in a zigzag fashion (Fig. 11). With the use of magnification, the fatty tissue, the fibrotendinous interconnections, and the nerves are carefully divided. The tourniquet is released, and hemostasis is secured with bipolar coagulation. The interdigitating flaps are sutured, creating skin bridges, and the residual defects are covered with full-thickness skin grafts from the non-hair-bearing area of the groin. Absorbable suture material is used, and a bulky dressing is applied. The dressing is removed at 2 weeks, and the hand is soaked and cleaned in warm water daily until all wounds have healed.

Discussion

Until 1986 we used full-thickness skin grafts to close the defects in the fingertips in complex syndactyly. A deformed fingertip (Figs. 2 and 3) often occurred, with a deficient nail fold and a rotated contracted nail. To correct this problem, we designed the double opposing palmar flaps and have been better satisfied with the results achieved with this technique. We have encountered no wound infections or other complications (Figs. 8 and 10). This procedure can be performed on an outpatient basis, with an interval of 2 weeks between operations.

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Long-term functional results after pollicization for the congenitally deficient thumb

This study objectively investigated the functional results of 28 index finger pollicizations for correction of congenital deficiency of the thumb. The results indicate that the average total active range of motion at the pollicized digit was 98 degrees, or approximately 50% that of a normal thumb. The average grip strength was 21% of standard values; lateral, tripod, and tip pinch strength values ranged from 22% to 26% of standard values. The pollicized digit was used in the manner of a normal thumb or in modified fashion in 84% of 14 defined activities, with increased use for handling large objects (92%) and less use for small objects (77%). The time required to perform activities averaged 22% longer than the standard for a normal hand. Patients with a radial club hand, a five-finger hand, or a mirror hand on the affected extremity had significantly poorer results; however, patients without one of these associated conditions had near normal use of the pollicized digit, except for reduced strength. These results were not influenced by the age of the patient at the time of operation. This information should be helpful in counseling parents with children who are candidates for pollicization as to what functional results they might anticipate. (J HAND SURG 1992;17A:1064-72.)

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Received for publication Nov. 6, 1991; accepted in revised form April 10, 1992.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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3/1/38954

Numerous articles have described the technical and conceptual aspects of pollicization for treatment of congenitally deficient thumbs.[1-18] Most report normal sensation, a pleasing cosmetic appearance, and improved function after pollicization. Impairment of sensation should not occur in a properly performed procedure. Cosmetic appearance is a highly subjective evaluation on the part of the surgeon and is not subject to objective measurement standards. Only a few published reports have attempted to objectively measure the functional results of pollicization, and the scope of these previous reports is somewhat limited.[19-24]

Roper and Turnbull[19] studied range of motion and pinch and grip strength of the polliziced digit in nine patients with congenitally deficient thumbs at an average of 5 years postoperatively. Djikstra-Zwolle and Bos[20] measured pinch strength in three postpollicization patients. Egloff and Verdan[21] reported range of motion in 14 patients with pollicized thumbs at an average of 8 years postoperatively. Sykes and Percival[22, 23] evaluated 30 pollicizations according to an assessment score based on cosmetic appearance, sensation, mobility, opposition ability, and relative pinch and grip strength at an average of 7 years' follow-up. Several additional authors[24-26] obtained objective postpollicization measurements after traumatic loss of the thumb, but there are significant differences between this group of patients and those with congenitally deficient thumbs.

The purpose of this study was to objectively determine (1) function in patients with congenitally absent or nonfunctioning thumbs who were treated with index finger pollicization, (2) the effect of various associated conditions (including radial clubhand [RCH], five-finger hand, mirror hand) that are presumed to predispose to poorer function, and (3) the influence of age at operation on the functional results, since it has been postulated that operating on the younger child gives better results. The measured parameters included active range of motion, grip and pinch strength, the manner in which the "thumb" was used to perform 14 defined activities, and the time required to perform a standardized timed-activity test.

Material and methods

Between 1971 and 1990, 52 patients with congenitally deficient thumbs underwent index finger pollicization. Twenty-three patients with 28 index finger pollicizations (five had bilateral procedures) were evaluated in this study. The remainder could not be located or would not come in for evaluation and are not included. Preoperatively, each patient had an absent or nonfunctioning thumb (pouce flotant); all pollicized index digits had normal sensation and active flexion/extension preoperatively; all were independently stable, and none had syndactyly to an adjacent digit.

