

Index finger pollicization for treating a congenitally nonfunctioning thumb in patients with radial longitudinal deficiency

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Abstract. Radial longitudinal deficiency (radial club hand) is a congenital deformity in the upper extremity that can present with a range of thumb deficiencies. A variety of surgical procedures to correct for absence of a thumb have been described, such as pollicization, osteoplastic reconstruction, toe to hand transfer, and extension with distraction.

We have reviewed 8 index finger pollicizations in 6 patients after correction of the radial club hand deformity through wrist centralization. Four hands used were the dominant hand. Buck-Gramcko's technique was used with a mean age of 4.6 (range from 2 to 14) years.

The mean follow-up time was 6 (range from 2 to 10) years. The mean active range of motion at the pollicized digit was 121.4 (range from 83 to 150) degrees. The result was considered excellent in 5 cases (62.5%), good in 2 cases (25%), and fair in 1 case (12.5%) in accordance with Percival's scoring system; none of the outcomes were poor. The younger patients adapted easier.

Index finger pollicization is a method that provides dramatic improvement to hand function in thumb aplasia or severe hypoplasia, which may be preferred in treatment. The operations improved hand cosmetic appearance and functional ability.

Key words: Radial longitudinal deficiency, nonfunctioning thumb, pollicization

1. Introduction

Radial longitudinal deficiency (radial club hand) is a congenital deformity in the upper extremity that can present with a range of thumb deficiencies. A variety of surgical procedures to correct for an absent thumb have been described, such as pollicization, osteoplastic reconstruction, toe to hand transfer, and extension with distraction (1-4). Pollicization includes transferring an index finger with the neurovascular pedicle to the thumb position. In the past, it has been used for traumatic thumb amputations. Currently, it is used for congenital thumb absence and a nonfunctioning thumb (5).

The aim of this study was to discuss the results from our cases with radial club hand and a nonfunctioning thumb in which we performed index finger pollicization and to review the literature.

2. Patients and methods

We have reviewed 8 index finger pollicizations in 6 patients that were performed between 2002 and 2010. The mean age of the patients during the operation was 4.6 (range from 2 to 14) years. The mean follow-up age was 6 (range from 2 to 10) years. The sex ratio was 2 males and 4 females. The nonfunctioning thumbs were associated with a radial club hand deformity.

The patients were examined for range of motion, grasp and pinch strength in the new thumb; radiographs were generated. We further evaluated the ability to perform daily activities as well as manipulate small and large objects using the new thumb. The parents were asked if they were satisfied with the outcome. Percival's scoring system was used to assess strength,

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mobility, sensation, dexterity and appearance (6). Grip, thumb-key and tip-pinch strengths were measured with a Jamar dynamometer, and sensation was recorded using Semmes-Weinstein monofilaments (Table 1).

Surgical Technique

Before index finger pollicization, centralization was performed in a previous session to stabilize the hand at the ulna (Figure 1a-b). The surgeries were performed under general anesthesia. A tourniquet and loop magnification was routinely used.

Table 1. Percival's assessment method

Tip pinch strength (bulb manometer: %)		
✚ <25		0
✚ 25 to 75		1
✚ >75		2
Accuracy (pin and coin)		
✚ Unable		0
✚ Difficulty		1
✚ Ease		2
Pulp pinch strength (bulb manometer: %)		
✚ <75		0
✚ >75		1
Accuracy (key)		
✚ Unable		0
✚ Able		1
Opposition		
✚ Middle		1
✚ Ring		1
✚ Little		1
Grasp		
✚ Tennis – ball		1
✚ Table – tennis ball		1
✚ Strength >75%		1
Mobility		
✚ CMCJ		1
✚ MPJ		1
✚ IPJ		1
Sensation (two - point: mm)		
✚ < 5		3
✚ 5 to 10		2
✚ > 10		1
Cosmesis		
✚ Tip to within 0.5 mm PIPJ index		1
Position		
✚ 45 to 80° abduction		1
✚ 90 to 160° rotation		1
✚ Appearance		1
Scores		
❖ >20		Excellent
❖ 16 to 19		Good
❖ 12 to 15		Fair
❖ <12		Poor

CMCJ: carpometacarpal joint, MPJ: metacarpophalangeal joint, IPJ: interphalangeal joint, PIPJ: proximal interphalangeal joint.

