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Outcomes of Opening Wedge Osteotomy to Correct Angular Deformity in Small Finger Clinodactyly

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Abstract

Purpose—To evaluate the outcomes and complications in a series of children with clinodactyly treated with opening wedge osteotomy of the abnormal phalanx.

Methods—We performed a retrospective review of all children with clinodactyly treated at our institution with opening wedge osteotomy of the abnormal middle phalanx between 2003 and 2013. Patients with concomitant pathology or prior surgery in the affected finger were excluded. Pre and postoperative clinical angle, radiographic angle, digital range of motion, and pain were compared, and complications were recorded.

Results—Thirteen digits in 9 patients were included. All had greater than 20° of preoperative clinical angulation (mean 36°). Mean age at the time of surgery was 11 years and mean duration of follow-up was 25 months (12–43 months). All digits had significant improvement (mean 32°) in clinical and radiographic angles after surgery. This improvement was maintained at final follow-up in 12 digits. Six patients had pain preoperatively and no patient had pain postoperatively. One digit had a recurrent deformity at final follow-up, and 3 digits developed stiffness at the distal interphalangeal joint.

Conclusions—Opening wedge osteotomy is an effective treatment for angulation in children with clinodactyly. We counsel families regarding the risk of distal interphalangeal joint stiffness. Level of Evidence: Therapeutic Level IV

Keywords

Clinodactyly; Osteotomy; Opening Wedge; Surgery

INTRODUCTION

Clinodactyly is an angular deformity of a digit in the coronal plane usually caused by an abnormal phalangeal shape. The small finger middle phalanx is most commonly involved and has radial deviation due to either a trapezoidal phalangeal shape (brachymesophalangism) or a longitudinal bracket epiphysis that unilaterally limits longitudinal growth. This results in a triangular or trapezoidal phalangeal shape (delta phalanx) (Figure 1).¹⁻⁴ A familial form of clinodactyly has been described with a dominant pattern of inheritance and variable penetrance, most commonly involving the small fingers.⁵ Over 60 syndromes are associated with clinodactyly, the most common of which is Down syndrome.⁶ Clinodactyly can also be acquired through injury to the physis or phalanx. The angular deformity of the digit can result in an unsatisfactory appearance and can interfere with normal hand function.⁴ Specifically, the angular deformity can result in scissoring that interferes with grip and activities requiring a high level of dexterity, such as playing musical instruments or using the keyboard.

Most cases of clinodactyly are treated with observation and do not require surgical intervention. Surgery is considered when the angular deformity is severe, and either function is altered or appearance is unacceptable to the patient or family. There is no consensus regarding the degree of deformity that merits surgical correction. Some groups have suggested that it should be greater than 20°. ⁷⁻⁹ Several surgical techniques have been described to treat clinodactyly. These include epiphyseal bar resection with fat interposition, closing or opening wedge osteotomies, and reverse wedge osteotomy.^{1,7,9-12} Epiphyseal bar resection with fat interposition is performed in skeletally immature children with an identifiable bracket epiphysis. With removal of the tether, angular correction occurs gradually as the remaining physis grows.⁹ For older children, corrective osteotomies can be used to address the deformity. The closing wedge osteotomy can appropriately correct the angulation, but causes further shortening of the digit, which is undesirable if brachydactyly is already present.¹³ The reverse wedge osteotomy can be technically challenging in a small angular bone. An opening wedge osteotomy has the benefit of preserving length while allowing for correction of the deformity without pre-calculating wedge size.^{1,12,14} The purpose of this study was to evaluate the clinical and radiographic outcomes and complications after opening wedge osteotomy for treatment of clinodactyly of the small finger.

MATERIALS AND METHODS

After obtaining approval from our institutional review board, we performed a retrospective review of the medical charts and radiographs for all patients with isolated congenital clinodactyly of the small finger treated with opening wedge osteotomy. All patients were treated by a single surgeon (C.A.G.) at either St. Louis Children's or St. Louis Shriner's Hospitals between 2003 and 2013. Indications for surgical treatment included an angle greater than 20° and specific functional limitations or dissatisfaction of the patient or parents with the appearance of the digit. We excluded patients with a more complex presentation (such as multiple hand anomalies or co-existent syndactyly) and patients treated with revision procedures.

