Perception of the esthetic and functional outcomes of duplicate thumb reconstruction

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Introduction

Polydactyly is one of the most frequently encountered congenital anomalies of the hand. Surgery for the duplicate thumb has progressed from a concept of simple ablation [10] to complex reconstruction. Ablative procedures commonly result in complications that include narrowed first web space, scar contracture, thumb angular deformity, and joint stiffness or instability. Wassel in 1969 stated that “ablation of a supernumerary digit can create problems resulting in deformation and functional limitation” [22]. More recently, surgeons have utilized soft tissue spare parts such as tendons and ligaments from the removed component to augment the function of the reconstructed thumb with improved outcomes [1–5, 7, 14, 16, 18]. Unfortunately, unfavorable functional and esthetic outcomes can still occur and secondary corrective procedures are often performed [11].

Only a few published studies assess the surgical outcomes with emphasis on subjective and objective parameters that evaluate the patient’s or family’s perception of the reconstructed thumb [1, 5, 6, 8, 12, 13, 19]. Objective evaluation is typically based upon certain measurable parameters such as thumb length, girth, angulation, and nail properties, characteristics

dictated by the investigating surgeon. There is a potential disparity in objective assessments and the parent’s or patient’s perception of the outcome and progress after polydactyly surgery. The purpose of this study was to assess the postoperative functional and esthetic outcomes of the reconstructed duplicate thumb in our own series with emphasis on the subjective perception from the parent’s or patient’s perspective.

Materials and Methods

Demographics

We performed a retrospective study of patients who had primary duplicate thumb reconstruction at INTEGRIS Baptist Medical Center from 1994 to 2011 by the senior author (GMR). An inventory of patients who underwent radial polydactyly surgery was generated through computer billing archives, surgery-scheduling books, and archived operative reports. Patients with other associated congenital hand anomalies were included in this study as long as their affected thumb could be classified using Wassel’s classification. From all these sources, 63 patient names were determined to have undergone radial polydactyly surgery during the study period. Thirty-two patients could not be located despite attempts through hospital and commercial resources. Thirty-one patients, with 33 reconstructed thumbs, were located, examined, and included in the study. The following demographic criteria were determined: gender, age at surgery and last follow-up, side of reconstruction, time since surgery, the presence of other congenital anomalies, and family history of congenital hand anomalies. We categorized each duplicate thumb according to Wassel’s classification [22], and the frequency of each type was determined.

Type of Study: Therapeutic

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Surgical Procedure

The senior author or hand fellows with supervision performed all surgical procedures. We removed the radial component in 27 thumbs and the ulnar component in two thumbs because it was more hypoplastic. Four thumbs were fused longitudinally utilizing the Bilhaut-Cloquet technique for Wassel's type I (two thumbs) and symmetric type II (two thumbs) duplicate thumbs. The remaining 29 reconstructed thumbs underwent the standard technique of combined procedures. On rare cases, we used a Z-plasty or skin graft from the supernumerary digit to correct the remaining soft tissue defect. More often, a proximally based random skin flap from the removed component covered the remaining skin defect in 26 of 33 thumbs. This random flap was typically smaller and did not require all of the soft tissue from the extra digit as previously suggested [23]. Type II and IV Wassel classified thumbs had collateral ligament reconstruction. Thenar muscle transfer from the discarded to the retained thumb's proximal phalanx was done for Wassel's type IV cases.

We did not remove the supernumerary phalanx in either of our type VII triphalangeal duplication because the remaining thumb was not very long. Instead, a closing wedge osteotomy through the delta phalanx was used to correct any angular deformity. Similarly, a closing wedge osteotomy was performed (17 thumbs) at the proximal phalanx or metacarpal level (depending on the Wassel type) when joint angulation was greater than 20° in the frontal plane, after removal of the extra digit. Additionally, 14 thumbs had contouring osteotomy to debulk and reshape any metacarpal head prominence or abnormality.

