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# Long-Term Outcome of Corrective Derotation Osteotomies to Treat Congenital Radioulnar Synostosis in Children

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## Abstract

**Objective:** To evaluate the clinical and functional outcomes of a technical procedure in the surgical treatment of congenital synostosis in children.

**Materials and Methods:** A prospective study was conducted from January 1995 to December 2010. Fifty-five patients (Eighty-four forearms) with congenital synostosis in internal rotation were recruited. Congenital synostosis in internal rotation was classified into two types according to Tachdjian. All patients were treated by resection of the proximal radius and distal ulna and partial resection of both forearms. After intramedullary K-wire insertion into both bones, the forearms were rotated manually, followed by cast immobilization.

**Results:** There were 36 males (65.5%) and 19 females (34.5%). The mean age at surgery was 6 years and 9 months. The distribution was 9 right forearms and 17 left forearms; 29 patients (52.7%) had bilateral lesions. Type 1 "headless type": 19 forearms (22.6%) and Type 2: 65 forearms (77.4%). The mean follow-up period was 19 years and 3 months. Excellent results were achieved in 24 forearms (28.6%), good results in 41 forearms (48.8%), fair results in 19 forearms (22.6%), no poor results and no complications in all patients

**Conclusion:** Congenital proximal radial fixation can be successfully treated by surgical resection of the radius and ulna, shortening of both bones and fixation with Kirschner wires at the radius and ulna. This technique is safe and effective

***Keywords:** Congenital Radioulnar Synostosis; Radial Fixation; Radial Head Dislocation; Radial Osteotomy; Forearm Function*

## Introduction

Congenital radioulnar synostosis (CRUS) is a rare upper limb anomaly in which the proximal portions of the radius and ulna fuse together and restrict rotation of the forearm.

The majority of patients present with bilateral involvement. Generally, the forearm is fixed in a pronated position, which is the most prominent feature of this anomaly. In mild anomalies, the ipsilateral shoulder and wrist can effectively compensate for any functional deficit. However, daily activities may be significantly limited in severe cases of permanent pronation or whenever both sides are affected [1,2].

In 1932, Fahlstrom reviewed all cases reported in the world medical literature and found only 185 cases since Sandifort's initial description in 1793 [3]. In cases where the forearm is fixed in a pronated position greater than 60° and the patient complains of disability in activities of daily living, rotational osteotomy is recommended to achieve a more functional position. Disappointing results have been reported with previous attempts to resect the fusion and restore forearm rotation [4]. The osteotomy is usually performed through the fusion site but requires extensive soft tissue release around the osteotomy to achieve adequate correction. Otherwise, soft tissue tension may lead to loss of correction or vascular complications because significant rotation occurs in a very limited area [5]. Most attempts to resect the fusion and achieve forearm rotation have ended in failure.

The treatment of CRUS remains controversial. Although the literature has reported that surgery is essential to improve the quality of life of children with CRUS, there are no specific guidelines to help surgeons decide between nonsurgical and surgical treatment options for CRUS because each patient's condition is unique [6]. Therefore, surgical considerations should be based on functional impairment in addition to significant rotational deformity. Several surgical options, such as acute or staged rotational and rotational rehabilitation, have been described in the literature. However, there is still no general consensus on surgical technique [1]. A widely accepted surgical approach to treat CRUS is rotational osteotomy [3]. This procedure moves the forearm from a hyperpronated state to a more functional position, reducing pronation limitations and making it easier for patients to perform daily activities with shoulder and wrist support. There are several types of osteotomies, including isolated osteotomies of the radius [7], rotational osteotomies of the radius and ulna, and rotational osteotomies at the fusion site [8].

## Aim of the Study

The aim of this study was to evaluate the long-term results of this technique with osteotomies of the radius and ulna, combined with segmental osteotomies, shortening both bones.

## Materials and Methods

From January 1995 to December 2010, we performed proximal and distal ulnar osteotomies in 59 patients (91 forearms) as described above. Four patients (7 forearms) were lost to follow-up. The remaining 55 patients (84 forearms) formed the basis for this study. The patients were operated on by only one surgeon (Author). They were 36 men (65.5%) and 19 women (34.5%). All relevant clinical and surgical records were reviewed prospectively.

### Clinical and radiographic examinations

All patients completed a questionnaire and were interviewed by one of us. A comprehensive clinical examination of the upper limb was performed, including measurements of range of motion, forearm position, weight-bearing angle, and forearm length.

The degree of supination-ulnar extension of the forearm is measured by the angle between the longitudinal axis of the humerus and the line of the radial and ulnar processes (forearm rotation). In patients with congenital radioulnar synostosis, some degree of supination-ulnar extension of the palm can be achieved through compensatory rotation at the wrist and carpometacarpal joint (cf. Figure 1). Therefore, the degree of supination-ulnar extension of the palm is determined by the angle between the longitudinal axis of the humerus and the axis of the metacarpophalangeal joint from the index finger to the little finger in the palm (apparent rotation) [9].