The average age of the patients at the time of pollicization was 4 years (range, 9 months to 16 years). The patients were divided into four groups: nine patients were less than 2 years (only one patient was less than 1 year), seven patients were 2 to 3 years, seven patients were 3 to 4 years, and six patients were more than 4 years of age at the time of the operation. Follow-up averaged 8 years (range, 1 to 19 years). The left index finger was pollicized 16 times and the right one 12 times.

Several important *associated conditions* were present in 18 hands: there were 14 radial clubhands (13 required centralization or radius lengthening), 2 mirror hands, and 2 five-finger hands. Although these patients had a spectrum of associated deficiencies, they will be considered as a subgroup of patients. Ten hands had no other associated abnormalities.

Ten patients had a normal thumb on the opposite extremity, and 13 (including the 5 patients with bilateral pollicization) had manifestations of radial deficiency (i.e., RCH, hypoplastic thumb, absent thumb, etc.) on the opposite hand.

The pollicization procedure followed the description of Buck-Gramcko[11-12] with minor modifications.[27] After pollicization all patients had two-point discrimination at <6 mm as determined by standard testing methods, which was equal to that of the adjacent digits. No vascular insufficiency was noted in any of the pollicized digits.

A total of 26 other operative procedures were performed on 15 hands. These included correction of the radial club hand in 13 hands before pollicization; 8 opposition transfers, 3 arthrodeses, and 2 miscellaneous procedures were performed after pollicization.

Evaluation included four different sets of measurements. All measurements were made by a single examiner (L.A.D.), a registered occupational therapist who has had more than 10 years' experience testing children. The measurements are noted as follows:

1. **Range of motion.** A standard goniometer was used to measure the active range of motion (ROM) at the metacarpophalangeal (MP), proximal interphalangeal (PIP), and distal interphalangeal (DIP) joints of the pollicized digit. (The joints are identified according to the nomenclature of a finger, that is, the pollicized index digit, rather than by the nomenclature of a thumb.)
2. **Strength measurements.** *Grip strength* was measured with a Jamar dynamometer (Asimov Engineering Company, Los Angeles, Calif.) or with a Vigorimeter (J. A. Preston Corporation, Clifton, N.J.) for children below 5 years of age, according to standard testing protocol.[28-31] The average of three measurements was obtained, compared with standard values[28, 32, 33] for age, sex, and hand tested (right vs. left), and recorded as per cent of standard. Similar measurements were also obtained for the opposite hand in the 10 patients who had a normal opposite thumb.

   Pinch strength was measured with a pinch gauge (B & L Engineering, Sante Fe Springs,

Table I.

Gross grasp, large objects	*Fine manipulation, small objects*
Pick up pail with handle	Turn 1-inch dowel
Pick up school bag with handle	Turn key
Hold 3.75-inch plastic ring	Pick up sewing needle
Hold carpenter's hammer	Position pencil for writing
Grasp 2.5-inch diameter glass	Thread string through 0.5-inch bead
Grasp 2.75-inch diameter ball	Pick up 0.75-inch cube
Twist open 3-inch diameter plastic barrels	Pick up 5 mm pellet

Table II. Timed activities subtests[36, 37]

1. Turn over five 3 × 5 inch cards
2. Pick up small common objects and place them in a can
3. Simulated feeding with a spoon
4. Stack four checkers
5. Place five large light objects on a board
6. Place five large heavy objects on a board

Calif.) in the *lateral* (pollicized digit to side pulp of the long finger), *tripod* (end pulp of the pollicized digit to end pulp of the adjacent long and ring fingers), and *tip* (end pulp of the pollicized digit to end pulp of the long finger) positions. Again, the average of three measurements was compared with standard values[28, 32, 33] and recorded as per cent of standard.