We performed a chondroplasty or cartilage shaving procedure as needed by removing 1–2 mm from the cartilage of the wide metacarpal head with a scalpel to provide stability, especially for a very hypermobile metacarpophalangeal joint with a spherical head. One Kirschner wire across the bone osteotomy site or cartilage contouring procedure stabilized the thumb and allowed healing without motion stress. The reconstructed thumb was immobilized in a thumb spica splint for 4 weeks, after which time the Kirschner wire was removed

Table 2 Patient demographics

Average age at surgery (months)	20
Average follow-up (months)	61
Male (<i>N</i>)	17
Female (<i>N</i>)	14
Thumb Wassel type	Number of thumbs
I	3
II	12
III	2
IV	12
V	2
VI	0
VII	2
Total	33

and range of motion was allowed out of the splint for additional 2 weeks before discontinuation of splinting.

Subjective Evaluation

We documented patient or parent responses to questions about how the reconstructed thumb looked and was functioning. To assess their perception of the functional aspects of the thumb, the patient's ability to perform activities of daily living was evaluated including manipulating large and small objects and writing if applicable (Table 1). We asked the parents or patients whether the task in question can be performed with ease, with difficulty, or could not be performed.

Objective Evaluation

We evaluated the reconstructed thumb's appearance and function using objective criteria and documented any measurable thumb length or angular deformity. The surgical scars were evaluated for evidence of contracture, hypertrophy, or tenderness. Reconstruction flaps were assessed for any abnormal scarring or thickening, i.e., bulk effect. Contour deformities or

Table 1 Protocol for determining thumb function of daily living

	Left			Right		
Feeding self	Easy	With difficulty	Unable	Easy	With difficulty	Unable
Fastening buttons	Easy	With difficulty	Unable	Easy	With difficulty	Unable
Using zippers	Easy	With difficulty	Unable	Easy	With difficulty	Unable
Writing	Easy	With difficulty	Unable	Easy	With difficulty	Unable
Manipulating large objects using thumb	Easy	With difficulty	Unable	Easy	With difficulty	Unable
Manipulating small objects using thumb	Easy	With difficulty	Unable	Easy	With difficulty	Unable
Opposing thumb to base of small finger	Easy	With difficulty	Unable	Easy	With difficulty	Unable

Fig. 1 General comments and assessment of the reconstructed thumb

prominences of the metacarpal head at the metacarpophalangeal (MP) joint were assessed clinically and radiographically to help determine whether they were caused by soft tissue or bone. The thumb length from the MP joint to the tip and the thumb diameter at the interphalangeal (IP) joint were measured in millimeters with a measuring tape and calipers, and comparisons were made between the reconstructed and contralateral thumbs. We assessed first web space angles of both hands as previously described [17]. Active and passive range of motion (ROM) of the MP and IP joints was assessed. Thumb malalignment or angulation in degrees if any was measured with a goniometer (Prestige Medical Northridge, CA, USA) for both reconstructed and contralateral thumbs. Joint stability was determined by direct stress test and any instability was measured in degrees. Opposition was then assessed by asking the patient to place the thumb tip to the base of the small finger. Young patients unable to follow commands were observed while using the hand for evidence of opposition. We recorded opposition function as easily

performed, performed with difficulty if less than full thumb to small finger MP joint crease approximation could be achieved, or cannot be performed if no apparent opposition activity was observed.

Radiographic Evaluation

We examined the preoperative X-rays to determine the type of thumb polydactyly and detect any associated bony deformities. Standard posteroanterior and lateral X-ray views of the thumb were obtained during the follow-up examination. The average time interval from surgery to final radiographic assessment was 43 months. These X-rays were analyzed to determine the source of angulation, if present, and to assess for epiphyseal growth plate shape, abnormalities, or premature closure. Additionally, radiographic assessment of any areas of prominence, such as at the metacarpal head in type IV reconstructed thumbs, was made to help determine whether the prominence was of bony or soft tissue origin.