### The radiographic examination

The radiographic examination: includes the elbow and wrist in two planes and is compared with previous radiographs. The anteroposterior and lateral radiographs demonstrate radioulnar synostosis, involving one and a half inches of the upper bone. The result of this synostosis is posterior displacement of the distal ulna. The metacarpal base appears slightly atrophied, probably due to disuse.

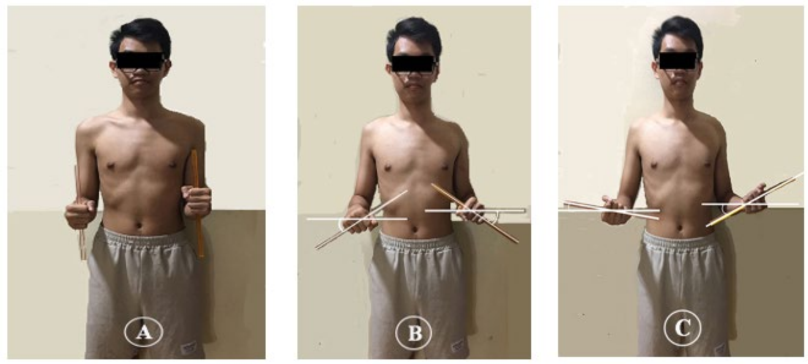


***Figure 1A-1C:*** *Measure functional forearm. A. Measure the forearm in neutral position; B. Measure the forearm in pronation; C. Measure the forearm in supination.*

### Classification of congenital fusion of the radius and ulna (cf. figure 1 and 2)

Our patients were classified according to Tachdjian's criteria [10]: (1) Type 1 (CF. figure 2), the head of the radius may be fused to the ulna or may be completely absent (called "headless type"); and (2) Type 2 (CF. figure 3), the head of the radius is deformed and may be dislocated.

***Figure 2:*** *Radioulnar synostosis with hypoplastic ulna and without dislocation of the radial head.*

***Figure 3:*** *Radioulnar synostosis with dislocation of the radial head.*

### Operative procedures and postoperative management

### Indication

The average preoperative fixed rotation of the operated forearm is greater than 60°. In such cases, the child has significant functional limitation when trying to hold a rice bowl, drink from a cup, or receive coins with an open palm, and is unable to use a spoon or chopsticks and wash his face. The patient has obvious bone fusion and with or without radiographic dislocation of the head of the radius.

### Operative technique

The first skin incision is made using the Thompson method, approaching the ulna from posterior to anterior, approaching the ulna through an incision along the subcutaneous border starting 5 cm proximal to the styloid process and continuing proximally for 4 cm. The second skin incision is made using the Henry method, approaching the radius from anterior to posterior, approaching the radius through an incision along the subcutaneous border starting at the fusion site and continuing distally for 4 cm. The superficial radial nerve, ulnar nerve, and radial and ulnar arteries are identified and gently pulled to protect.

Perform a short osteotomy, cutting the bone in the shaft, i.e. in the distal third of the ulna and the proximal third of the radius, where the bone is more accessible and is thought to heal better. This is different from a fusion osteotomy. Contact the proximal radius and identify the distal border of the joint with the needle and introduce the teres radialis. Cut the radius approximately 2 cm from this mark. Cut the ulna approximately 5 cm from this mark. With both bones exposed under the periosteum, make a number of holes in two horizontal lines on each bone in the shaft using Kirschner wire and use a non-slip hand saw to enter the bone through these holes (cf. figure 4A). Perform a horizontal osteotomy with a hand saw.

After the osteotomy, a 1.5 cm section of bone is removed from both forearm bones (See figure 5) and 1.5 mm diameter K-wires are inserted into the radius and ulna, passing through the osteotomy sites (cf. figure 4B, 5 and 6). The two bones were realigned and K-wires were passed through the osteotomy sites (cf. figure 4C). The K-wires were then radiographically controlled to exit at that point without damaging the growth plate or joint.

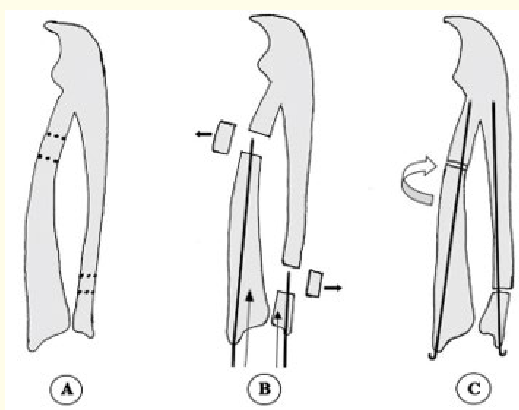


***Figure 4:*** *Surgical method: A. The osteotomies resections are drawn on both; B. Both bones. Perform the resection, resect a 1.5 cm long segment of bone on both forearm bones, and thread the K-wire into the radial styloid and ulnar styloid bones; C. Align the two bones and insert the K-wire into the osteotomy sites; manually rotate the forearm to a neutral position of 30° pronation for the dominant hand and neutral for the non-dominant hand.*

