



Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Middle Phalangectomy for the Correction of Toe Clinodactyly With Longitudinal Epiphyseal Bracket in Young Children

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ARTICLE INFO

Level of Clinical Evidence: 4

Keywords:

children
clinodactyly
longitudinal epiphyseal bracket
phalanx
toe

ABSTRACT

Toe clinodactyly is often owed to the presence of a longitudinal epiphyseal bracket. We developed middle phalangectomy as a simple surgical solution for correction of toe clinodactyly because of longitudinal epiphyseal bracket in childhood. Ten children (ages 1–5 years) were operated on by the same surgeon between October 2007 and May 2012 (n = 15 feet). The same surgical technique was used in all the cases. A clinical evaluation included the appearance of the foot, the parents' level of satisfaction, and the presence or absence of bothersome symptoms (such as pain and discomfort when wearing footwear). A radiological evaluation under weight-bearing conditions enabled us to 1) rate the achievement of a natural-looking toe parabola and 2) detect the recurrence of clinodactyly (defined as an angle of >40° between 2 adjacent phalanges). The mean follow-up period was 5.4 (range 3.3 to 8.1) years. Nine sets of parents (90%) were satisfied with the results of the procedure. None had difficulties wearing boots, and only 1 child (10%) had residual pain during sports activities. Clinodactyly recurred in 3 feet in 3 patients (20% of feet, 30% of patients). Two (20%) of the latter patients underwent repeat surgery and achieved a lasting, satisfactory outcome. Middle phalangectomy is an appropriate procedure for the treatment of toe clinodactyly because of longitudinal epiphyseal bracket in young children. However, the patients' long-term outcomes (notably once bone growth has ended) must be assessed.

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Clinodactyly is defined as a lateral deviation of the fingers or toes (1,2). It can occur as an isolated condition but can also form part of a polymalformative syndrome (1,3). Clinodactyly is often linked to the presence of an anatomical anomaly known variously as “delta phalanx” (3,4) or “longitudinal epiphyseal bracket” (5,6). Longitudinal epiphyseal bracket results from union of a normal, proximal, epiphyseal nucleus and a second, distal supernumerary core located on the concave side of the deformity. By modifying the distribution of stresses, the longitudinally oriented, bridged physis and epiphysis lead to disruption of phalangeal growth. This results in a C-shaped, trapezoidal phalanx (5). Toe clinodactyly has been studied much less extensively than finger clinodactyly. It can affect all the toes of the foot. In addition to aesthetic concerns, toe clinodactyly may be responsible for true functional impairment (including pain and footwear problems) in young children. In fact, clinodactyly worsens with age and leads to overlapping toes. Positional orthoses do not give satisfactory results; therefore, only surgery can ensure correct toe

alignment (7,8). Several surgical techniques are commonly used. Physioly-sis or resection of the longitudinal epiphyseal bracket's epiphyseal bridge (1,5,7,9,10–13) can be performed early in life, whereas opening- or closing-wedge osteotomies are performed when the bones are mature (4,14). In the present study, we developed middle phalangectomy as a surgical alternative in young children with clinodactyly.

Patients and Methods

This preliminary, single-center, retrospective study was based on prospectively collected clinical and radiographic data. Patients were aged between 1 and 5 years and presented with unilateral or bilateral clinodactyly of ≥ 1 toes (Fig. 1). All operations were performed by the same surgeon and followed the same procedure. Before surgery, the presence of a longitudinal epiphyseal bracket was confirmed on posterior-anterior and latero-lateral radiographs (Fig. 2).

Surgical Technique

Surgery was performed under general anesthesia. The patient was placed in the supine position, and a tourniquet was applied to the leg concerned. A dorsolateral incision was made at the second phalanx. After the distal and proximal interphalangeal joints had been identified, the phalanx was simply excised by detaching it from its capsular and tendon attachments (Fig. 3). After having performed a skin wedging on the convex side of the deformation, the capsule and skin were sutured to help with proper alignment of the toe (Fig. 4). No intraosseous K-wires were used. The bandage was removed 5 days after

Financial Disclosure: None reported.

Conflict of Interest: None reported.

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Fig. 1. Clinical appearance of a case of fourth-toe clinodactyly.



Fig. 3. Intraoperative view of longitudinal epiphyseal bracket excision.



Fig. 2. Preoperative posterior-anterior X-ray of a case of fourth-toe clinodactyly with a longitudinal epiphyseal bracket (white arrow).