Fig. 2 **a** Type II Wassel thumb preoperatively. **b** Thickening of the thumb following reconstruction and removal of the radial duplicate. This esthetic concern to the parents did not affect their overall satisfaction because the thumb function was not adversely affected

Table 3 Evaluation of ability to perform activities of daily living

Activates of daily living	Easy	Difficult	Unable to assess due to young age
Feeding	31	0	0
Buttoning	14	6	11
Using zippers	20	0	11
Writing	24	1	6
Manipulating large objects	30	1	0
Manipulating small objects	29	2	0

Complications

Patient charts were reviewed and the parents were asked during the last follow-up visit about any immediate postoperative complications such as infection, soft tissue loss, or flap necrosis. At follow-up, we assessed patients for late complications such as web creep, thumb Z-deformity, residual angulation greater than 15° [9], and joint instability. We performed a statistical analysis using paired *t* test, comparing first web space angle and active and passive ROM of the operated vs the nonoperated side.

Results

Patient demographics are outlined in Table 2. The average follow-up period from the time of surgery to last evaluation was 43 months. Ten patients had other congenital anomalies including hand and feet syndactyly, cleft hand, and cleft palate.

Subjective Evaluation

Comments made by patients or parents about the reconstructed thumb are outlined in Fig. 1. Type II thumb reconstructions had the most unfavorable comments (8/12 type II reconstructed thumbs), mainly because of increased girth (Fig. 2a, b). Sometimes, more than one comment was reported. For example, a type II thumb polydactyly patient who underwent combined reconstructive procedures stated the thumb appeared thicker and had limited flexion. Although several families thought at least one aspect of the reconstruction could be improved, all expressed overall satisfaction and would have their child undergo the procedure again. According to the parents, all patients were able to use their reconstructed thumbs in daily activities, although several reported some limitations (Table 3). One patient with difficulty writing and manipulating small objects had radial instability at the MP joint. Type IV thumb reconstruction had the most reported functional deficits (five out of ten).

Objective Evaluation

The percentage of abnormal flaps or scars is outlined in Fig. 3. A total of 26 small random flaps were utilized for thumb reconstruction. The clinical appearance of the scars revealed well-healed incisions (Fig. 4), although nine thumbs did appear to have a bulky flap (Fig. 5). In addition, two thumbs had scar contracture resulting in angular deformity. One was a type VII thumb reconstruction utilizing a small random flap plus a full thickness skin graft for web space reconstruction. A contracture developed in the skin

Fig. 3 Scar and flap assessment of the reconstructed thumb, percent in each group

Fig. 4 Satisfactory esthetic thumb appearance and scar of utilized flap with adequate motion and function after duplicate thumb reconstruction

graft. The second contracture occurred along the volar edge of the random skin flap. Clinical prominence was present at the reconstruction site in 15 thumbs (Fig. 2b). This prominence was due to excess soft tissue in nine patients, abnormal metacarpal head contours in three patients or both in three patients. Operative and nonoperative thumbs had similar lengths (averages measuring 44 and 45 mm, respectively) and widths at the IP joint (averages measuring 18 and 17 mm, respectively). The average web space angle was 91° on the operative and 99° on the nonoperative side. Comparison of these revealed no significant difference (t test: $P=0.36$). The active and passive ROM at the IP but not the MP joints was significantly decreased when comparing the operative vs nonoperative side (IP-active ROM, $P=0.0006$; IP-passive ROM, $P=0.0033$) (Table 4). When the study population was further stratified for Wassel type II and type IV, there was a decreased ROM at the IP and MP joints in type II and type IV, respectively, but neither was statistically significant.

Fig. 5 Bulky flap is one of the esthetic setbacks after duplicate thumb reconstruction, which did not affect function

Table 4 Thumb motion and first web space parameters of operative vs nonoperative side

Thumb parameter	Statistical significance (P value)
Web space angle	0.36
Thumb IP ROM	
Active	0.0006
Passive	0.0033
Thumb MP ROM	
Active	0.289
Passive	0.988

No statistically significant difference of the web spaces was observed. There was a decrease in the active and passive range of motion at both the IP and MP joints but only the ROM at the IP joint was statistically significant

ROM range of motion

Radiographic Evaluation

Seven patients had growth plate disturbances: two closure of the physis (one patient had early complete closure of physis and one patient had partial early closure of physis, both did not have chondroplasty) and five patients had abnormal shape of the physis with three of these undergoing chondroplasty (Figs. 6 and 7a, b). Although the chondroplasty was performed on the head of the metacarpal without disturbing the physis, it may have been indirectly affected by the Kirschner wire to stabilize the joint after chondroplasty.