A certified hand therapist evaluated the patients before and after surgery. We measured clinical angulation of the digit in the coronal plane with a standardized technique. In full extension, a goniometer was placed dorsally to measure digital angulation. We measured radiographic angulation of the digit in the coronal plane on an anteroposterior radiograph with the digit in full extension.⁸ We quantified finger flexion and extension at the metacarpophalangeal, proximal interphalangeal, and distal interphalangeal joints using a small goniometer. Postoperative complications were identified and recorded.

Statistical significance was set at $P < .05$, and was determined with a two-tailed student t-test.

Surgical technique

The positions of the distal and proximal interphalangeal joints were marked, and a V-shaped incision was made between them to produce a medially based dorsal flap (Figure 2). If necessary, redundant medial skin can then be advanced into the lateral defect after deformity correction by extending the incision at its apex and translating the tip of the medial flap laterally (a Y to V advancement). The extensor mechanism was elevated at the lateral side of the deformity. At this point, a 1.1 mm (.045-inch) K-wire was driven longitudinally, retrograde through the distal phalanx, across the distal interphalangeal joint (DIP), and into the distal third of the middle phalanx to stabilize the DIP joint during opening of the osteotomy. This K-wire was positioned parallel to the long axis of the distal phalanx and in a position to be able to pass across the planned osteotomy site. A temporary .9 mm (.035-inch) K-wire was driven obliquely across the proximal interphalangeal (PIP) joint, stabilizing the joint and allowing opening of the osteotomy (Figure 3). Thus, both the DIP and PIP joints were stabilized, ensuring that the observed correction occurred at the osteotomy site and not through the joints.

The mid-point of the middle phalanx was then identified using fluoroscopy. If a bracketed epiphysis was present, a segment of the longitudinal portion of the growth plate was excised. The bone was exposed subperiosteally for the osteotomy. We used a small osteotome for the osteotomy (Figure 2), which was opened to obtain neutral parallel alignment of proximal and distal joint lines of the middle phalanx and hinged on the medial side of the middle phalanx. The 1.1 mm K-wire was then advanced across the osteotomy, and a second retrograde longitudinally placed .9 mm K-wire was advanced across the osteotomy for rotational stability (Figures 2 and 3). The K-wire across the proximal interphalangeal joint was removed. Distal radius bone graft was used in older children with deformities greater than 45°.

The digit was immobilized with an ulnar gutter orthosis with the fingers in intrinsic plus position for 2 weeks, followed by a cast or removable orthosis for an additional 3 weeks. The K-wires were removed 5 to 7 weeks after surgery once healing was confirmed radiographically. Range of motion exercises were then initiated.

RESULTS

Thirteen digits in 9 patients (5 boys) fit the inclusion criteria. Average age at the time of surgery was 11 years (5–14 years). One patient had syndactyly on the ipsilateral hand that

did not involve the digit with clinodactyly, and 4 patients had a documented family history of clinodactyly. No other patient had additional hand anomalies or medical conditions. All cases involved the small finger and all had radial deviation. Five digits had brachymesophalangism and 9 had bracketed epiphyses.

The mean duration of follow-up was 25 months (range 12–43 months). There was a significant improvement in both clinical and radiographic angles between preoperative and final evaluations, with a mean clinical improvement of 32° ($P<.001$) and radiographic improvement of 29° ($P<.001$). There was not a significant difference between immediate postoperative and final follow-up clinical angle ($P=.57$) or radiographic angle ($P=.6$), indicating maintenance of the correction of angulation (Appendix).