3. **Usage.** The patient was observed during the performance of 14 defined activities well known to children and young adults (Table I), which were previously used to evaluate the function of congenital hand abnormalities.[34, 35] Seven tasks required gross grasp for handling large objects, and seven tasks required fine manipulation for handling small objects. The patients were advised to perform these tasks in a manner that was normal or comfortable for them. It was emphasized that they should not alter their usual method of accomplishing the tasks for purposes of this evaluation. The examiner observed whether the patient used the pollicized digit in the normal prehensile pattern of a thumb, in a modified fashion, or not at all.

Table III. Active range of motion*

Joint	*All patients (n = 28)*	*Associated conditions (n = 18)*	*No associated conditions (n = 10)*	*Associated vs. no associated (p value)*
MP	31	26	41	0.023
	(0-65)	(0-50)	(25-65)	
PIP	42	29	65	
	(0-95)	(0-90)	(0-95)	0.006
DIP	25	17	41	
	(0-55)	(0-55)	(25-55)	0.002
TAM	98	69	146	0.001

Range is shown in parentheses.
*Degrees of motion.

4. **Timed-activity test.** An objective standardized timed-activity test for hand function was administered according to the methods defined by Jebson et al.[36] as modified by Taylor et al.[37] for children. The time for completion of each subtest noted in Table II was measured with a stopwatch and compared with standard values[36, 37] for age, sex, and hand tested. The results are expressed as the percent of standard for each subtest and for the total test.

Statistical analysis. A statistical analysis was computed with PC ANOVA statistical analysis software (Human Systems Dynamics, Northridge, Calif.). Statistical significance was defined as a p value <0.05. All p values were computed with the use of analysis of variance for a simple randomized design with unweighted means.

Results

Range of motion. The average range of active motion for the MP, PIP, and DIP joints is noted in Table III. The total active motion (TAM) for all patients averaged 98 degrees. The 18 pollicized digits with an associated condition (i.e., RCH, five-finger hand, mirror hand) affecting the hand had significantly less motion at all three joints (TAM, 72 degrees) than the 10 without an associated condition (TAM, 145 degrees).

Strength. Average *grip strength* measurements (Table IV-A) were 21% of standard values for age, sex, and hand tested. Average *pinch strength* measurements were as follows: *lateral* 22%, *tripod* 23%, and *tip* 26% of standard. Substituting the grip and pinch strength values of the opposite hand for the standard values in the 10 patients in whom a normal thumb was present gave similar average values (grip 24%, lateral 24%,

Table IV-A. Average strength measurements*

	All patients (n = 28)	*Associated conditions* (n = 18)	*No associated conditions* (n = 10)	*Associated vs. no associated* (p value)
Grip	21	15	31	
	(1-52)	(1-32)	(8-52)	0.005
Lateral	22	14	38	
	(0-60)	(0-29)	(17-60)	0.000
Tripod	23	16	35	
	(0-56)	(0-37)	(20-56)	0.001
Tip	26	16	44	
	(0-71)	(0-45)	(20-71)	0.000

Results are expressed as percent as of standard values.
Range is shown in parentheses.

Table IV-B. Average strength measurement related to age at operation

	Age (yr)			
	<2 (n = 8)	2-3 (n = 7)	3-4 (n = 7)	>4 (n = 6)
Grip*	9	25	24	29
Lateral†	11	29	22	30
Tripod*	9	36	26	23
Tip*	11	36	31	28

Results are expressed as percent of standard value.
*Significant differences between the <2 and the 2-3, 3-4, and >4 groups at $p < 0.05$. No significant difference between the 2-3, 3-4, and >4 groups.
†Significant difference between the <2 and the 2-3, >4 groups at $p < 0.05$. No significant difference between the <2 and the 3-4 groups. No significant difference between the 2-3, 3-4, and >4 groups.

tripod 26%, and tip 27%). For the sake of consistency, all strength measurements in this study are related to standard values.

Strength measurements related to associated conditions are noted in Table IV-A. The strength values were significantly affected in the 18 hands that had an associated condition. The average *grip strength* in this group was 15% of standard value, compared to 31% in the hands that had no other associated conditions. The average lateral, tripod, and tip *pinch strength* values ranged from 14% to 16% in patients with the noted associated conditions, compared to a range from 35% to 44% when there were no associated conditions. These differences are highly significant.