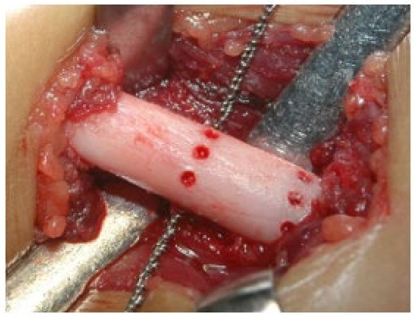

***Figure 5:*** *Several holes were made and Osteotomized by saw hand.*

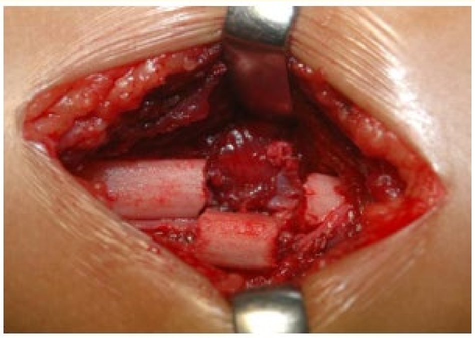

***Figure 6:*** *Defect of bone and removing a segment bone.*

After the intramedullary K-wires were passed through both bones, the forearm was manually rotated to a neutral position of 30° pronation for the dominant hand and neutral for the nondominant hand. Appropriate rotation was achieved without difficulty at both the distal radioulnar joint and the osteotomy sites. Following this procedure, the forearm was immobilized by placing a cast above the elbow on the operating table (cf. figure 7).

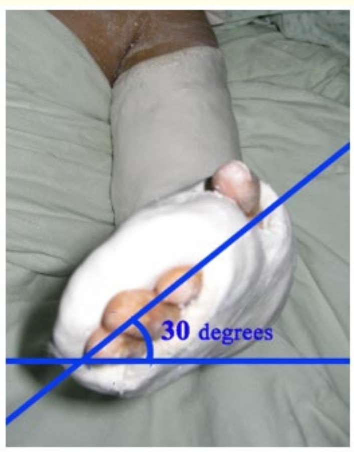


***Figure 7:*** *The upper extremity was immobilized in a long arm cast to hold the elbow in 90 degrees of flexion and forearm position according to planned preoperation (Pronation 30°).*

### After operation

At 6 to 8 weeks postoperatively, when sufficient scar tissue is seen on X-ray, the cast is removed and the forearm is protected with a removable splint. The K-wire is left percutaneously and removed in the operating room under local anesthesia after confirmation of bony fusion on X-ray.

### Follow-up

Patients were re-examined after 3 weeks, 6 weeks, 3 months, 6 months, 1 year, and then annually. All patients were monitored clinically or radiographically for forearm healing.

### The criteria used for assessing the results of operation

| | Forearm Position (Degree pronation) | Rate of Results at latest follow-up (%) | Activities of daily living (holding a rice bowl, use chopsticks, washing face, dressing and button clothes ...) |
|---|---|---|---|
| Excellent | > 0° - ≤ 15° | 100% - ≤ 85% | No difficulty |
| Good | > 15° - ≤ 30° | ≥ 70% - < 85% | Mild difficulty |
| Fair | > 30° - ≤ 45° | ≥ 50% - < 70% | Moderate difficulty |
| Poor | > 45° | < 50% | Severe difficulty or Unable or There are complications |

***Table 1:*** *The criteria used for assessing the results of operation.*

### Complications

Surgical treatment of radioulnar ankylosis is generally well tolerated. Risks associated with surgical intervention include the standard surgical risks of pain, bleeding, infection, and complications of anesthesia, as well as:

- Recurrence of ankylosis or malrotation
- Neurological injury
- Compartment syndrome secondary to osteotomy
- Fracture
- Nonunion or abnormal union
- Soft tissue contracture or contracture.

## Results

Between January 1995 and December 2010, 55 patients (84 forearms) were operated on. The mean age of patients at surgery was 6 years 9 years (range, 4 years 6 months to 10 years 11 months). The distribution was 9 right forearms and 17 left forearms; 29 patients (52.7%) were affected bilaterally.

None of the patients had other congenital anomalies and no family history of congenital radioulnar synostosis.

### Classification of congenital radioulnar synostosis

Type 1 "headless type": 19 forearms (22.6%) and Type 2: 65 forearms (77.4%) (radial head dislocation in 31 forearms (47.7%).

Mean follow-up was 19 years 3 months (range 14 years 2 months to 28 years 6 months).

### Long-term follow-up

Excellent outcome in 24 forearms (28.6%), good outcome in 41 forearms (48.8%), fair outcome in 19 forearms (22.6%), no poor outcome and no complications in all patients (cf. figure 8-12).