Three digits in 2 patients lost motion at just the DIP joint. There was no change in active metacarpophalangeal or PIP joint range of motion between preoperative, postoperative, and final follow-up values in any digit. Mean loss of DIP joint motion in the 3 affected digits was 45° (Appendix). Preoperative coronal angulation in these 3 digits was 40° , 20° , and 45° , respectively. Two digits had brachymesophalangism and 1 had bracketed epiphyses. There was no correlation between DIP joint stiffness and duration of immobilization. The patient with 2 stiff DIP joints had poor compliance with range of motion exercises. Mean total arc of motion for all digits preoperatively was 269° (range 250 – 270°) and at final follow-up was 258° (range 210 – 270°) ($P=.12$).

Six digits were painful preoperatively, and none were painful postoperatively. Preoperative pain was usually a result of abnormal pressure on the medial side of the digit or skin irritation from digital scissoring. No children complained of decreased or abnormal sensation postoperatively. All osteotomies healed. Distal radius bone autograft was used in 2 digits that each had 50° of clinical angulation preoperatively.

One deformity recurred at final follow-up. This was in a 12 year-old boy with no family history and a bracketed epiphysis. He had 40° preoperative clinical and radiographic angles and did not have bone grafting. His immediate postoperative angulation, was 0° and his final clinical and radiographic angulation was 30° . Complications occurred in 3 digits; loss of motion occurred in 3 DIP joints, and the recurrence of angular deformity occurred in one of these digits.

DISCUSSION

The 2 most accepted techniques to correct the angular deformity in clinodactyly are physiolsysis and osteotomy. Vickers described physiolsysis with fat grafting, and several subsequent studies have emphasized that it is ideal in children under the age of 6 or with at least 3 years of longitudinal growth remaining at the digital physes and with an identifiable bracket epiphysis.^{7,9,10}

For children over the age of 6 years, osteotomy is the preferred treatment, however controversy remains regarding the most appropriate type of osteotomy. Al-Qattan showed that closing wedge osteotomy provides satisfactory correction of clinodactyly of the index finger, with a mean correction from 44° to 13° in 10 cases.¹³ Full motion was retained in the

metacarpophalangeal and proximal interphalangeal joints, however there was a 15° to 20° loss of extension in the DIP joints. The closing wedge osteotomy resulted in shortening of the finger, which was unacceptable in fingers with preoperative brachydactyly (index finger tip would not reach the DIP joint of the middle finger postoperatively), and likely led to the observed extensor laxity. Ali et al reviewed the outcomes of 25 digits (20 small, 4 index, and 1 middle finger) with more than 25° angulation treated with closing wedge osteotomy in 17 patients aged one to 15 years.¹¹ At a follow-up of 6 years, the mean clinical angulation had improved from 33° to 9 degrees, radiographic angulation improved from 29° to 5 degrees, and range of motion was maintained. While the effect of closing wedge osteotomy on finger length and extensor laxity was not specifically investigated, these results are favorable.

Several small series have shown variable results with reverse wedge osteotomies, in which a wedge of bone is removed from the concave side of the affected phalanx, rotated 180°, then reinserted with the wide end first, thus buttressing the osteotomy open. Carstam and Theander treated 5 digits (1 thumb, 4 digits) with reverse wedge osteotomy; 4 had acceptable results, but in one, the wedge slipped out of position leading to loss of correction.¹² Burke and Platt treated 2 digits (1 small, 1 ring) with reverse wedge osteotomy for proximal phalanx involvement and had an average correction of 33° with a maintained total arc of motion.⁴ The technical difficulty of reverse wedge osteotomy may make it a less appealing option.

Opening wedge osteotomy maintains or increases the length of the phalanx and allows for a simple correction that does not require pre-calculation of wedge size. This contrasts to closing-wedge osteotomy, which will further shorten an already shortened digit.^{11,13} Extensor laxity, as described by Al-Qattan in the closing wedge osteotomy,¹³ has not been encountered in our series. Instead, the extensor mechanism may be placed under tension with opening of the osteotomy, which may explain the loss of DIP flexion in some of our patients. However, in our study, the degree of osteotomy opening did not consistently correlate with the loss of DIP joint motion. Of the 6 digits with a 35° or greater correction, only 2 developed DIP joint stiffness, suggesting that soft tissue tension alone was not the cause of decreased motion. Immobilization duration also did not correlate with the development of DIP joint stiffness. While the patient with bilateral stiff DIP joints had poor compliance with post-immobilization exercises, he did regain motion in all other joints, suggesting that this alone was not the cause of the DIP joint stiffness. No patient demonstrated articular pathology on postoperative radiographs that would have limited DIP joint motion.

