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Special Issue

Long term functional outcomes after early childhood pollicization

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ABSTRACT

Study design: Retrospective Cohort
Introduction: Important outcomes of polliciation to treat thumb hypoplasia/aplasia include strength, function, dexterity, and quality of life.
Purpose of the Study: To evaluate outcomes and examine predictors of outcome after early childhood pollicization.
Methods: 8 children (10 hands) were evaluated 3–15 years after surgery. Physical examination, questionnaires, grip and pinch strength, Box and Blocks, 9-hole pegboard, and strength-dexterity (S-D) tests were performed.
Results: Pollicized hands had poor strength and performance on functional tests. Six of 10 pollicized hands had normal dexterity scores but less stability in maintaining a steady-state force. Predictors of poorer outcomes included older age at surgery, reduced metacarpophalangeal and interphalangeal range of motion, and radial absence.
Discussion: Pollicization resulted in poor strength and overall function, but normal dexterity was often achieved using altered control strategies.
Conclusions: Most children should obtain adequate dexterity despite weakness after pollicization except older or severely involved children.
Level of evidence: IV
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Introduction

Thumb hypoplasia or aplasia accounts for up to 16% of all congenital hand deformities and is bilateral in 12–63% of patients.[1] Absence of the thumb results in a loss of up to 40% of hand function.[2] Surgical options to reconstruct the thumb include toe to thumb transfer, distraction lengthening, and pollicization.[3] Pollicization is the process of creating a thumb from the next most radial finger. It involves surgical translocation of the radial most digit into a position of thumb function. Nerves and arteries are rotated on a pedicle, and muscle and tendon transfers are performed to create a "new" thumb that can perform the functions of flexion, extension, abduction, adduction, and opposition. Pollicization changes the anatomy of the hand, but the brain must also adapt to accommodate and control the new structural setup. Brain imaging studies have shown that neuroplasticity occurs after thumb reconstruction with increased brain activity in regions that control the thumb.[4]

Most assessments of hand function involve functional testing that evaluates the ability to perform specific tasks, the time it takes to perform those tasks, or the quality of movement during task performance. Many established functional measures are available such as Box and Blocks,[5] Jebsen Taylor,[6] peg board,[7] Functional Dexterity Test (FDT),[8] Assisting Hand Assessment (AHA),[9] ABILHAND-Kids,[10] Melbourne Assessment (MA2),[11] and Shriners Hospitals Upper Extremity Evaluation (SHUEE).[12] These tests generally examine whole-arm function, assessing a combination of strength, coordination, and gross and fine motor control. To focus specifically on manual dexterity and neural control for fingertip force

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magnitude and direction, the Strength-Dexterity (S-D) test can be used.[13–15] Subjective assessments have also been performed using questionnaires such as the Michigan Hand Outcomes Questionnaire (MHQ),[16] Canadian Occupational Performance Measure (COPM),[17] Disability of Arm, Shoulder, and Hand (DASH),[18] Pediatric Outcomes Data Collection Instrument (PODCI),[19] and Short Form 36 (SF-36).[20]

Existing studies of outcomes after early childhood finger pollicization for thumb hypoplasia have demonstrated decreased strength and performance on functional tests compared to age-matched norms and non-operated contralateral hands.[21–25] Despite their functional limitations, patients and parents tend to rate their satisfaction and quality of life unexpectedly high.[26–29] Less is known about the recovery and development of neuromuscular control of fingertip forces after pollicization. Neural and muscular contributors to dexterous manipulation are particularly plastic during development and improve over an extended period,[30–33] and thumb absence and reconstruction are likely to alter the brain via this process of neuroplasticity.

Purpose of the study

The purpose of this study was to evaluate mid- to long-term outcomes after early childhood pollicization using a combination of functional tests and questionnaires, as well as the S-D test and to examine potential predictors of surgical outcomes. This evaluation may help to guide surgical intervention and rehabilitation strategies to maximize musculoskeletal and neural control capabilities in this population.