***Figure 8:*** *Stir food.*

***Figure 9:*** *Unlock door.*

***Figure 10:*** *Use spoon to eat.*

***Figure 11:*** *Hold pen to write.*

***Figure 12:*** *Use chopsticks to eat rice.*

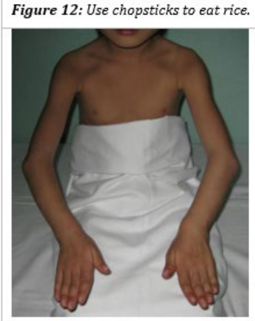

***Figure 13:*** *Postoperative 5 years 6 months, forearm pronation.*

***Figure 14:*** *Forearm in neutral position.*

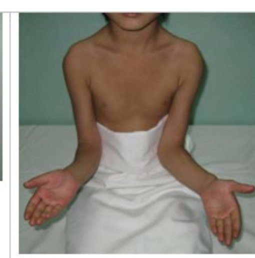

***Figure 15:*** *Postoperative 5 years 6 months, forearm supination with compensatory movement around the wrist and elbow.*

| | Preoperative ROM | | Postoperative ROM | |
|---|---|---|---|---|
| | Forearm Rotation. deg (average) | Apparent Rotation Pro/Sup.deg (average) | Forearm Rotation. deg (average) | Apparent Rotation Pro/Sup.deg (average) |
| Dominant 26 Forearms 26 Patients | 85°, pro | 110° / 0° | 8°, pro | 31° / 40° |
| No-dominant 58 Forearms 29 Patients | 78°, pro | 115° / 10° | 18°, pro | 34° / 48° |

***Table 2:*** *Compare Preoperative ROM and Postoperative ROM.*

Preoperative forearm position ranged from 66° to 88° of internal rotation (mean 85° of internal rotation in the dominant hand and 78° of internal rotation in the non-dominant hand). Postoperative forearm position angle was corrected from 0° to 38° of internal rotation (mean 8° of internal rotation in the dominant hand and 10° of internal rotation in the non-dominant hand).

Sixteen forearms had good results, with an average postoperative forearm position of 38° of internal rotation. These patients still had some difficulty holding a rice bowl, using chopsticks, and had little disability in daily activities, and these patients were also satisfied with the results of the surgery.

There was a slight loss (14°- 19°) of adjustment during cast immobilization in five forearms (6 forearms in the dominant hand - post-operative forearm position was 25° internal rotation; on cast removal, forearm position was 45° internal rotation; 4 forearms in the non-dominant hand - post-operative forearm position was neutral; on cast removal, forearm position was 39° internal rotation.

38 Patients (16 bilateral) were younger than 6 years old and had surgery, with a mean internal rotation of 6° in 25 forearms at postoperative follow-up and the remaining 6 patients (5 bilateral) were older and had surgery, with a mean internal rotation of 30° in 21 forearms at postoperative follow-up.

In the bilateral case, the operated hand was the dominant hand and therefore the patient's ability to use chopsticks, wash the face and button clothes improved significantly after surgery. Unilateral cases also showed significant improvement in performing daily activities such as holding rice bowls, dressings, and washing; and these patients were also satisfied with the surgical results (cf. figure 13-15).

Bone fusion was achieved in all patients after 6.9 weeks (range 6.4-7.5 weeks), and the time to complete cast removal ranged from 6 to 9 weeks (median 8 weeks) (cf. figure 16 and 17).

Radial and ulnar growth was not affected; Significant functional improvement in performing daily activities, typing was achieved in all patients.

## Discussion

Congenital fusion of the radius and ulna is a rare anomaly of the upper limb. Blaine [11], citing Mouchet and Leleu [12], states that congenital fusion of the radius and ulna was apparently first observed by Lenoir in an autopsy in 1817. However, the earliest record is that

***Figure 16:*** *K-wires are inserted intramedullary into both bones the forearm.*

***Figure 17:*** *Postoperative Union bone 8 weeks.*

of Sandifort, who reported three cases in 1793. Smith, Verneuil, and Dubois reported a single case in 1852. Malgaigne wrote of a case in 1856, followed by Voigt in 1863. Thereafter, no cases were reported until 1880, when Allen reported another case. Pye-Smith followed in 1883 with another case [13]. In 1892, Morrison reported one case, and Abbott contributed the largest series, as it included seven cases. The latter series occurred in a family spanning four generations. This was the first definitive evidence of a familial tendency [13]. In 1932, Fahlstrom reviewed all cases reported in the world medical literature and found only 185 cases since Sandifort's original description in 1793 [14].

### Etiology

The cause of congenital ankylosis of the radius is unknown. Congenital ankylosis of the radius can occur in Tetrasomy X or any of several genetic syndromes, including Poland, Cornelia de Lange, Holt-Oram, Crouzon, and Apert syndromes. Ankylosis of the radius may result from a deficiency in SMAD6; SMAD6 encodes an intracellular inhibitor of the bone morphogenetic protein (BMP) signaling pathway [1-3]. The developing limb bud normally undergoes longitudinal segmentation around the 7$^{th}$ week of gestation; If this process fails or occurs abnormally, congenital radioulnar synostosis may develop [4]. An autosomal dominant inheritance model has been proposed for radioulnar synostosis, but no clear cause or definite inheritance pattern has been demonstrated [5].