Strength measurements related to age at operation are noted in Table IV-B. The results do not indicate improved strength in patients operated on at an earlier age. There was a trend toward poorer results in the less than 2-year age group, but there was no significant difference between the groups aged 2 to 3, 3 to 4, and more than 4 years. These results do not support the concept of performing pollicization at an early age to obtain better strength.

The age-at-operation results were also reviewed for only the 18 patients with associated conditions; at the time of the operation 6 of the 18 were less than 2 years, 3 were 2 to 3 years, 6 were 3 to 4 years, and 3 were over 4 years of age. Although the individual groups are small, the results indicate no significant difference in grip and pinch strength values between groups.

Usage. The manner in which the pollicized digit was used in performing the 14 activities is noted in Table V-A. The pollicized digit was used in some fashion in 84% of the 14 activities, either in the manner of a normal thumb or in a modified manner. It was not used at all for 15% of the activities.

In performing the seven activities related to handling large objects, the pollicized digit was used for 92% of the activities, either in the normal manner or in modified fashion. However, for activities that required manipulation of small objects, patients used the pollicized digit in a normal manner or in a modified fashion for only 77% of the activities. The difference between the use of the pollicized digit for manipulating large and small objects by all patients, as well as by patients with an associated condition, is statistically significant.

Usage related to associated conditions is noted in Table V-A. The pollicized digit was used extremely well by the 10 patients who had no associated condition, averaging 95% of all activities with little difference between handling of large and small objects.

In contrast, usage of the pollicized digit was significantly affected by the presence of an associated condition. The pollicized digit was used by these patients for 79% of all activities. The difference was particularly notable for the handling of small objects. The digit was used for only 67% of these activities; it was not used at all for one third of the activities related to small objects. The differences between patients with and without associated conditions is statistically significant with respect to usage for all objects tested, as well as for the large- and small-object groups.

Usage related to age at operation is noted in Table V-B. There was no relationship between usage of the pollicized digit and age at the time of operation. The

Table V-A. Manner of usage

	All pollicizations (n = *28*)	*Associated conditions* (n = *18*)	*No associated condition* (n = *10*)	*Associated vs. no associated* (p *value*)
All objects (14 activities)				
Normal	67	58	84	
Modified	17	21	11	
	84	79	95	0.015
No use	15	21	4	
Large objects (7 activities)				
Normal	78	68	96	
Modified	14	21	3	
	92	89	99	0.027
No use	7	10	1	
Small objects (7 activities)				
Normal	58	49	73	
Modified	19	18	20	
	77	67	93	0.034
No use	23	33	7	
Large versus small objects (p value)	(0.006)	(0.01)	(NS)	

Results are expressed as percent of activities.
NS = Not significant.

Table V-B. Manner of use related to age at operation

	Age			
	>2 (n = *8*)	*2-3* (n = *7*)	*3-4* (n = *7*)	>*4* (n = *6*)
Normal	55	82	59	76
Modified	25	8	24	9
	80	90	83	85
No use	20	10	16	14

Results are expressed as percent of activities.
Differences between all groups for combined normal/modified use are not significant.

differences between the four compared age groups for normal/modified use were small and not statistically significant. When only the 18 patients with an associated condition were considered, there was no significant difference between the four compared age groups.

Timed-activity test. The average time it took for patients with pollicized digits to complete the total of six subtests was 122% standard (Table VI-A), indicating that it took 22% longer than the standard for age, sex, and hand tested. A review of the individual subtests indicates that the best results occurred with turning cards, moving checkers, and simulated feeding; all of these activities required the handling of small objects. The subtests that required the handling of large objects took much more time for both light (141% of standard) and heavy (143% of standard) objects. These results indicate that even though the pollicized digit facilitates the handling of large objects, this activity actually requires more time than the handling of small objects.

Timed-activity related to associated conditions is noted in Table VI-A. The total timed-activity score in patients with an associated condition of the pollicized hand was 133% of standard (with the longest time required for large-object activities), while the patients without an associated condition had an average timed-activity score of 101% of standard; this difference is statistically significant. The results of the subtests for patients who had no associated condition approached standard values in all but subtest 6 (handling of heavy large objects), which is a reflection of the decreased strength of the pollicized digit. These results suggest that a patient who has a pollicized digit with no other associated conditions can function as quickly and rapidly as the average patient with a normal thumb.

