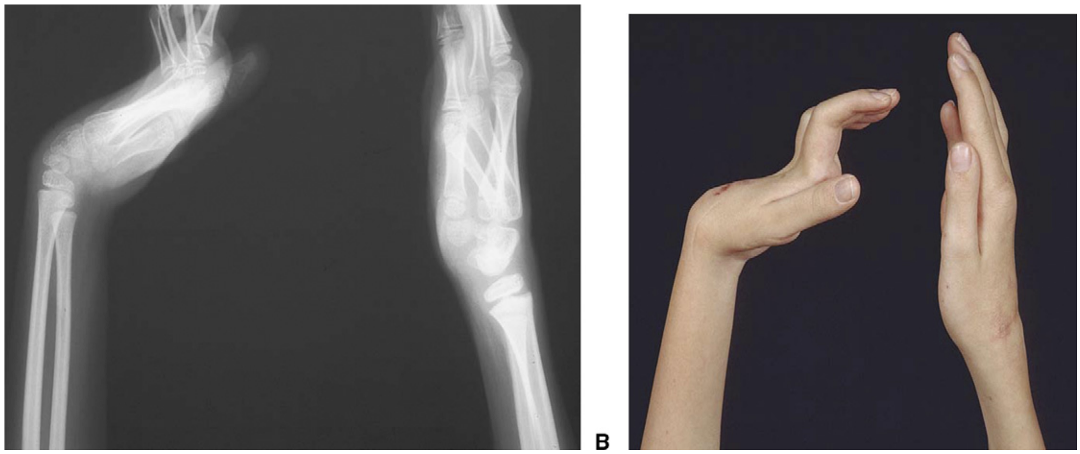


**FIGURE 1: A** When the patient returned for the left DCWO, we took these radiographs preoperatively (left) and postoperatively (right). **B** Clinical photographs showing preoperative wrist flexion deformity resulting from amyoplasia on the left, and postoperative correction of wrist flexion deformity from amyoplasia on the right.

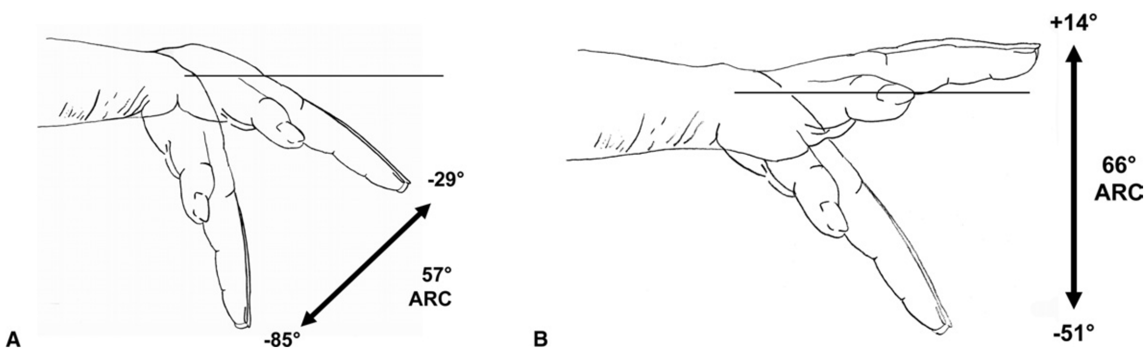


**FIGURE 2: A** Mean preoperative wrist extension was 29° from full extension and mean preoperative wrist flexion was 86°, for a preoperative arc of wrist motion of 57°. **B** Mean postoperative wrist extension was 15° and mean postoperative wrist flexion was 51°, for a postoperative arc of wrist motion of 66°. Mean improvement of wrist extension was 44° ($P \leq .010$). Mean loss of wrist flexion was 35° ($P \leq .010$).

joint often has coalesced and is the apex of the deformity, which lends itself to an osteotomy. Other procedures used in the arthrogrypotic wrist have included proximal row carpectomy, arthrodesis at maturity, and distal radius extension osteotomy. Each has its limitations. These other procedures do not address the deformity at its apex, may be difficult to perform with a midcarpal coalition, and may lead to loss of wrist motion. Dorsal carpal wedge osteotomy has been used to reposition the wrist toward functional alignment of greater wrist extension in cases that have not been responsive to therapy and casting.

In our case series of patients, we found that DCWO significantly improved wrist extension while preserving wrist motion. Children older than 7 years gained a greater amount of wrist extension than those 7 years of age and younger. We found significant differences based on age, ambulatory status, sex, and use of a concomitant ECU tendon transfer.

One explanation for the greater increase in wrist extension is that the preoperative wrist flexion deformity was significantly worse in the older group. Another possible reason why the older children had better wrist extension is that ossification of the carpus in the older group may be more correctable than in the younger group, as the latter patients may have had an unossified carpus at the time of DCWO. Another potential factor is that younger children may not cooperate with therapy to the same extent that older children can. In addition, it is possible that when it is performed at an early age, the correction accomplished with DCWO can remodel over time.

When we compared the arc of motion based on ambulatory status, we found that the postoperative arc of motion of the nonambulatory group was significantly

**TABLE 2. Age Comparison for Mean Wrist Range of Motion Measurements**

| | Age ≤ 7 (n = 13) | Age > 7 (n = 7) | *P* (2-tailed) |
|---|---|---|---|
| Preoperative wrist extension | –19 | –47 | .050 |
| Postoperative wrist extension | 12 | 19 | .590 |
| Diff wrist extension | 31 | 66 | .010 |
| Preoperative wrist flexion | 79 | 97 | .004 |
| Postoperative wrist flexion | 54 | 46 | .590 |
| Diff wrist flexion | –25 | −51 | .150 |
| Range of motion (preoperative) | 60 | 50 | .490 |
| Range of motion (postoperative) | 66 | 65 | .970 |
| Diff range of motion | 6 | 15 | .650 |

Diff = difference; Difference = postoperative to preoperative. Data are represented as degrees.