The posttraumatic variant of radioulnar synostosis can result from any fracture of the radius, ulna, or olecranon [6-8]. There have been reports of patients who underwent surgical repair of olecranon fractures or distal biceps tendon ruptures who subsequently developed proximal radioulnar synostosis [8-10]. Fractures involving both the radius and ulna with increased comminution at or near the same level may also increase the risk of developing radioulnar synostosis [11]. In addition to the characteristics and location of the fracture, the severity of the surrounding soft tissue injury also increases the risk of developing ankylosis [12]. Disruption of the interosseous membrane during surgical fixation of forearm fractures also increases the risk of developing ankylosis [13]. Forearm fractures associated with head trauma are also a significant risk factor for reasons that are not yet well understood [14].

### Epidemiology

Congenital or syndromic ossification of the radioulnar column is extremely rare; fewer than 700 cases have been reported in the literature [3]. Patients with congenital or syndromic ossification of the radioulnar column usually present as young children with significant functional deficits or difficulty with activities of daily living. However, diagnosis may be missed or delayed in unilateral cases when shoulder or wrist motion may compensate for the rotational deficit caused by the syndrome. Bilateral syndromic ossification of the radioulnar column may present with asymmetric symptoms and functional deficits [3]. Traditionally, congenital ossification of the radioulnar column has been thought to be more common in males; current data do not support a sex predilection. Posttraumatic ossification of the radioulnar column has been reported in 1.2% to 6.2% of patients with combined radius and ulna fractures [4]. The incidence of this condition may be underestimated due to inadequate follow-up or asymptomatic radioulnar synostosis [15]. Posttraumatic radioulnar synostosis is less likely to be asymptomatic than congenital variants; adults are less likely to perform compensatory movements than children [3].

The incidence of posttraumatic radioulnar synostosis increases when the initial injury occurs in conjunction with traumatic head injury or neurologic injury [7]. Garland., *et al.* reported complications of surgical treatment of combined radial and ulnar fractures in 3 patients with associated spinal cord injuries; all 3 developed posttraumatic radioulnar synostosis [15].

### History and physical

Although radioulnar synostosis can occur at any age, children with congenital radioulnar synostosis typically present around age 6, when tasks or activities of daily living that require rotation of the forearm are limited by the inability to achieve full pronation or supination. Affected children may have difficulty turning a doorknob or throwing a ball. However, the degree of anatomic fusion will determine which activities are most negatively affected. For example, children with fixed pronation may have difficulty performing tasks that require pronation, such as washing the face, brushing teeth, eating, or catching a ball. Conversely, children with fixed rotator cuff syndrome will have difficulty performing tasks that require rotation, such as typing, writing, or other tabletop activities that require the palm facing down. Patients may also present with elbow flexion or extension if the ankylosis extends proximally or is associated with an abnormal position of the radial head.

The diagnosis of radioulnar ankylosis may be delayed until adolescence if the patient can adequately compensate for the impaired forearm rotation with range of motion of the shoulder, elbow, or wrist. For this reason, the diagnosis may also be missed altogether. There are reports of adults with new range of motion deficits without previous trauma who have been diagnosed with congenital or idiopathic ankylosis [4]. However, the initial presentation of congenital ankylosis in adults is extremely rare.

Patients with posttraumatic ankylosis may present in the acute postoperative period or years later, depending on the degree of functional disability. The development of ankylosis is often noted on routine postoperative imaging to assess fracture healing. The extent of functional limitation secondary to ankylosis may be difficult to determine until the fracture heals and the postoperative pain resolves; both may cause the patient to inadvertently lose range of motion.

If the patient develops ankylosis outside the acute postoperative period, they may describe an elbow, forearm, or wrist injury that requires surgical intervention. Radial and ulnar fractures treated nonoperatively may progress to loss of range of motion. These patients report no pain, limited internal rotation, and limited external rotation, making it difficult to perform activities of daily living or work-related tasks.

Physical examination of a patient with ankylosis will reveal decreased or blocked range of motion when testing active and passive range of motion. Complete fixation typically presents with painless restriction of motion of the forearm, whereas partial or incomplete fixation may allow some motion, which may be painful. These findings are seen in congenital and traumatic ankylosis.

In 1924, Davenport [16] reported the largest series of fifteen cases and the most comprehensive treatment of this condition. Davenport, as the principal author of this group, made a complete phylogenetic and phylogenetic study, and put forward all known hypotheses about the origin of the deformity. He stated that in fifty-five percent of the fifteen cases, one of the parents had craniosynostosis. He concluded that craniosynostosis was limited to only one sex and that its occurrence depended on several modulating factors. He believed that inbreeding was a probable factor and that the condition was twice as common in males as in females. Our patient was 65.5% male and 34.5% female.

### Surgical correction

### The surgical indications

for CRUS is controversial. Simmons., *et al*. [17] recommended that tilt greater than 60 degrees is an absolute indication for surgical intervention.

Ogino., *et al.* [18] suggested that a fixed tilt of 60 degrees, based on functional limitations, constitutes a relative indication for surgery. However, Cleary., *et al*. [19] believe that the majority of patients have fairly good function and do not require surgical intervention. It is difficult to generalize the reported indications for CRUS surgery because each patient's condition is different. Therefore, surgical considerations should be based on functional deficits beyond a predetermined tilt level. In our study, all patients had a mean deformity of 56.67 ± 14.36° (range, tilt 40°-80°) on tilt and significant disability.