Timed activity related to age at operation is noted in Table VI-B. The average total score in each of the four age groups showed no significant difference, indicating that there is no advantage to a child's having the operation at an earlier age. Although there was a trend toward an increase in time required by patients less than 2 years old (138% of standard) and those over 4 years old (127% of standard), the differences were not significant. When only the 18 patients with an associated condition were considered, there was again no significant difference related to age at operation in any of the four compared age groups.

Table VI-A. Timed activities

	All patients (n = 28)	*Associated condition* (n = 18)	*No associated conditions* (n = 10)
1. Turning cards	102	114	82
2. Small objects	142	160	109
3. Moving checkers	111	117	100
4. Simulated feeding	109	116	98
5. Light large objects	141*	161*	106
6. Heavy large objects	143†	156†	122
	122	133‡	101‡

Results are expressed as percent of standard for age, sex, and hand used.
*One patient could not complete task because object was too large.
†Two patients could not complete task because object was too large.
‡Difference between associated conditions and no associated conditions significant at $p = 0.007$.

Table VI-B. Timed activities related to age at operation

	Age (yr)			
	>2 (n = 8)	*2-3* (n = 7)	*3-4* (n = 7)	*>4* (n = 6)
Total	138	107	113	127

Results are expressed as percent of standard for age, group, sex, and hand tested. Differences between all groups are not significant.

Discussion

This study objectively investigated the functional results of index finger pollicization for correction of congenital absence or hypoplasia of the thumb. Few previous reports have objectively measured postpollicization functional parameters as extensively as this study. The influence of radial clubhand or other associated anomalies and the influence of age at operation on the postoperative functional results have not been objectively investigated at all. The results of this study indicate that the pollicized digit had significant function when compared to a hand with a normal thumb. The results were not as good in the presence of radial clubhand, five-finger hand, or mirror hand on the affected extremity. The results were not significantly influenced by the age of the patient at the time of operation. This information should be helpful in counseling parents with children who are candidates for pollicization as to what functional results they might anticipate.

Range of motion. Egloff[21] reported the average active range of motion (ROM) of the MP and IP joints of the "new thumb" (i.e., the PIP and DIP joints of the pollicized index finger) in 14 patients as 42 degrees and 35 degrees, respectively. This corresponds with the 42 degrees and 25 degrees noted in this study. The functional assessment method of Sykes and Percival[22, 23] included the presence of mobility at the three involved joints, but the average amount of motion was not studied.

The total ROM of the three joints in a normal index finger is 260 degrees.[38] It is to be anticipated that the ROM of a pollicized index finger would be significantly reduced, in part because of the reduced ROM of the index finger in patients with radial deficiency,[13] the restriction of motion at the MP and PIP joints by the operative procedure itself, the relative lengthening of the flexor tendon mechanism by the proximal transposition of the index finger, and the tethering of the extensor mechanism by the attachment of the intrinsic muscles to the lateral bands.

The active ROM of the pollicized digits in this study was 40% to 75% of the 185-degree flexion/extension motion of a normal thumb,[38] depending on whether one of the associated conditions was present or absent. The TAM in patients with an associated condition was less than half that of patients without such a condition. It is recognized that thumb motion may be reduced without significant impact on function.[39-41]

Strength. In a previous study Roper and Turnbull,[19] using a spring balance, determined that grip strength averaged 63% of the opposite side; pinch strength with use of an intrinsicometer averaged 56% of the opposite side. Dijkstra-Zwolle and Bos[20] reported grip strength after pollicization for thumb aplasia in three patients to be less than the 73% of the opposite hand in patients who had pollicization after trauma. Sykes and Percival[22, 23] included relative pinch and grip strength (i.e., more or less than 75% of the normal side) in their point system to assess functional results; however, the number of patients whose strength was greater or less than 75% of the opposite side and the average strength measurements for this group of patients were not available.