Fig. 4. View after longitudinal epiphyseal bracket excision and skin closure.

surgery, and the scars were left open to the air. The patients were allowed to put weight on the operated foot immediately.

Clinical Assessment

The children's parents were asked whether they were "very satisfied," "moderately satisfied," or "not satisfied" with the outcome at final follow-up. We also asked the parents whether (in view of the operation's outcome) they would agree to the same surgery again. Pain, discomfort when wearing footwear, and the parents' opinion of the foot's appearance were also rated.

Radiological Assessment

Posterior-anterior and latero-lateral weightbearing radiographs were acquired at the last follow-up. These enabled us to determine whether clinodactyly had recurred (defined as persistent deviation of the toe, with an angle of $>40^\circ$ between the axes of the first and the third phalanx) (15) or, conversely, whether a normal "toe parabola" was present and the operated toe was intermediate in size (relative to the 2 neighboring toes).

Results

Ten children (8 [80%] boys and 2 [20%] girls) underwent longitudinal epiphyseal bracket excision between October 2007 and May 2012. The mean age at the time of surgery was 4.1 (range 1 to 5) years, and the mean follow-up duration was 5.4 (range 3.3 to 8.1) years. Five (50%)

Table
Surgical cases with a preoperative radiological angle more than 40 degrees between the axis of the first and third phalanx (N = 15 feet in 10 patients)

Case	Age (y)	Sex	Side	Preoperative Assessment		Recurrence	Follow-Up Duration (y)	Last Follow-Up Assessment			
				Pain	Discomfort			Radiological Angle R/L	Pain	Discomfort	Parent Satisfaction
1	2	M	Bilateral	No	Yes	No	4.1	0°/0°	No	No	VS
2	4	M	Bilateral	No	Yes	No	5.6	0°/0°	No	No	VS
3	5	F	L	No	No	Yes	8.1	47°	Yes	No	VS
4	2	M	L	No	No	No	3.3	0°	No	No	VS
5	2	M	R	Yes	Yes	No	3.4	0°	No	No	VS
6	5	F	R	No	Yes	No	5	0°	No	No	VS
7	3	M	Bilateral	No	Yes	Yes/first phalanx osteotomy at 11 mo (1 side)	8.1	0°/0°	No	No	VS
8	1	M	Bilateral	No	No	No	5.2	0°/0°	No	No	VS
9	3	M	R	No	Yes	Yes/capsular and skin plasty at 15 mo	7.4	15°	No	No	VS
10	5	M	Bilateral	Yes	No	No	3.9	0°/10°	No	No	MS (for the 2 feet)

Abbreviations: F, female; L, left; M, male; MS, moderately satisfied; R, right; VS, very satisfied.

patients had unilateral clinodactyly, and 5 (50%) had bilateral clinodactyly. In all, 15 feet were treated surgically (Table). The fourth toe was involved in 7 patients (70%), the third toe was involved in 2 patients (20%), and the second toe was involved in 1 child (10%). In 1 case (10%), clinodactyly was associated with syndactyly. None of the children had polymalformative syndrome. Three patients (30%) had a family history of this type of disorder, with similar lesions in a cousin, a brother, and a grandfather, respectively. Surgical decision criteria were pain (2 patients [20%]), discomfort when wearing footwear (6 patients [60%]), and clinical deformity, assessed with a radiological angle $>40^\circ$ between the axis of the first and third phalanx (10 patients [100%]). Aesthetic components were considered but were not surgical criteria unless the radiological angle assessment warranted intervention.

Clinical Assessment

The mean average follow-up period was 5.4 (3.3 to 8.1) years. Nine sets of parents (90%) were satisfied with the intervention (Fig. 5). After healing, none of the children appeared to experience discomfort when wearing footwear. Only 1 child (10%) reported occasional, residual pain. All sets of parents said that they would agree to have their child undergo the same procedure again, if the condition warranted doing so. Eight sets of parents (80%) were very satisfied with the appearance of their child's foot, and 2 (20%) were moderately satisfied.



Fig. 5. Clinical appearance at last follow-up after longitudinal epiphyseal bracket excision in a case of bilateral fourth-toe clinodactyly (white arrows).