After centralization, we performed pollicization on the index finger. We generated a slightly “S” shaped incision with a distal limit at the midpoint for the proximal phalanx length on its midpalmar aspect. The incision proximal limit was on the level of the second metacarpal base. The second incision was on the proximal phalanx dorsum, and its length comprised the proximal interphalangeal joint to the metacarpophalangeal joint. The third line encircled the finger by passing from a point obliquely palmar ward on either side of the metacarpophalangeal joint transversely across the palmar aspect of the finger and intersected the other line (Figure 2a-b). For these fingers, the common neurovascular pedicles beneath the ligament were identified and dissected. The hand was turned over and both neurovascular bundles for the index were freed as proximally as possible. We freed the proximal and distal flexor tendons. The flexor tendon was cut away from the palmar plate. The intrinsic tendons proximal to the musculotendinous junction were dissected and freed, and the muscles from the dorsum were mobilized. Then, the wing tendons distal to the dorsum at the proximal interphalangeal joint were freed from the central extensor tendon. They remained attached to the extensor mechanism over the joint. The extensor digitorum communis and extensor indicis proprius were identified, and the former were cut on the level of the metacarpophalangeal joint. The extensor digitorum communis proximal end was later tagged and reattached as the abductor pollicis longus. The flare at the base of the metacarpal was identified, and the bone was cut on this level. Distally, the cartilaginous head was sliced off with the growth plate. The thumb was freed to be fixed in place. A pocket was developed in the soft tissue for the metacarpal head (new trapezium). The head was properly rotated and anchored with sutures. The proximal end of the extensor digitorum communis was attached to the old proximal phalanx base to produce the new abductor pollicis longus. The dorsal interosseous became the new abductor pollicis brevis, and the palmar interosseous became the new adductor pollicis. The flexor tendons were not shortened, but the extensor indicis proprius was (Figure 3a-b). After the thumb was freestanding with the muscle balance, the thenar area was closed with skin. We applied voluminous dressing and a plaster of Paris slab molded to hold the thumb in the proper abduction and opposition position. We resumed immobilization for 6 weeks (Figure 4a-b).

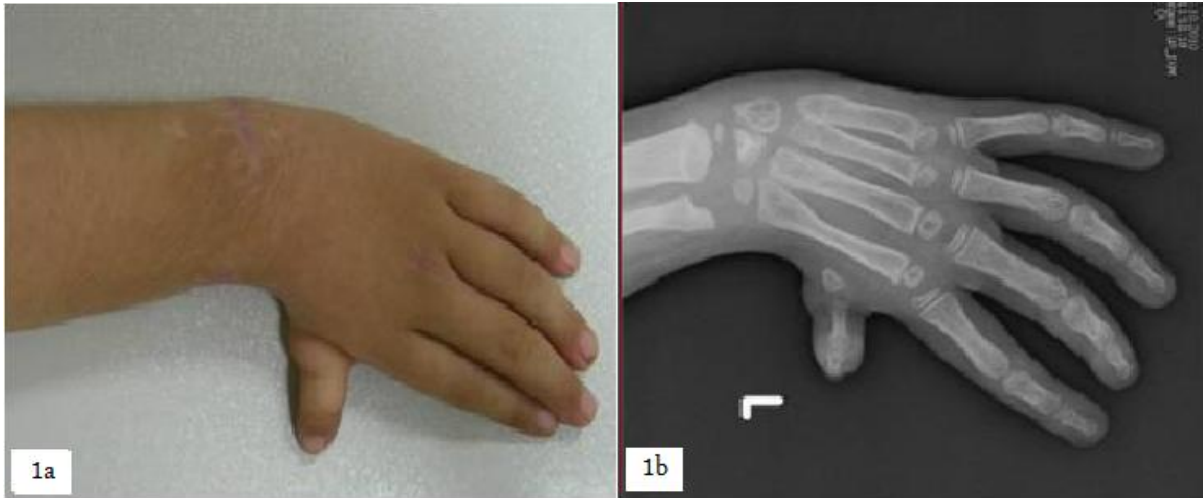


Fig. 1a-b. The hand after centralization.



Fig. 2a-b. Skin incisions for index finger pollicization.



Fig. 3a-b. The flexor tendons were not shortened, but the extensor indicis proprius was.