Regarding the appropriate age for surgery, Griffet [20] recommended that surgery should be performed preferably between the ages of 4 and 10. Poureyron [21] suggested that surgical treatment for congenital radioulnar synostosis should consider several issues: indications, technique, and ideal age (more vascular or neurological complications after surgery if older). We believe that the optimal age is between 3 and 6 years. At this age, osteotomy is easy and has the potential to ensure complete reconstruction of the radius and ulna. Postoperative results, patients who were operated on when they were younger than 6 years old had an average tilt of 6° and older patients had an average tilt of 25°.

From our review, we conclude that all patients can benefit from this rotational osteotomy. Ideally, it should be reserved for patients who complain of specific limitations or are working or entering a profession where forearm repositioning would improve function. However, delaying the procedure until adolescence or adulthood may increase the risk of surgical complications due to long-term bone and soft tissue deformities. However, this study demonstrates that most procedures performed in children can be functionally beneficial. None of the patients in this study demonstrated pathological findings at the wrist or shoulder; therefore, forearm repositioning may be positively compensated for by adjacent joint motion.

### Surgical technique

Currently, there are two main surgical procedures that can be applied to this congenital anomaly. One is a mobilization surgery to separate the radioulnar joint and restore the ability to rotate the forearm [22]. In theory, mobilization surgery is considered the best method; however, this method requires a vascularized fat graft after joint release and is often difficult to realign the radial head in the correct position when the radial head is dislocated posteriorly or anteriorly [8]. Another surgical procedure is an osteotomy to realign the forearm to accommodate the patient's daily activities. There are three types of osteotomies used to correct forearm rotation: osteotomy involves surgical complexity, significant rotation occurs over a much narrower space, and excessive soft tissue stress can lead to loss of adjustment, circulatory failure, or nerve compression. Several postoperative complications have been reported, including vascular injury, such as Volkmann ischemia, short and angulated forearm, and posterior interosseous nerve palsy [18]; single-site osteotomy of the distal radius; and compound osteotomy of the radius and ulna. In cases of unequal compound osteotomy of the radius and ulna, the procedure is easier and has fewer complications, although internal fixation is required, requiring a second surgery to remove the hardware.

The length of the joint varies from three to five cm [19,23], usually from two to six cm. We measured a mean fusion block length of 18 mm (range 13 mm to 25 mm) in type 1 and a mean of 15 mm (range 12 mm to 22 mm) in type 2. Some authors have performed forearm shortening by removing bone from the fusion block or the radius and ulna to reduce soft tissue tension from three to twenty-two mm in length [24,25]; We adopted Yammine's opinion that forearm shortening by removing bone < or = 2 cm [25] and we performed a 1.5 cm bone resection. In our technique, rotation occurs between the two osteotomies and the resection of a segment of bone reduces excessive soft tissue tension. In addition, because the ulna is osteotomized distal to the insertion of the quadratus radialis muscle, rotation does not cause compression of the median nerve and brachial artery near the muscle. Another major advantage of this approach is the ease of surgical technique. Access to the osteotomy sites of the radius and ulna is simple and does not require extensive soft tissue release. Once the K-wire is inserted into the marrow, the forearm can be manually rotated into the desired position.

Adequate blood supply is another important factor for bone healing. In the adult ulna, the proximal shaft receives its blood supply from the main nutrient artery, which enters the anterior surface of the bone 7.5 cm distal to the olecranon. The artery courses proximally, providing the main blood supply to the proximal portion of the ulna. Distal to the entry point of this artery, several small perforators from the anterior interosseous artery provide the main blood supply [26]. Therefore, there is a relative boundary at the junction of the proximal and middle thirds of the ulna just distal to the nutrient artery [1,25]. Fractures at this boundary of the ulna are associated with poor bone healing. The relationship between bone healing of one forearm bone and the other suggests that factors that influence ulnar healing also influence the radius in the same limb [26]. Szabo and Skinner [27] reported nonunion in 7 of 28 isolated closed ulnar fractures.

They determined that fractures in the proximal third of the ulna were predictive of increased nonunion. Dalton [28] performed forearm osteotomies with the osteotomy site at the proximal ulna and reported delayed union or nonunion in 21 of 69 forearms. The union rate of the ulna was significantly reduced when osteotomies were performed at the proximal third of the ulna, so we do not perform osteotomies at this site.

Murase [29] lost 20 degrees in one of four cases, Tsuyoshi [30] lost 20 degrees in one of four cases, and in 5 of our 54 forearm cases, loss of adjustment occurred during cast immobilization. Therefore, the surgeon should be cautious about the position of the forearm in the cast until the bone is fixed. When strong bone is fixed, the possibility of loss of adjustment due to bone growth is low because this method does not put pressure on the flexors, extensors, or interosseous membranes.

