The Snow-Fink technique as an opposition tendon transfer for children born with a hypoplastic or absent thumb

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Abstract

Background A novel opposition tendon transfer, previously described by Snow and Fink in adults but not in children, can provide better functional results and cosmetic appearance than the currently preferred Huber transfer.

Methods Thirty-one children were born either without a thumb (17) or with a hypoplastic thumb (14). Thirty-eight thumbs were classified according to the Blauth classification as stages II, IIIA, IIIB, IV, and V respectively. The opposition tendon transfer was performed between the ages of 4 and 10, using the expendable flexor digitorum superficialis (FDS) tendon from the ring finger which was passed through a 3-mm-diameter window in the transverse carpal ligament, routed subcutaneously across the palm and attached to the insertion of the abductor pollicis brevis on the base of the proximal phalanx of the thumb. This creates a vector of pull from the ulnar side of the hand which both abducts and pronates the thumb. Twenty-one hands underwent additional procedures such as four-flap Z-plasty (11), ulnar collateral ligament reconstruction (6), joint transfer, full-thickness skin grafting, and distraction lengthening.

Results The ability of each child to oppose their thumb to the index finger (score 2), middle finger (score 3), ring finger (score 4), or small finger (score 5) was assessed preoperatively and postoperatively by their Kapandji score. Thirty-one children (81.6 %) achieved a postoperative Kapandji score of 5, while 7 children (18.4 %) had a postoperative Kapandji score of

4. No deformities were observed, and the metacarpophalangeal (MCP) joint was stabilized with the other slip of the FDS when necessary.

Conclusions An opposition transfer using the FDS tendon of the ring finger through a window in the transverse carpal ligament is a simple and reliable technique for improving thumb function in children born with an absent or hypoplastic thumb. This transfer does not produce a concave deformity in the hypothenar eminence like the Huber transfer, provides better pronation, and affords concurrent stabilization of the MCP joint.

Keywords Tendon transfer · Opponensplasty · Thumb hypoplasia

Introduction

Congenital thumb deficiencies are classified according to the classification system initially developed by Mueller and later refined by Blauth [2]. Opposition tendon transfers may be considered for Blauth type II and IIIA hypoplastic thumbs. Some surgeons have advocated opposition tendon transfers for Blauth type IIIB thumbs [24]. The true incidence of opposition tendon transfers for Blauth types IV and V after pollicization is not known. Depending on surgeon preference, the rate of opposition tendon transfer after pollicization ranges from 0 to 100 % [8, 11, 13, 15, 17, 27, 28].

Several opposition transfers have been described in children—the abductor digiti minimi (ADM—Huber transfer) [5, 8, 9, 13–15, 20, 21], extensor pollicis longus (EPL) [18], palmaris longus (Camitz transfer) [9], and the flexor digitorum superficialis (FDS) [19]. Of all these techniques, the Huber transfer seems to be the most frequently used. However, the

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biomechanical characteristics of an FDS transfer restore 60 % of thenar muscle strength whereas the ADM transfer is significantly weaker [7]. This finding lends credence to using the FDS for opposition tendon transfers in adults. Royle and Thomson described a technique in which the FDS of the ring finger is routed subcutaneously above the carpal tunnel and sutured to the head of the thumb metacarpal [23, 30]. Bunnell routed the FDS through a pulley using a distal-based slip of the flexor carpi ulnaris (FCU) or a free tendon graft at the level of the pisiform bone [3]. Snow and Fink introduced a novel routing of the FDS through a window in the flexor retinaculum for adults with median nerve palsy [25]. To our knowledge, this method has only been used in a few adults with Charcot-Marie-Tooth disease and paralytic claw-thumb deformity [19, 26, 31] but has never been described in pediatric patients.