Fig. 4a-b. Early postoperative period for index finger pollicization.



Fig. 5a-b. The hand after pollicization at 24 months postoperation.

3. Results

Four hands were the dominant hand. Buck Gramcko's technique was used, with a mean age of 4.6 (range from 2 to 14) years. The mean follow-up time was 6 (range from 2 to 10) years (Figure 5a-b). The mean active range of motion at the pollicized digit was 121.4 (range from 83 to 150) degrees (Table 2). None of the patients lost his/her digit. The result was considered excellent in 5 cases (62.5%), good in 2 cases (25%), and fair in 1 case (12.5%) in accordance with Percival's scoring system; none of the outcomes were poor (Figure 6a-b).

4. Discussion

The thumb is the most important finger in people's daily activities. Its absence impairs adaptation to the individual's environment and the ability to manipulate objects. A thumb's absence,

which may result from congenital or traumatic events, is a major problem for hand function because 40% of hand function relies on a sufficiently strong thumb (1,2). The objectives of thumb reconstruction include stability, position, sense, strength, mobility and aesthetics.

Index finger pollicization is a commonly used method that has been generally accepted in surgical treatment for congenital thumb hypoplasia or aplasia (7). In 1971, Buck and Gramcko standardized and popularized this method, and in the 2 years that followed, pollicization became popular. Since then, the method has only changed slightly. Currently, Buck-Gramcko's suggestions and results are followed throughout the world (2,8).

Pollicization method has two goals. The first goal is to improve the patient's ability to hold and grip large objects. Children without a thumb can manipulate small objects with an index finger and

the next finger through a pinch (side-by-side pinch). However, it is difficult to grasp large objects. The second goal is to improve the appearance of the hand and make it appear more normal because a hand with 3 fingers and a thumb has a more normal appearance than a hand with 4 fingers without thumb (5). Thumb hypoplasia covers a broad range from a light little finger to complete absence of a finger. It may be isolated or with additional radial longitudinal deficiencies. It may be associated with other organ system diseases (9-13). Thumb hypoplasia is characterized by a reduced thumb size, metacarpal adduction, MCP joint instability, thenar muscle aplasia or hypoplasia, and extrinsic tendon dysplasia. In severe cases, thumb aplasia and CMC joint instability may be observed (14). In three of our patients, the additional abnormality was present.

Congenital anomalies in the thumb are divided into 4 types by Müller and 5 groups by Blauth in accordance with the degree of hypoplasia and associated structural anomalies; type 3 was divided into two sub-groups by Manske and Mc Carroll (1,15-18).

Type 1: Minimal thumb hypoplasia

Type 2: Moderate thumb hypoplasia; 1. web-space narrowing, MCP joint instability, and thenar muscle hypoplasia

Type 3a: Type 2 features plus extrinsic tendon abnormalities, hypoplastic metacarpal, and stable CMC

Type 3b: Type 3a features plus unstable CMC.

Type 4: Floating thumb

Type 5: Absent thumb (1,15,16,18)

The goal of treatment is to provide a stable and functional thumb (9). Pollicization is performed

for congenital absence of or a nonfunctioning thumb (5). Currently, index finger pollicization is the reconstruction method for type IIIB, type IV and type V cases (1). In our cases, three were Type III, and 5 were type IV. The reconstruction philosophy for congenital deficiency in a thumb is different from reconstruction of a posttraumatic thumb. The disadvantage of this method is that it is destructive. It is difficult to convince a patient's parents on the difficult decision to amputate the remains of the useless thumb and use the second finger for reconstruction (1).

Pollicization results depend on the type and associated anomalies. For example, the results from cases with radial club hand may be less successful (1,7,19,20). These observations are also true for severe anatomic deficiencies in an index finger. The lack of movement in index finger joints for patients with radial clubhand is also observed in the ulnar fingers related to such index fingers. Depending on the severity of radial dysplasia, index finger stiffness has also been observed. Corrected or uncorrected with distraction, it may be aggravated by radial club hand. Further, the muscles on the radial side of the index finger are abnormal in radial club hand, including dorsal interossei aplasia or hypoplasia (1). Blauth has produced the best results for type III and IV deformities. Weak results have been generated in patients with type V and radial hypoplasia (19). The results from seven thumbs herein were excellent or good. Our oldest patient had accompanying diseases, and his result was assessed as insufficient. The patient also underwent forearm lengthening from forearm shortness (7cm lengthening aided by a circumferential external frame).