Complications

None of the patients had immediate postoperative complications. For late complications, 11 of 33 thumbs (33.3 %) had clinical evidence of residual angular deformity at the IP or MP joint with an average of 25° and range of 15° to 42° (Fig. 8). Type IV thumb reconstruction had the most

Fig. 6 Smaller diameter thumb compared to the normal side and contour prominence of the metacarpal head radially after duplicate thumb reconstruction. Parents were satisfied with overall outcome despite these esthetic issues because function was not compromised

residual angular deformity (six total), but none of the thumbs with residual angular deformity required additional corrective surgery. Four of these had Z-deformity and three

showed signs of instability greater than 15° with passive ulno-radial deviation stress testing. Longitudinal ridging of the nail after the Bilhaut-Cloquet procedure did not cause functional problems in any patient (Fig. 9).

Discussion

Surgical treatment of thumb polydactyly has evolved over the years and outcomes have improved, but postoperative complications and unsatisfactory results continue to be encountered. A satisfactory outcome is described as a functional thumb with less than 15° of angulation, less than 20 % difference in the contralateral thumb length or girth, and minimal nail deformities [17, 21]. Reported complications in the literature include prominent or painful scars, first web space contractures, thumb length and girth changes, significant nail deformities, joint angular deformity and instability, contour prominences, and Z-deformity [15, 20]. The most frequently encountered complications that adversely affect function are joint instability, angulation, and stiffness. The complexity of the reconstruction can significantly contribute to postoperative complications [17].

Other less serious adverse outcomes are the esthetic setbacks, which may not affect the thumb function but can be unsightly. These can be in the form of pincushion thickening of a flap, hypertrophic scarring and bony prominences adjacent to joints, and alteration in the length or width. The treating physician usually evaluates outcomes after thumb duplication surgery using objective criteria for function, with some feedback from parents about subjective criteria. The question pertaining to subjective outcomes is often limited to an inquiry as to whether the parents or patients are satisfied or unsatisfied with the procedure. This is

Fig. 7 **a** Preoperative X-ray of type V thumb polydactyly. **b** Postoperative X-ray of the same thumb after reconstruction

Fig. 8 Angular deformity at the MP joint is one of the esthetic setbacks after duplicate thumb reconstruction

understandable because children cannot be subjected to elaborate outcome measures such as the Disabilities of the Arms, Shoulder and Hand (DASH) questionnaire.

Ogino et al. [19] subjectively evaluated 113 reconstructed duplicate thumbs. The reasons for unsatisfactory results were malalignment in seven thumbs and prominence of the soft tissue in four thumbs.

Kemnitz et al. [12] reviewed 16 patients' functional and esthetic outcomes after thumb reconstruction. The most frequent cause for esthetic dissatisfaction was thumb malalignment.

Hung et al. [8] evaluated the cosmetic outcomes of 21 patients after thumb polydactyly surgery. Only four patients were dissatisfied with their outcomes, due to hypertrophic scarring, residual deviation, or stiffness.

Dobyns et al. [5] reviewed their series of 54 thumbs and subjectively rated their patients' cosmetic outcomes. Good results in 32 patients were reported with obvious abnormal thumb reconstruction but well accepted by family. Three patients had cosmetically poor results.

Larsen et al. [13] subjectively assessed the functional and cosmetic results of 19 polydactyly thumbs using a visual analogue scale (VAS). Dissatisfaction was mainly due to poor esthetic outcome in seven thumbs.

Goldfarb et al. [6] subjectively assessed 31 thumbs after radial polydactyly reconstruction. The overall appearance of the reconstructed thumb was evaluated by utilizing VAS. The most common feature that negatively affected the outcome was angulation deformity followed by increased thumb width, decreased thumb width, and abnormal nail.

