

The Effect of Soft Tissue Distraction on Deformity Recurrence After Centralization for Radial Longitudinal Deficiency

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Purpose To assess recurrence and complications in children with radial longitudinal deficiency treated with or without external fixator soft tissue distraction prior to centralization.

Methods Thirteen upper extremities treated with centralization alone were compared with 13 treated with ring fixator distraction followed by centralization. Resting wrist position between the 2 groups was compared before surgery, approximately 2 years after surgery (midterm), and at final follow-up, which was at a mean of 10 years for the centralization-alone group and 6 years for the distraction group. Radiographs were reviewed for hand-forearm angle, hand-forearm position, volar carpal subluxation, ulnar length, and physeal integrity.

Results The clinical resting wrist position was improved significantly after surgery and at final follow-up in both groups, but recurrence was worse at final follow-up in the distraction group patients. Radiographically, in the centralization alone group, the hand-forearm angle improved from 53° before surgery to 13° at midterm but worsened to 27° at final follow-up. In the distraction group, the hand-forearm angle improved from 53° before surgery to 21° at midterm but worsened to 36° at final follow-up. The hand-forearm position improved between preoperative and final assessment in both groups, but at final follow-up, the centralization-alone group had a significantly better position. Volar subluxation was 4 mm improved in the centralization alone group and 2 mm worse in the distraction group at final follow-up.

Conclusions Centralization, with or without distraction with an external fixator, resulted in improved alignment of the wrist. Distraction facilitated centralization, but it did not prevent deformity recurrence and was associated with a worse final radial deviation and volar subluxation position compared with wrists treated with centralization alone. (*J Hand Surg Am.* 2014;39(5):895–901. Copyright © 2014 by the American Society for Surgery of the Hand. All rights reserved.)

Type of study/level of evidence Therapeutic III.

Key words Radial deficiency, recurrence, centralization, distraction, fixator.

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RADIAL LONGITUDINAL DEFICIENCY (RLD) is a congenital disorder characterized by hypoplastic or aplastic radial-sided forearm structures. It is one of the most common congenital abnormalities affecting the hand and upper extremity with an incidence between 1 in 30,000 to 100,000 births.^{1,2} In contrast to other congenital longitudinal deficiencies of the upper limb, it is more often bilateral and more commonly associated with other syndromes and anomalies.³ The clinical presentation of this

disorder is varied, ranging from thumb hypoplasia to complete aplasia of the radius. In more severe types of RLD (Bayne and Klug types III, IV, and V),^{4,5} the absent distal radius leaves the carpus unsupported, resulting in radial deviation and flexion of the wrist. In addition to deficiencies of the osseous structures, radial-sided soft tissue structures, including skin, tendons, nerves, and vessels, are also deficient and often contribute to the deformity and impair function.

The aim of treatment of RLD is to improve both the appearance and the function of the extremity. Many believe that correcting the radial deviation and balancing the wrist on the forearm, while preserving range of motion and allowing for continued growth of the ulna, will accomplish these goals.⁶ Centralization, a surgical procedure to reposition the carpus in neutral alignment on the ulna, has been commonly used for this purpose.⁷⁻⁹ However, in many patients, tight radial-sided soft tissues impede the reduction of the carpus on the ulna, making centralization a technically challenging procedure with a high likelihood of recurrent deformity^{1,9-11} and with an increased risk of physeal injury.¹²

In 1989, Kessler¹³ introduced the concept of pre-centralization soft tissue distraction with an external fixator to prepare the soft tissues for centralization and facilitate the reduction of the carpus on the ulna. The concept of gradual stretching of soft tissues has been described by several authors¹⁴⁻¹⁷ since Kessler's description in order to simplify the centralization procedure and minimize complications.¹⁸

Nanchahal and Tonkin¹⁷ evaluated 6 limbs treated with a unilateral distractor prior to radialization and 6 limbs treated without pre-radialization distraction. There was a 19° improvement in hand-forearm angle (HFA) in the radialization-only group and 38° in the distracted group. Furthermore, in the radialization-only group, 5 of 6 patients required carpal resection to facilitate radialization, whereas only 1 of 6 patients in the distraction group required carpal resection. The authors' conclusions that soft tissue distraction with an external fixator was useful for facilitating radialization, avoiding carpal resection, and decreasing tension of neurovascular structures have been adopted by many as the justification for distraction prior to centralization or radialization.

The purpose of this study was to compare the outcomes of children with RLD treated with soft tissue distraction with a ring external fixator followed by centralization with those treated with centralization alone. Specifically, we assessed the magnitude of deformity recurrence and ulnar growth in patients with severe RLD.

MATERIALS AND METHODS

After obtaining approval from our institutional review board, we retrospectively reviewed all cases of Bayne and Klug types III and IV RLD (near-complete or complete absence of the radius) between 1997 and 2009 at our institution treated with soft tissue distraction with an external fixator followed by centralization as we have previously described.¹⁴ We included only skeletally immature patients at time of centralization who had at least 3 years of follow-up. A second group of patients, treated with a centralization procedure alone, represented the comparison control cohort and were chosen from our historically treated patients based on type of RLD, overall similarity in presentation, and duration of follow-up. Patients who had undergone previous wrist surgeries were excluded.

We have a standardized protocol for the treatment of patients with RLD at our institution, although it has evolved over the years. Prior to 1997, we performed centralization with notching the distal ulna to stabilize the centralized carpus. Between 1997 and 2002, we discontinued notching the distal ulna. In 2002, we began using distraction with a ringed external fixator prior to centralization without notching. In patients older than 11 years and with marked recurrence of wrist flexion and radial deviation and with a well-developed epiphysis of the distal ulna, we offer wrist ulnocarpal arthrodesis for permanent improvement of alignment.

Ten patients (4 boys, 6 girls) with 13 affected upper extremities (7 right, 6 left) who had undergone distraction followed by centralization were identified for inclusion in the study. Twelve extremities were Bayne and Klug type IV, and 1 was type III RLD. The mean age at time of centralization was 3.6 ± 1.8 years. The mean duration of fixator placement was 56 ± 15 days. Mean duration of follow-up was 6.0 ± 2.2 years. These patients comprised the distraction group.

The centralization-only group included 10 patients (7 boys, 3 girls) and 13 affected upper extremities who underwent notched centralization only. Twelve extremities were Bayne and Klug type IV, and 1 was type III. The mean age at time of centralization was 2.0 ± 0.8 years, significantly younger than the age at centralization in the distraction group ($P = .003$). Mean duration of follow-up was 10.0 ± 2.7 years (Table 1).

Clinical assessment

The medical record for each patient was reviewed, specifically evaluating 3 time points: pre-centralization,

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