### Bilateral radioulnar joint fixation

Green and Mital [31] stated that, in bilateral cases, the dominant hand should be placed at an angle of 20° to 35° from supination and the other hand should be rotated significantly, while in unilateral cases, a rotation angle of 10° to 20° is ideal. Ogino and Hikino [9] recommended that for unilateral cases or the non-dominant hand of bilateral cases, the forearm should be adjusted between a neutral position and an angle of 20° from supination, and for the dominant hand of bilateral cases, the forearm should be adjusted between a neutral position and an angle of 20° from supination. We accept Tsuyoshi's opinion that the forearm is manually rotated to a neutral position of 30° from supination for the dominant hand and a neutral angle for the non-dominant hand [30]. However, with the increase in computer use over the past decade, people have begun to use the keyboard much more frequently. Fixed rotation of the forearm requires shoulder abduction and internal rotation to bring the forearm into internal rotation, and maintaining this position for long periods of time while typing is extremely tiring. Fixed rotation of the non-dominant hand is also undesirable because Asians hold their rice bowls in a slightly rotated position with their non-dominant hand when eating. For these reasons, we prefer to adjust the forearm position between neutral and 30° of internal rotation for the dominant hand and neutral for the non-dominant hand in both unilateral and bilateral cases. Wrist hypermobility may occur. In patients with congenital radioulnar synostosis with significant compensatory motion around the wrist [32], rotational osteotomy to bring the forearm into a more comfortable position is a reasonable alternative in cases of fixed radioulnar synostosis / During our follow-up, preoperative forearm position ranged from 66° to 88° of internal rotation (mean internal rotation 85° in the dominant hand and 78° in the nondominant hand). Postoperative forearm position angle was corrected from 0° to 38° of internal rotation (mean internal rotation 8° in the dominant hand and 10° in the nondominant hand). Postoperative forearm position angle was corrected from 0° to 30° (mean internal rotation 6° in the dominant hand and 10° in the nondominant hand). Nine forearms lost 15°-20° of internal rotation during cast immobilization.

No complications were observed. Surgical techniques were evaluated.

### Comparison of surgical results of several authors for CRUS

| Authors | Postoperative follow-up of Forearm Position | Complications |
|---|---|---|
| Simmons BP. 1983 [33]<br>(n = 41 forearms) | 10° - 15°. Pro.<br>82% patients had good or excellent results | 8 complications,<br>4 involving neurovascular compromise |
| Castello JR.1996 [34]<br>(n = 4 forearms) | 15°- 0°. pro | No |
| Murase T. 2003 [29]<br>(n = 4 forearms) | 25°. pro | No |
| Ramachandran K. 2005 [32]<br>(n = 6 forearms) | 10°. sup | 1 forearm with compartment syndrome |
| Hung NN. 2024 (This study)<br>(n = 84 forearms) | 10° - 30°. Pro.<br>77.4% patients had good or excellent results | No |

***Table 3:*** *Compare results of postoperative follow-up with derotational osteotomy.*

With long-term postoperative results, the forearm is always in a 10 - 30 degree pronation position.

## Conclusion

1. Congenital proximal radioulnar synostosis is a rare anomaly, usually occurring bilaterally (52.7%) and 36 males (65.5%) and 19 females (34.5%). The distribution was 9 right forearms and 17 left forearms; 29 patients (52.7%) had bilateral lesions. The mean age at surgery was 6 years and 9 months.
2. This method is a simple and safe technique for rotating the forearm for patients with congenital proximal radioulnar synostosis.

## Limitations of the Study

The results of this study have several limitations:

- First, this study is a retrospective study.
- Second, patients did not have an initial idea of the frequency of follow-up of the final results.
- Third, because the time to obtain the final results with the patient's condition was too long.

## Bibliography


1. Rutkowski PT and Samora JB. "Congenital radioulnar synostosis". *Journal of the American Academy of Orthopaedic Surgeons* 29.13 (2021): 563-570.
2. Barik S., *et al*. "Results after treatment of congenital radioulnar synostosis: a systematic review and pooled data analysis". *Journal of Pediatric Orthopaedics B* 30.6 (2021): 593-600.
3. Michiyo F., *et al*. "Rotational osteotomy at the diaphysis of the radius in the treatment of congenital radioulnar synostosis". *Journal of Pediatric Orthopaedics* 25.5 (2005): 676-679.
4. Miura T., *et al*. "Congenital radioulnar synostosis". *Journal of Hand Surgery (British Volume)* 9B.2 (1984): 153-155.
5. Simmons BP., *et al*. "Congenital radioulnar synostosis". *Journal of Hand Surgery* 8.6 (1983): 829-837.
6. Barik S., *et al*. "Results after treatment of congenital radioulnar synostosis: a systematic review and pooled data analysis". *Journal of Pediatric Orthopaedics B* 30.6 (2021): 593-600.
7. Fujimoto M., *et al*. "Rotational osteotomy at the diaphysis of the radius in the treatment of congenital radioulnar synostosis". *Journal of Pediatric Orthopaedics* 25.5 (2005): 676-679.
8. Pei X and Han J. "Efficacy and feasibility of proximal radioulnar derotational osteotomy and internal fixation for the treatment of congenital radioulnar synostosis". *Journal of Orthopaedic Surgery and Research* 14.1 (2019): 81.
9. Ogino T and Hikino K. "Congenital radio-ulnar synostosis: compensatory rotation around the wrist and rotation osteotomy". *Journal of Hand Surgery* 12.2 (1987): 173-178.
10. Tachdjian MO [editors]. Pediatric Orthopaedics. Philadelphia, W.B. Saunder (1972).
11. Blaine ES. "Congenital Radioulnar Synostosis, with Report of a Case". *Journal of Surgery* 8.2 (1930): 429-434.
12. Mouchet A and Leleu A. "La Synostose CongénitaleRadio-cubitale Supérieure". *Rev. d'Orthop* XII (1925): 421.