**TABLE 3. Ambulation Status Comparison for Mean Wrist Range of Motion Measurements**

| | Ambulatory (n = 14) | Nonambulatory (n = 6) | *P* (2-tailed) |
|---|---|---|---|
| Preoperative wrist extension | −20 | −49 | .080 |
| Postoperative wrist extension | 20 | 2 | .070 |
| Diff wrist extension | 40 | 51 | .460 |
| Preoperative wrist flexion | 81 | 95 | .020 |
| Postoperative wrist flexion | 58 | 34 | .040 |
| Diff wrist flexion | −23 | −61 | .010 |
| Range of motion (preoperative) | 61 | 46 | .350 |
| Range of motion (postoperative) | 78 | 36 | .010 |
| Diff range of motion | 17 | 10 | .870 |

Diff = difference; Difference = postoperative to preoperative. Data are represented as degrees. Minus value indicates wrist flexion.

**TABLE 4. Use of Tendon Transfer: Comparison for Mean Wrist Range of Motion Measurements**

| | With Tendon Transfer (n = 9) | Without Tendon Transfer (n = 11) | *P* (2-tailed) |
|---|---|---|---|
| Preoperative wrist extension | −29 | −29 | .940 |
| Preoperative wrist flexion | 94 | 79 | .010 |
| Postoperative wrist extension | 33 | 0 | .004 |
| Postoperative wrist flexion | 43 | 58 | .290 |
| Diff wrist extension | 62 | 28 | .010 |
| Range of motion (preoperative) | 65 | 50 | .140 |
| Range of motion (postoperative) | 76 | 57 | .330 |
| Diff range of motion | 11 | 8 | .870 |

Diff = difference; Difference = postoperative to preoperative. Data are represented as degrees. Minus values represent wrist flexion.

**TABLE 5. Comparison of Mean Wrist Range of Motion Measurements for Both Sexes**

| | Boys (n = 6) | Girls (n = 14) | *P* (2-tailed) |
|---|---|---|---|
| Preoperative wrist extension | −53 | −19 | .030 |
| Preoperative wrist flexion | 97 | 81 | .020 |
| Postoperative wrist extension | 17 | 14 | .840 |
| Postoperative wrist flexion | 31 | 60 | .010 |
| Diff wrist extension | 69 | 33 | .020 |
| Range of motion (preoperative) | 44 | 62 | .280 |
| Range of motion (postoperative) | 48 | 73 | .160 |
| Diff range of motion | 3 | 11 | .690 |

Diff = difference; Difference = postoperative to preoperative. Data are represented as degrees. Minus value indicates wrist flexion.

more limited than in the ambulatory group. Although the nonambulatory group displayed a significantly greater correction of wrist flexion deformity than the ambulatory group, the preoperative flexion deformity was more severe in the nonambulatory group than the ambulatory group. These findings show that the nonambulatory group had a more severe form of the condition.

The correction of the deformity was not significantly different when comparing ambulatory status.

We also found that boys had a greater preoperative deformity than girls. The mean wrist extension gain in boys was also significantly greater than in girls. Again, the group with the greater deformity preoperatively experienced the greater correction.

In addition to DCWO, soft tissue balancing and tendon transfers have been described as supplemental techniques to improve the position of the wrist.[8–10] Some of the patients in this retrospective study underwent an ECU tendon transfer in addition to DCWO to help correct the flexed and ulnarly deviated wrist deformity. As reported by Ezaki and Carter,[8] the ECU is often not affected by the disease, contrary to the case for the other wrist extensors. In these cases, the ECU can be transferred to a central position on the dorsum of the wrist to correct the ulnar deviation deformity and provide a balancing force to the wrist flexors. We found that patients who had an ECU tendon transfer at the time of DCWO had a greater average improvement in wrist extension than the non–tendon transfer group. This fact supports the concept that balancing the tendon forces around the wrist helps correct the deformity.

Dorsal carpal wedge osteotomy has been described as a surgical approach to the arthrogrypotic wrist that is resistant to nonoperative treatment. Our retrospective study with an average of 45 months of follow-up provides valuable information with regard to the clinical outcomes of DCWO.

Weaknesses of this study include those inherent in a retrospective case series report. There are no controls with which to compare the subjects; thus, we are unable to determine to what degree DCWO versus the natural process of development and adaptation was responsible for the improvement in wrist position and function. No specific objective functional testing was reported, so functional improvement was limited to parent and patient interpretation. Valid preoperative functional testing was not available for comparison. We could not assess functional improvements resulting from growth or maturation versus improvement because of the surgery. In addition to wrist position, function of the hand is significantly affected by stiffness of the fingers, which we did not specifically assess. Furthermore, subjective improvements in ADL reported by the parents may not have been directly related to improved wrist position. Finally, our patient cohort was small, and some patients were excluded because of limited follow-up.

This study presents objective data showing that the excessive flexed wrist position of the children affected with arthrogryposis can be improved with DCWO. This may in turn facilitate patients' ability to become more independent in ADLs and school-related tasks, as reported by parents.

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