Methods

Patients

From 1995 to 2013, Snow-Fink opposition tendon transfers were performed in 38 thumbs in 31 children. Twenty-two were post-pollicization thumbs while 16 were hypoplastic thumbs. Of the 31 children, seven had bilateral and 24 had unilateral procedures. Preoperatively, the thumbs were classified according to the Blauth classification modified by Manske and McCarrol [16]. The patient cohort consisted of 4 type II thumbs, 9 type IIIA thumbs, 3 type IIIB thumbs, 3 type IV thumbs, and 17 type V thumbs. Two thumbs were part of five-fingered hands. The mean age at the time of operation was 5.22 years with a range from 4 to 10 years. All children were followed postoperatively for an average of 4.7 years (range of 1 to 14 years).

Surgical Technique

A 1-cm-long transverse or oblique incision at the base of the ring finger or an oblique incision over the proximal phalanx is extended down to the flexor tendon sheath. The A1 pulley is incised and the two slips of the FDS tendon are identified. With flexion of the finger, the two slips of the FDS tendon are transected. A second curved incision is made at the base of the hand and extended down through the subcutaneous tissues to the anterior surface of the transverse carpal ligament. A 3-mm-diameter window is made along the ulnar border of the transverse carpal ligament midway between the proximal and distal margins (Figs. 1 and 2). The FDS tendon to the ring finger is extracted through this window (Fig. 3). A third incision is made over the radial aspect of the metacarpophalangeal (MCP) joint of the

Fig. 1 Three incisions for the Snow-Fink opposition transfer—one at the base of the ring finger, one overlying the transverse carpal ligament, and one over the radial aspect of the MCP joint of the thumb. A 3-mm-diameter window has been excised from the ulnar aspect of the transverse carpal ligament midway between its proximal and distal margins

thumb, and a flap is elevated to identify the insertion of the abductor pollicis brevis tendon. A subcutaneous tunnel is made connecting this incision with the incision at the base of the hand (Fig. 4). Using a tendon passer, the FDS tendon is routed through this tunnel to the insertion of the abductor pollicis brevis tendon. With the wrist in neutral and the thumb in full abduction, the FDS tendon is retracted to its resting position and sutured to the abductor pollicis brevis tendon just proximal to the MCP joint. Additional procedures such as ulnar collateral ligament (UCL) reconstruction (Fig. 5), four-flap Z-plasty, full-thickness skin graft, distraction lengthening, and joint transfers are performed when necessary. The thumb is immobilized in full abduction for 6 weeks.

Fig. 2 Close-up view of the window in the transverse carpal ligament

Fig. 3 The ring finger FDS tendon has been extracted from the carpal tunnel up through the window in the transverse carpal ligament. The tendon of insertion of the hypoplastic abductor pollicis brevis tendon is identified

Measurements

We determined that the most pertinent assessment of opposition was the modified Kapandji scale [9, 12]. In this modified scale, a score of 2 is given if the thumb pad can oppose to the index finger pad. A score of 3, 4, or 5 describes if the thumb pad can oppose to the pads of the long, ring, and small fingers respectively. The opposition of all children was assessed preoperatively and postoperatively using this Kapandji scale.

Fig. 4 The FDS tendon is routed subcutaneously and obliquely across the palm into the incision over the radial aspect of the MCP joint of the thumb. One slip of the FDS tendon may be sutured to either the hypoplastic abductor pollicis brevis tendon itself, the radial collateral ligament, or through a drill hole in the base of the proximal phalanx of the thumb. The other slip of the FDS tendon may be used for reconstruction of the ulnar collateral ligament if necessary

Fig. 5 In this Blauth IIIA hypoplastic thumb, both slips of the FDS have been passed through a drill hole in the metacarpal head, but only one slip will be used for reconstruction of the ulnar collateral ligament of the MCP joint. The other slip will be sutured to the hypoplastic abductor pollicis brevis tendon