The patient with recurrent deformity (Patient 3 in Appendix) had a 40° angulated digit preoperatively. In retrospect, we hypothesize that placement of a bone graft would have supported the healing phalanx even after K-wire removal, preventing recurrent deformity. As a result, we have begun using distal radius autograft in all cases with a visible gap after opening the osteotomy to prevent nonunion and recurrent angulation. Light et al warned against placing bone graft into an opening wedge osteotomy for fear of creating an epiphyseodesis that could tether phalangeal growth, however we have not encountered this in short term follow-up of patients where bone graft was used.¹ Longer term follow-up will be

required to further evaluate this, and to adequately assess the effects of osteotomy and pinning on the growing phalangeal bone and physis.

Our study is limited by the small number of patients and retrospective reporting. Because of the retrospective analysis, quantified subjective evaluation of patient function and satisfaction was not available. This information would add to our understanding of a successful outcome, especially in those patients with complications. Additionally, our minimum follow-up of one year is relatively short when considering that several patients have substantial growth potential. Longer term follow-up will be important for the assessment of the effects of this procedure on growth.

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Appendix

Appendix

Individual Patient Data

Patient	Side	Age at Surgery (y)	Bone Graft	Duration f/u (m)	Pre-op Clinical Angle (°)	Post-op Clinical Angle (°)	Final Clinical Angle (°)	Pre-op Radiographic Angle (°)	Post-op Radiographic Angle (°)	Final Radiographic Angle (°)	Change in DIP Joint Range of Motion (°)
1	R	13	No	18	30	0	0	30	0	0	0
1	L	13	No	16	20	0	0	20	0	0	0
2	R	12	No	16	30	0	0	30	0	0	0
2	L	12	No	12	40	25	25	33	28	28	0
3	L	12	No	21	40	0	30	40	0	30	25
4	R	7	No	43	25	0	0	25	0	0	50
4	L	8	No	38	45	0	0	45	0	0	60
5	L	9	No	39	40	0	0	27	0	0	0
6	L	5	No	39	35	20	20	35	22	22	0
7	R	12	No	36	30	0	0	35	0	0	0
8	R	13	Yes	13	50	0	0	44	0	0	0
8	L	13	Yes	13	50	15	15	49	15	15	0
9	R	14	No	18	40	0	0	32	0	0	0
Mean		11		25	37	5	7	34	5	7	10

R, right; L, left; y, year; m, month; f/u, follow up

Figure 1.

Clinodactyly. Top left; radial angulation of the small finger due to an abnormal middle phalanx. Top right; scissoring as a result of the angulation. Bottom left; a PA radiograph shows the abnormal trapezoidal shaped middle phalanx. Bottom right; a lateral view of the small finger shows no sagittal plane deformity.

Figure 2.

Opening wedge osteotomy of the middle phalanx. A. The distal and proximal interphalangeal joint lines are palpated and marked, and a V-shaped incision is made with its apex over the lateral aspect of the digit, creating a medially based flap. B. The extensor mechanism is mobilized and protected after raising the full thickness skin and subcutaneous flap. C. An osteotomy is made at the concave aspect of the middle of the middle phalanx. D. The osteotomy is opened to the extent needed to obtain neutral alignment of the finger, and 2 K-wires are driven across. E. The skin is then closed.

Figure 3.

K-wire placement during the opening wedge osteotomy. A 1.1 mm K-wire is driven through the distal phalanx across the distal interphalangeal joint, and a .9 mm K-wire is driven through the proximal interphalangeal joint. These stabilize the joints and allow for opening of the osteotomy (Left). After opening the osteotomy, the 1.1 mm K-wire is driven across the osteotomy, a second .9 mm K-wire wire is driven across the osteotomy for rotational stability, and the K-wire stabilizing the proximal interphalangeal joint is removed (Right).