Materials and methods

This study examined 8 children who had undergone pollicization surgery to address thumb hypoplasia or aplasia (10 pollicized hands, Blauth V) at a young age (≤5 years) (Table 1). Two children had bilateral involvement; all but 2 children were diagnosed with VACTERL Association[34]; 1 child with VACTERL and bilateral involvement also had Klippel-Feil syndrome.[35] Pollicization was performed between 1994 and 2010 by a single surgeon at a single hospital using the modified Buck-Gramcko technique.[36] Post-operative care consisted of 6 weeks of casting, 6 months of night splinting, and 6 months of a home rehabilitation program with or without occupational therapy services. The time since pollicization ranged from 2.9 to 15.7 years (mean ± standard deviation, 8.2 ± 4.1 years). The average age at testing was 10.6 ± 4.5 years (range 4–17) (Table 1). Written assent and consent were obtained from the participants and their parents or legal guardians following IRB-approved protocols.

Surgical technique

A modified Buck-Gramcko surgical technique was utilized (Fig. 1). Manual compression was used to exsanguinate the extremity and the tourniquet was elevated to 200 mm Hg. The dorsal skin was incised primarily to identify the critical dorsal veins, and then the palmar incision was completed to identify the radial and ulnar neurovascular bundles to the index and middle fingers. Using 8-0 nylon, the radial digital artery to the middle finger was divided just distal to the common branching. The common nerve was microdissected in line with the fascicles to the level of the carpal tunnel. The A1 pulley was opened; next the middle finger was spread away from the index finger and the transverse intermetacarpal ligament was released.

The tendons of the first dorsal and palmar interossei muscles were harvested for transfer. The metacarpophalangeal (MP) head was cut at the epiphysis, and the shaft of the metacarpal was removed. The epiphysis was sewn into the carpal insertion in 45-degrees of abduction and 120-degrees of pronation. The extensor tendons were separated and shortened with the IP joint in full extension. The extensor digitorum communis (EDC) index was inserted as the abductor, and the extensor indicis proprious (EIP) became the new extensor pollicis longus (EPL). The tendons of the first dorsal and palmar interossei were transferred to the ulnar and radial lateral bands at the level of the new thumb proximal phalanx. The skin was closed transposing the dorsal flaps laterally and maintaining the position of the thumb in relation to the rest of the hand.

Rehabilitation

Following surgery, the child was placed in a cast for 4–6 weeks. After cast removal, a forearm-based removable night orthosis was fabricated placing the new thumb in abduction with the IP joint extended, which the child was asked to wear for an additional 6 months. The night splint was intended to maximize the 1st web space. If necessary, tape or a soft splint was used to maintain the new thumb in an abducted position during the day. A thermoplastic day splint was generally not recommended as this does not give the child the opportunity to actively develop the musculature of the new thumb. Additionally, the family was educated in scar management, edema control and ways to promote active movement of the new thumb.

Post-operative therapy primarily consisted of family training to instruct the child's caregiver(s) in thumb passive and active range of motion (ROM) exercises followed by age-appropriate activities to facilitate the use of the pollicized digit as a thumb. Buddy taping all fingers together was a helpful technique to isolate the thumb for more active movement during grasp. Fine motor activities generally began with repetitive radial digital grasp and release of larger objects, moving to static pinches of smaller objects. With more

Table 1
Characteristics of the study participants

Participant	Sex	Side	Dominant hand	Original diagnosis	Age at pollicization (yr)	Age at test (yr)	Time since pollicization (yr)	Bayne classification
1	F	Right	Left	None	2.7	9.9	7.2	II
2	F	Left	Left	VACTERL, Klippel–Feil syndrome	3.1	13.9	10.8	III
2	F	Right	Left	VACTERL, Klippel–Feil syndrome	5.0	13.9	8.9	IV
3	M	Right	Left	VACTERL	3.4	15.2	11.7	IV
4	M	Right	Left	VACTERL	2.5	5.3	2.9	IV
5	M	Right	Left	VACTERL	3.5	11.2	7.6	I
6	M	Left	Right	None	1.2	16.9	15.7	I
6	M	Right	Right	None	1.2	16.9	15.7	I
7	M	Left	Right	VACTERL	2.0	7.3	5.4	II
8	M	Right	Left	VACTERL	1.8	5.1	3.3	II

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