All of these previously reported results are significantly greater than the 21% to 26% (Table IV-A) range for average grip and pinch strength values in this study. The values from the previous studies may be inappropriately high, since the strength of the affected hand was always compared with the strength of the *opposite* side (rather than with standard values). If this study had compared the strength with that of the opposite hand, the average values would have been as follows: grip, 75%; lateral pinch, 65%; tripod pinch, 75%; and tip pinch, 64%. Unfortunately, the opposite hand is not always normal and is likely to have reduced strength because of radial dysplasia or other congenital abnormalities.[13, 15, 42] Comparison with the opposite hand is likely to inappropriately show increased strength values of the pollicized hand. The results presented in our study, which compares strength to a known standard scale, more accurately represent the relative strength of the pollicized digit than have previous studies.

The reduced strength is likely to be due to the impaired musculotendinous function. The abductor/flexor brevis muscle is usually absent, and the transferred first dorsal interosseous muscle is a relatively poor substitute; its muscle mass is not as great, it is partially devascularized as it is dissected off the index metacarpal, and it is poorly positioned biomechanically after transfer to function as an effective abductor/flexor. Although its transfer is appropriate, reduced strength must be anticipated. When the first dorsal interosseous hypoplasia is severe, it would be appropriate to consider a primary opponensplasty to improve strength rather than to perform it as a secondary procedure.[42]

The flexor digitorum profundus and flexor digitorum sublimis musculotendinous units are in a lengthened position as a result of the proximal transposition of the index ray. Although no author has advocated shortening of these musculotendinous units, this must be considered as a potential solution to improve flexor power, either primarily or secondarily.

Usage and timed activity. The 14 specific activities used to determine the manner in which the thumb was used were adapted from previous reports[34, 35] on evaluating the function of hands with congenital anomalies. The subdivision into the two groups of large and small objects was at our discretion. We have chosen to identify this measured parameter as *usage* rather than as *function*, since the manner in which the child uses the hand is only one aspect of function. The timed-activity test[36, 37] is standard and has been used frequently to evaluate hand function. No previous study objectively measured these parameters of postpollicization hand function.

Dijkstra-Zwolle and Bos[20] attempted an evaluation of functional activities by means of a questionnaire and reported that six patients (three with pollicization to correct congenital deficiencies and three with posttraumatic pollicizations) indicated that they could perform an average of 85% of five activities (lift cup, hold bottle, turn key, "do up" a button, pick up match). Those authors made no mention of whether the thumb itself was used or how it was used in performing these activities. Sykes' and Percival's[22, 23] assessment included the ability to grasp a tennis ball and a table tennis ball, but no other objective functional activities were observed.

The results of these tests clearly support the concept that the pollicized digit is used by most patients and is not ignored or bypassed. It is used particularly in handling large objects, which is the major functional deficit in the child with a congenitally deficient thumb. Although pollicization facilitates the handling of large objects, it takes more time to accomplish such tasks.

The pollicized digit was also used for handling small objects, although not as frequently as for handling large ones. The difference between manipulation of large and small objects is significant. It probably is related to the ability of patients with congenitally deficient thumbs to manipulate small objects with side-to-side pinch of adjacent digits. When patients performed these activities adequately by side-to-side motion of the long and ring or ring and small digits preoperatively, it should not be expected that the pollicization procedure should induce them to change their established prehensile pinch patterns. Absence of grasp is a more significant deficiency, for which a patient without a thumb cannot easily accommodate. These patients adapt more readily to the large-object grasp provided by pollicization.

We also compared the usage and timed activity of the pollicized digit in the subgroup of 10 patients with a *normal opposite* thumb and in patients with an *abnormal opposite* thumb. The results showed that patients with an abnormal opposite thumb used the pollicized digit more extensively in a normal/modified manner than did those with a normal opposite thumb (88% vs. 79%); however, the difference was not significant. Similarly, the patients with an abnormal opposite thumb had better results on the timed-activity test than did those with a normal opposite thumb (115% vs. 134%); again, the results were not statistically significant. These results suggest that there is a tendency to use the pollicized digit more extensively when the opposite thumb has limited function. This supports and encourages the concept of bilateral pollicization and pollicization in the presence of a functioning but hypoplastic contralateral thumb.