Table 2. Patients' clinical data

N	Age	Sex	Bilateral Side	RLD Type (R/L)	Blauth Type (R/L)	Associated Anomalies	Follow-up(yr)	TAM ¹ (R/L)	Percival Score (R/L)	Parents Score
1	2.5	F	Right	IV	5	No	9	145	21	9/10
2	4	M	Left	III	4	Vater Synd	4	99	19	8/10
3	14	M	Left	IV	5	Vater Synd	2	83	15	6/10
4	2	M	Bilateral	IV/III	4/3	No	4	150/140	21/20	10/10
5	2	M	Left	III	5	Brachyphalangia	5	94	18	8/10
6	3	Male	Bilateral	IV/IV	5/5	No	10	120/140	20/21	9/10

TAM¹: Total active motion (Degrees) F: Female, M: Male

Excellent: 5 (62.5%)

Good: 2 (25%)

Fair: 1 (12.5%)



Fig. 6a-b. Functional result from index finger pollicization.

There are differences for patients depending on their age at surgery in the various series. Certain authors recommend surgery at an early age, which produces better functional results, and the index finger is perceived as the thumb by the cortex. Certain authors do not recommend surgery at an early age because the absent thumb is not perceived by the cortex, and the brain detects it as the radial finger, for example, the index finger. Such authors have approved the early surgery for social rather than functional reasons. Surgical intervention should be delayed with an associated syndrome (Fanconi, Holt-Oram, etc.) (1,4,21-23). Performing the surgery after 2 years of age has advantages, as the patients are more compatible and learn a variety of tasks much easier in the early postoperative period. However, such patients perform poorly in daily activities. Under stress, they prefer the side-by-side pinch movement to hold small objects (1). Early surgery is beneficial for brain adaptation, and the patient adapts to daily activities easier, but these benefits are limited by the anatomical sizes of the neurovascular and musculocutaneous structures (24). As the sensory for a child's thumb develops in the cerebral cortex after 12 months, Buck and Gramcko recommend performing the surgery at 9 to 12 months. Thus, the newly created thumb will be perceived as normal. In addition, the transposed index finger will have long growth period as a thumb, and thus its functions will be affected. However, without the congenital thumb, the cortex perceives the index finger as in the radial position. Therefore, at this age, moving the index finger to the thumb position may not be important. In previous studies for pollicizations performed in the range 9 months to 16 years, age-

related differences in function were not observed. In most cases, early intervention was due to aesthetic and social reasons rather than functional effects (5,8).

Most surgeons perform surgery early. New pinch pattern formation should not be the purpose for the operation; the aim should be to correct the current pattern. Foucher et al. (21) prefer to perform surgery at approximately one year of age. Thus, a better view is obtained, and parents' anxiety may be reduced.

Another method used for reconstructing a nonfunctional thumb is toe to thumb transfer. Frequently, thumb deformities due to congenital abnormalities include a range of anomalies from hypoplasia to aplasia in muscular, tendinous, vascular, nervous and bony structures on the radial side of the hand, which are distinct from traumatic deformities. Thus, the donor's vascular, nervous or tendinous structures may not be available during toe to thumb transfer. Muscles that can be adapted for abduction and adduction may be insufficient due to anomalies in the thenar and dorsal muscles. Nerve repair is another disadvantage and produces a sensory deficit on the fingers. From an appearance perspective, the index finger is more similar to the thumb than the toe. Thus, pollicization yields better function and appearance results compared with the toe to thumb transfer for congenital anomalies.

As a result, the advantages of pollicization are appearance, movement for all thumb joints and sensory protection. The thumb power after pollicization is good; for example, many patients can easily hold a key. Loop use and meticulous work is necessary for a satisfactory result. Despite the small number of cases, younger patients adapt easier. Therefore, the process

should be completed as early as possible. In the situations with an accompanying radial club hand, muscle hypoplasia and aplasia may yield worse results. To improve the results, additional surgery may be necessary. Index finger pollicization is a method that provides a dramatic improvement in hand functions for thumb aplasia or severe hypoplasia, which may be preferred in treatment.

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