Fig. 9 Type II thumb polydactyly before (*left*) and after the Bilhaut-Cloquet procedure (*right*). Nail ridge did not cause functional problems

Baek et al. [1] subjectively assessed seven thumbs after type II or type III polydactyly reconstruction using a modified Bilhaut-Cloquet procedure. Both the parents and patients were asked to assess the overall appearance of the reconstructed thumb. All the parents and patients were satisfied with the reconstructed thumb.

We used a detailed subjective evaluation coupled with objective assessment regarding the thumb esthetics after reconstruction: first, by asking question regarding the reconstructed thumb, next by soliciting information from the patients or parents about their satisfaction with specific esthetic aspects of the thumb, and finally, by objectively assessing the esthetic findings in addition to the functional outcome. We encountered a variety of esthetic outcome trends. The most common concern about the reconstructed thumb was increased girth or thickness (11 thumbs), followed by abnormal angulation (six thumbs), contour prominence (five thumbs), decreased flexion (two thumbs), and nail abnormality (two thumbs). The increased girth of the reconstructed thumb was most often due to the thickness of the soft tissue (nine thumbs). We recommend thinning the random skin flap to match the thickness of the surrounding soft tissue of the retained thumb to improve appearance. Functional assessment revealed that the most difficult task of daily living performed was buttoning (six patients). This could be due to the higher degree of thumb dexterity and stability required to perform this task especially in children as compared to other functions tested. These postoperative functional limitations may be due to an underlying musculoskeletal anomaly inherent within the retained thumb component. In many cases of thumb duplication, both components are usually hypoplastic and their size is smaller than the normal contralateral side. Even though a number of our patients had concerns or unfavorable comments, all parents were satisfied with the overall function, cosmetic outcome of the reconstructed thumb, and the fact that their child has one rather than two thumbs. They all stated they would have their child undergo the procedure again.

Our study has limitations. There are no established validated outcome measures for esthetics and function in children. Due to the young age of our patient population, they could not be subjected to other elaborate outcome measures of the hand such as the DASH questionnaire. Therefore, we established our own unvalidated outcome measure to best assess our study population. We were only able to re-examine 50 % of the patients. In some cases, a long time elapsed since the surgery which contributed to this challenge. We made multiple attempts to locate and contact all the families but were sometimes unsuccessful possibly due to increased family mobility and change of cell phone numbers and contact information. Our study is underpowered but we believe that we are able to identify and generalize a few trends, especially among type II and IV duplicate thumbs. Reconstruction for type II duplicate thumbs especially after the Bilhaut-Cloquet procedure seems to be prone to having greater residual thumb girth. Careful thinning

of the rotational flap may help that problem. In addition, type IV duplicate thumbs had the most residual angular deformity and reported functional deficit. A larger study population or a meta-analysis could provide greater insight comparing esthetic and functional outcomes between the Wassel groups.

Our study demonstrates that even in the face of some esthetic drawbacks, the families of children with polydactyly are often pleased with surgery as long as there are no major complications that hinder the functional outcome. Parents usually seek treatment primarily with the main objective of eradicating one of the duplicate thumbs. From the collective comments made, we inferred that the following are the most important elements for an esthetically pleasing reconstructed polydactyly thumb: similar girth to the non-operative side, minimal length discrepancies to the normal contralateral side, minimal or no angular deformity, and no nail deformity. The family of a child with thumb duplication seeks treatment primarily for esthetic concern but with the expectation of maintaining good function after surgery. Oftentimes, the parents do not appreciate that both thumb duplicates are hypoplastic including the one spared even though it may appear more developed. Therefore, one of the most important aspects of polydactyly thumb reconstruction is the preoperative education of the parents, tempering their esthetic expectations towards realistic outcomes and informing them that there may be some functional deficits after surgery due to inherent abnormal anatomy.

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Conflict of interest The authors declare that they have no conflicts of interest, commercial associations, or intent of financial gain regarding this research.

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