Other objective evaluations. Several authors have attempted to quantify the results of pollicization according to the ability to oppose the pollicized digit to the long, ring, or small fingers.[19, 21-23, 26] The normal thumb is able to oppose because of the saddle shape of the carpal metacarpal (CMC) joint. However, the transposed MP joint of an index finger has little rotational motion[43]; therefore, reported opposition of the pollicized digit most likely represents flexion activity. In this study we preferred to measure the active range of flexion/extension rather than opposition.

Appearance is difficult to quantify. Sykes and Percival[22, 23] attempted to quantify the appearance of the thumb as follows: length of the digit to within 0.5 cm of the PIP joint of the adjacent finger, the resting posture at 45 to 85 degrees of abduction, the rotation at 90 to 160 degrees in relation to the fingers, and the *opinion* of the child's parents as to whether they were satisfied with the appearance of the pollicized digit. We believe it is difficult to quantify the appearance of the thumb and did not attempt to do so in this study, since usually "beauty lies in the eyes of the beholder," including the patient's, the parent's, and the surgeon's. The pollicized digit on many "cosmetically improved" hands is observed to look more like a finger sticking out the side of a palm rather than like a thumb. In this series, one of the 28 patients was not satisfied with the appearance of the pollicized digit.

Pollicization and associated conditions (RCH, five-finger hand, mirror hand). Several authors have noted less favorable results of pollicization in the presence of RCH,[11, 12, 20, 22] mirror hand,[44, 45] or five-finger hand.[11, 12, 22] This study supports and objectively confirms that clinical impression. For simplification, patients with all three conditions were placed in a single subgroup when it became apparent that the results of all three were similar.

The difference between these two subgroups reflects the more severe anatomic deficiencies of the pollicized digit by the underlying condition. Lamb[13] and others[11, 12, 22, 34, 43, 46, 47] have noted in RCH patients decreased motion of the index finger joints as compared to the ulnar digits, as well as abnormalities in the thumb musculature. It is postulated that similar anomalies affect the most radial digit of the five-finger hand, and the central digits of the mirror hand.[11, 12, 44, 45]

The differences between patients with and without these associated conditions is dramatically apparent on review of all four parameters studied. The patients without the associated conditions had approximately two times as much active motion and a two- to threefold increase in grip and pinch strength values. They used the pollicized digit more often in performing the tested activities and used it in a normal (as compared to a modified) manner nearly 50% more frequently. Finally, the time required by patients without associated conditions to accomplish this task is at a rate equal to normal standards and about 33% faster than that required by patients with an associated condition.

Although patients with an associated condition had less usefulness of the pollicized digit, it is apparent that they did indeed use it, particularly in handling large objects; the deficiency in this group of patients is primarily with respect to small objects.

Pollicization and age at operation. Several authors[4, 11, 12, 16, 22] have indicated that pollicization should be performed at an early age on the premise that patients will develop a more appropriate cerebral cortical awareness of the index finger as a "thumb." Roper and Turnbull[19] suggested that the procedure should be performed when the child is between 1 and 2 years of age because of the influence it has on hand dominance. The results of this study clearly show no advantage to having the procedure at an early age. The strength measurement tests indicated a trend toward decreased values in patients operated on before the age of 2 years, but this trend was not significant when only the 18 patients with an associated condition were evaluated. The usage and timed-activity tests showed no significant difference when we compared the four different ages in the study groups as a whole, as well as when we compared only the 18 patients with an associated condition. We are not interpreting these data to suggest that operating on patients less than 2 years of age gives poorer results but, rather, that the results are not dependent on the patient's age at the time of operation.

The postulate that pollicization should be performed by the time the patient is 9 to 12 months of age to obtain the best functional results is flawed. Although the child with a normal thumb and hand begins to develop a cerebral cortical awareness of the thumb as the radial post at this age,[48] this concept does not directly apply to the child who is born without a thumb. In such cases, the index finger is cortically represented as the radial post. Since pollicization is simply the repositioning (and not the creation) of the radial post, the age at which the procedure is performed should not be critical from a functional point of view. The results of this study bear this out. Although we advocate performing the procedure early rather than late, it is for *social* rather than functional reasons. The results of this study advise parents that there is no rush to have the surgery, since there is no evidence that functional results are dependent on the patient's age at operation.

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