13. Stanley F. "Radio-Ulnar synostosis: Historical Review and Case Report". *Journal of Bone and Joint Surgery American Volume* 14.2 (1932): 395-403.

14. Michiyo F., *et al*. "Rotational osteotomy at the diaphysis of the radius in the treatment of congenital radioulnar synostosis". *Journal of Pediatric Orthopaedics* 25 (2005): 676-679.

15. Garland DE., *et al*. "Upper extremity fractures in the acute spinal cord injured patient". *Clinical Orthopaedics and Related Research* 233 (1988): 110-115.

16. Davenport CB., *et al*. "Radio-Ulnar Synostosis". *Archives of Surgery* 8.3 (1924): 705-762.

17. Simmons BP., *et al*. "Congenital radioulnar synostosis". *Journal of Hand Surgery (American Volume)* 8.6 (1983): 829-838.

18. Ogino T and Hikino K. "Congenital radio-ulnar synostosis: compensatory rotation around the wrist and rotation osteotomy". *Journal of Hand Surgery (British Volume)* 12.2 (1987): 173-178.

19. Cleary JE and Omer GE. "Congenital proximal radio-ulnar synostosis. Natural history and functional assessment". *Journal of Bone and Joint Surgery American Volume* 67.4 (1985): 539-545.

20. Griffet J., *et al*. "Les synostoses congénitales radio-cubitales supérieures. A propos de 43 cas". *International Orthopaedics* 10 (1986): 265-269.

21. Poureyron Y., *et al*. "Surgery of congenital radio-ulnar synostosis. Technical error and therapeutic strategy". *Revue de Chirurgie Orthopedique et Reparatrice de l'Appareil Moteur* 82.1 (1996): 80-84.

22. Funakoshi T., *et al*. "The use of pedicled posterior interosseous fat graft for mobilization of congenital radioulnar synostosis: a case report". *Journal of Shoulder and Elbow Surgery* 13.2 (2004): 230-234.

23. Fumino K and Kunio I. "Mobilization of a congenital proximal radioulnar synostosis with use of a free vascularized fascio-fat graft". *Journal of Bone and Joint Surgery* 80.8 (1998): 1186-1192.

24. Tadanao F., *et al*. "The use of pedicled posterior interosseous fat graft for mobilization of congenital radioulnar synostosis: A case report". *Journal of Shoulder and Elbow Surgery* 13.2 (2004): 230-234.

25. Wright TW and Glowczewskie F. "Vascular anatomy of the ulna". *Journal of Hand Surgery (American Volume)* 23A.5 (1998): 800-804.

26. John F D., *et al*. "Ulnar Nonunion After Osteoclasis for Rotational Deformities of the Forearm". *Journal of Hand Surgery (American Volume)* 31A.6 (2006): 973-978.

27. Szabo RM and Skinner M. "Isolated ulnar shaft fractures. Retrospective study of 46 cases". *Acta Orthopaedica Scandinavica* 61.4 (1990): 350-352.

28. Dalton JF., *et al*. "Ulnar nounion after for rotational deformities of the forearm". *Journal of Hand Surgery (American Volume)* 31.6 (2006): 973-978.

29. Murase T., *et al*. "Derotational osteotomy at the shafts of the radius and ulna for congenital radioulnar synostosis". *Journal of Hand Surgery* 28.1 (2003): 133-137.

30. Tsuyoshi M., *et al*. "Derotational Osteotomy at the Shafts of the Radius and Ulna for Congenital Radioulnar Synostosis". *Journal of Hand Surgery (American Volume)* 28A.1 (2003): 133-137.

31. Green WT and Mital MA. "Congenital radio-ulnar synostosis: surgical treatment". *Journal of Bone and Joint Surgery. American Volume* 61A.5 (1979): 738-774.

32. Ramachandran K., *et al*. "Rotational osteotomies for congenital synostosis". *Journal of Bone and Joint Surgery. British Volume* 87.10 (2005): 1406-1410.

33. Simmons BP., *et al*. "Congenital radioulnar synostosis". *Journal of Hand Surgery* 8.6 (1983): 829-837.

34. Castello JR., *et al*. "Congenital radiounar synostosis. Surgical correction by derotation osteotomy". *Annales de Chirurgie de la Main et du Membre Supérieur* 15.1 (1996): 11-17.

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