Radiological Assessment

Clinodactyly recurred in 3 patients (30%; 3 feet [20%]), giving an incidence of recurrence of 20%. Two patients (20%) underwent further surgery. In 1 case (6.6%), subtraction osteotomy of the proximal phalanx was performed 11 months after the initial surgery. With a lateral approach to the first phalanx, a wedge osteotomy was executed and maintained after skin closure with only a bandage. In the other case (6.6%), capsular and skin plasty were performed 15 months after the initial surgery. In both cases, the postoperative course was uneventful and gave satisfactory long-term outcomes. The third recurrence (6.6%)



Fig. 6. Posterior-anterior X-ray at last follow-up after longitudinal epiphyseal bracket excision in a case of bilateral fourth-toe toe clinodactyly (white arrow).

occurred in a female in whom clinodactyly was associated with syndactyly. At last follow-up (8.1 years), she experienced moderate pain when running but was satisfied with appearance of her toes. Eight patients (80%) displayed a normal toe parabola (Fig. 6). One (10%) of the 2 patients with an abnormal parabola was moderately satisfied with the outcome. No infections or other complications were observed.

Discussion

In the present study, we evaluated middle phalangectomy as a therapeutic option for the correction of toe clinodactyly because of longitudinal epiphyseal bracket in young children. Even though this was a retrospective study of a small number of cases (10 patients and 15 feet), all the children were evaluated clinically and radiologically at last follow-up visit. Furthermore, previous reports in this field did not feature a greater number of participants than in the present series (1,10). Our average follow-up time was 5.4 (range 3.3 to 8.1) years. Follow-up through to the end of the growth period appears to be necessary for assessment of the final outcome of these operations.

The recurrence rate (i.e., the proportion of operated feet with an angle $>40^\circ$ between the first and the last phalanges) was 20%. The incidence of 2 early recurrences might be related to our decision not to use an intraosseous pin (to avoid possible secondary epiphysiodesis) or to insufficient capsular plasty. The only late recurrence occurred in a patient with associated syndactyly. The latter patient was satisfied with the surgery's outcome.

Orthotics have proven not to be effective in clinodactyly, and so the treatments described in the literature are based on surgery (7,8). Although many different surgical techniques have been described, most concerned finger clinodactyly. In young children (under the age of 3), corrective procedures such as osteotomies are particularly difficult and can disrupt toe growth (2). Physiolysis (i.e., resection of longitudinal epiphyseal bracket, located on the short side of the longitudinal epiphyseal bracket) is indicated in such cases and can restore a normal growth plate (11).

Light and Ogden (7) as well as Bednar et al (12) have suggested resection of the epiphyseal bracket and the interposition of fat tissue. In the series of 12 cases of fifth finger clinodactyly reported by Vickers (1), this technique had generally good outcomes; there was only 1 recurrence (requiring corrective osteotomy) 6 years later. Mubarak et al (8) have suggested interposing a polymethylmethacrylate (PMMA) cement implant instead of fat. More recently, Shea et al (10) recommended interposing 1) a PMMA implant when the epiphyseal bracket is ossified and 2) fatty tissue (or even nothing) when bracket is not yet ossified. Bor et al (13) recommended interposing PMMA to treat metatarsal epiphyseal bracket at the preossified disease stage. In older children, osteotomies can be performed more easily (2,14). The outcome of osteotomy is better after the growth period has finished, and this technique is usually reserved for severe cases of clinodactyly. Phalangeal closing-wedge, opening-wedge, and reversed cuneiform osteotomies have been described (4,16). These operations are most appropriate and feasible when the phalanx is wide. However, they often require additional procedures for the soft tissues contractures on the shorter side of

the phalanx (such as Z-plasty or skin grafts); the latter are associated with a nonnegligible risk of skin complications.

Excision of the phalanx for longitudinal epiphyseal bracket has been suggested in the hand previously. Blauth (17) recommended it for finger clinodactyly when the longitudinal epiphyseal bracket is small and in young children (because of their remodeling capacity). Carstam and Theander (18) performed resections of supernumerary delta phalanges of the thumb, with good clinical outcomes. We believe that this procedure is a valid option for the correction of toe clinodactyly in young children because of 1) its simplicity, 2) the uneventful clinical course, 3) the lack of a need for soft tissue remodeling, and 4) the lack of a need for interposing material.

In conclusion, middle phalangectomy is an excellent technique for the correction of toe clinodactyly due to longitudinal epiphyseal bracket in young children. It has satisfactory clinical and radiological outcomes. The high rate of recurrence of clinical deformity does not affect satisfaction and can be treated very easily. However, the very long-term outcomes (i.e., after the end of the growth period) have yet to be comprehensively assessed.

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