Results

Table 1 shows the comparison of preoperative and postoperative Kapandji scores. Sixteen children had a preoperative Kapandji score of 2 and 22 patients had a preoperative Kapandji score of 3. Opposition improved in all children after tendon transfer. Thirty-one (81.6 %) children had a postoperative Kapandji score of 5, and 7 (18.4 %) had a postoperative Kapandji score of 4. There was no statistically significant difference in the Kapandji scores between hypoplastic thumbs (Blauth types II, IIIA, and IIIB) compared with pollicized index fingers (Blauth types IV and V). Thirteen of 16 Blauth II, IIIA, and IIIB thumbs (81.2 %); 16 of 20 Blauth IV and V thumbs; and 13 of 17 (76.5 %) Blauth V thumbs achieved Kapandji scores of 5 postoperatively (Figs. 6 and 7; Table 1). Postoperative Kapandji scores of 4 were similar in Blauth II, IIIA, and IIIB thumbs (18.8 %) and Blauth V

Table 1 Preoperative and postoperative Kapandji scores

Blauth stage	Number of thumbs	Kapandji score 2→5	Kapandji score 2→4	Kapandji score 3→5	Kapandji score 3→4
II	4	4	—		
IIIA	9	7	2		
IIIB	3	2	1		
IV	3			3	—
V	17			13	4
5-finger hand	2	2	—		
Total	38	15 (83 %)	3 (17 %)	16 (80 %)	4 (20 %)

Fig. 6 Blauth II hypoplastic thumb preoperatively (**a**) and the resulting opposition 2 years postoperatively (Kapandji score 5) after a Snow-Fink tendon transfer (**b**)

thumbs (23.5 %) (Table 1). Twenty-one thumbs underwent additional procedures such as UCL reconstruction, four-flap Z-plasty, full-thickness skin grafting, distraction lengthening, and joint transfer (Table 2). Postoperative improvement in functional activity is difficult to measure in young children, but from questionnaires evaluating thumb function and appearance, parents universally reported that the tendon transfer had improved their child's hand function as well as the appearance of the thenar eminence. No surgical complications occurred.tgrouptgroup

Discussion

The Huber transfer for the reconstruction of hypoplastic thumbs first gained attention after Littler's report in 1963 [14]. It has since become the preferred procedure by most hand surgeons to restore opposition of the thumb in children, and many studies have demonstrated its success [5, 13, 15, 20, 21, 27, 29]. Manske and Latimer have reported the two largest series of Huber transfers of 21 and 20 children respectively [13, 15].

Despite the popularity of the Huber transfer, many alternative opposition transfers have been reported in the literature. Mennen described an opposition transfer using the extensor pollicis longus (EPL) tendon dividing it proximal to the MCP joint and rerouting it subcutaneously anterior to the wrist deep to the extensor pollicis brevis tendon [18]. Bunnell described using the FDS of the ring finger, looping it around the FCU tendon or constructing a pulley at the pisiform bone using a distal-based slip of the FCU, to change the vector of pull diagonally across the thenar eminence [3]. Camitz described using the palmaris longus tendon elongated with a strip of the palmar fascia [4].

The Snow-Fink transfer uses the FDS of the ring finger passed through a small window in the transverse carpal ligament as a pulley for restoring opposition and has only been described in adults [25]. Snow claimed that the various techniques of pulley-based FDS opposition transfers were inefficient because of adhesions between the tendon and the pulley [25]. He described this technique in three adults with median nerve palsy. Srinivasan reported using the Snow-Fink transfer to restore opposition in patients with combined median and ulnar nerve palsy due to leprosy [26]. Successful abduction-opposition was achieved in 30 out of 33 thumbs (90 %) and

Fig. 7 Postoperative opposition (Kapandji score 5) 3 years after a Snow-Fink tendon transfer of an index finger pollicization of a Blauth V hypoplastic thumb

Table 2 Additional reconstructive procedures

Procedure type	Number of thumbs
4-flap Z-plasty	11
UCL reconstruction	6
Full-thickness skin graft	1
Distraction lengthening	1
Joint transfer	2

satisfactory stabilization of the distal phalanx in 85 %. However, his criterion of satisfactory opposition was pulp-to-pulp opposition of the thumb to the long finger, which corresponds to a modified Kapandji score of 3. Michelinakis and Vourexakis described using the Snow-Fink technique in 5 patients with thenar atrophy secondary to Charcot-Marie-Tooth disease [19] and reported good pulp-to-pulp opposition between the thumb and the small finger (modified Kapandji score 5).

The decision as to whether a child requires an opposition tendon transfer after pollicization appears to be mainly surgeon dependent. Review of 25 representative series of mainly hypoplastic thumb reconstructions revealed that only 12 studies mentioned performing an opposition tendon transfer. Varying frequencies of opposition tendon transfers were reported in these 12 studies ranging between 100 % [13, 15], approximately 50 % [8, 27], and almost none [11]. The senior author performs an opposition transfer as a secondary procedure after every pollicization to provide an improved functional and cosmetic outcome.

Evaluating functional outcomes of pollicizations has been recognized to be difficult due to cooperation and communication [8, 22]. Netscher described evaluating outcomes by measuring flexion and extension, grip strength, a functional dexterity test, and the Jebsen Hand Function Test [1]. Hovius assessed outcomes by measuring range of motion, grip strength, visual analog scale for function and appearance, and the Rotterdam Intrinsic Hand Myometer for strengths of individual fingers [8]. Percival evaluated outcomes by measuring tip pinch, pulp pinch, opposition, grasp, mobility, sensation, and cosmesis [22]. However, most of these studies measure general hand function and not specifically opposition. In our opinion, the modified Kapandji score and a specific questionnaire assessing thumb function and appearance are most applicable for evaluation of opposition tendon transfers. We have used a modified Kapandji score, rather than the full Kapandji score, because opposition of the thumb to the base of the small finger is difficult to achieve in hypoplastic thumbs and pollicized thumbs since the interphalangeal joint and extrinsic flexor and extensor tendons are usually abnormal.

We believe the Snow-Fink technique is a superior reconstructive method compared to the widely used Huber transfer

for several reasons. Firstly, it allows the surgeon to reconstruct the ulnar collateral ligament of the MCP joint at the same time. One slip of the sublimis is used for the opposition tendon transfer, and the other slip can be used to reconstruct the ulnar collateral ligament (Fig. 5). This is not possible with the Huber transfer. Secondly, the Huber transfer tends to leave an obvious concavity in the hypothenar eminence, which parents feel only increases the abnormal appearance of their child's hand. Thirdly, the opposition strength provided by the ring finger FDS has been shown to be significantly greater than the strength provided by the abductor digiti minimi or palmaris longus opposition transfers [7]. Finally, the vector of pull of the Snow-Fink transfer diagonally across the thenar eminence from the pisiform tends to abduct and pronate the thumb compared with the Huber transfer which only tends to flex the MCP joint of the thumb.

In addition to a window in the transverse carpal ligament used in the Snow-Fink technique, a distal-based slip of flexor carpi ulnaris (FCU), Guyon's canal, and a slit through the transverse carpal ligament have all been described as pulleys for an FDS opposition transfer. The FCU pulley may stretch out over time and provides less palmar abduction compared to the Snow-Fink technique since the location of the pulley is more proximal [10]. Routing the FDS tendon through Guyon's canal can irritate or compress the ulnar nerve. A recent study has reported incising the radial side of the transverse carpal ligament to use as a pulley [6], but this shifts the vector of pull radially which also decreases palmar abduction. Another advantage of the Snow-Fink technique is that the window minimizes tendon adhesions, which may occur in the FCU and Guyon's canal pulleys [25].

In conclusion, the Snow-Fink opposition tendon transfer is a simple, reproducible technique that consistently results in good outcomes (Kapandji scores 4 or 5) in children with hypoplastic thumbs or as a secondary procedure after pollicization.

Conflict of Interest The authors, Alfred P. Yoon and Neil F. Jones, declare that they have no conflict of interest.

Statement of Human and Animal Rights This article does not contain any studies with human or animal subjects.

Statement of Informed Consent Informed consent was obtained from all individual participants included in the study.

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