Polydactyly of the thumb: Abnormal anatomy and treatment

In nine years 26 duplicated thumbs were seen in the hand clinic of a hospital for crippled children. Using a classification based on the level and degree of duplication and a knowledge of the abnormal anatomy, reconstruction was done. This surgery was done with proper skin incisions, reconstruction of the collateral ligaments, centralization of the flexor and extensor tendons, and alignment of the bones and joints by corrective osteotomies. Simple ablation or incomplete correction produced complications such as skin contractures, increased angular deformities, unstable joints, and intrinsic weakness. In all of the patients, the appearance was improved, opposition was maintained, and postoperative function was not impaired.

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Polydactyly, or duplication of the thumb, is a complex anomaly. A basic understanding of the abnormal anatomy and some ingenuity are required for proper reconstruction.

Incidence

Ivy,¹ in 1957, reported congenital anomalies occurring in 8.5/1,000 live births. Sesgin and Stark,² in 1961, reported polydactylyism in 1.0/713 live births. Elliott,³ in 1971, reported his review from the University of Iowa on patients with polydactylyism of their hands. There were 255 digits involved. The thumb was the one most commonly involved, representing 113 of the involved digits. These statistics are impressive when one considers the fact that duplicated digits seldom are seen, except when they are concentrated in an area such as a hand clinic.

Embryology

Bardeen and Lewis,⁴ in 1901, described the development of the appendages from the primitive streak. The arm bud develops from the mesenchyme at the level of the eighth myotome. The arm bud is apparent at the third week of embryonic life. From this time until the eighth week of embryonic life, there is differentiation of the upper extremity. By the eighth week of embryonic life, all of the components of the upper extremities have differentiated completely, including the distal phalanges of the fingers. If duplication is associated with insult to the embryo, the trauma must occur before the eighth week of embryonic life.

Etiology

The cause of polydactyly of the thumb is unknown. Experimental studies by Bagg,⁵ in 1927, showed that
Table I

<table>
<thead>
<tr>
<th>Associated anomalies</th>
<th>No. of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asthma</td>
<td>1</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1</td>
</tr>
<tr>
<td>Inguinal hernia</td>
<td>1</td>
</tr>
<tr>
<td>Esophageal atresia</td>
<td>1</td>
</tr>
<tr>
<td>Ventricular septal defect</td>
<td>2</td>
</tr>
<tr>
<td>Syndactyly of fingers</td>
<td>3</td>
</tr>
<tr>
<td>Supernumerous digits</td>
<td></td>
</tr>
<tr>
<td>Fingers</td>
<td>1, bilaterally</td>
</tr>
<tr>
<td>Great toes</td>
<td>2, bilaterally</td>
</tr>
<tr>
<td>Partial absence of index finger</td>
<td>1</td>
</tr>
</tbody>
</table>

injury with hemorrhage was associated with polydactyly in rats. Woolf, in 1970, concluded that the most common type of preaxial polydactyly involving duplication of the first digit was sporadic in origin and concluded that it was a result of polygenes or of unknown exogenous factors. From a review of the literature and our cases, it is thought several patterns of inheritance can occur.

Material

This report is based on a study of 25 patients with 26 duplicated thumbs seen over a 9-year period in a hand clinic for crippled children. There were eight duplicated distal phalanges. Fourteen thumbs were duplicated at the proximal phalangeal level. Four thumbs were duplicated at the metacarpal level. There was a wide variation in the degree of duplication at each level. However, the degree of soft tissue duplication correlated well with the degree of bone duplication. There was equal involvement of the right and left thumbs. The records did not reflect which hand was dominant; however, it is interesting to note that the duplicated thumb was present on the dominant hand in two cases. Associated anomalies are listed in Table I.

In four patients there was a family history. Two patients had cousins with duplicated thumbs. The father of one patient had a duplicated thumb. The mother of the one patient with bilateral deformities had identical anomalies of both hands, including syndactylysm and duplicated thumbs.

Classification

Millesi, 1967, grouped 14 cases of polydactyly of the thumb into five types. Wassel, in 1969, classified 79 cases into seven types. With our cases being too varied to place in this many different types, they have been grouped according to the level of duplication; that is (1) distal phalanx, (2) proximal phalanx, and (3) metacarpal. The triphalangeal thumb and the thumb with a delta phalanx have not been included. There was a wide variation in the degree of duplication at each level. Therefore, it has been more appropriate for us to consider the level of duplication and the degree of duplication at each level when considering a surgical plan. There are certain basic abnormalities to anticipate at each level, and ingenuity at the time of operation must be applied to deal with the varied degree of duplication.

Abnormal anatomical findings

Skin coverage was not a problem, provided proper handling of the skin was carried out. Sensation and circulation were not problems because the ulnar component usually was preserved or the neurovascular bundle was preserved. The tendons were duplicated to the same degree as the bone. With angular deformity, there was subluxation of the tendon and a tethering effect which accentuated the angular deformity. The duplicated flexor and extensor tendons usually had only one muscle. In only one or two cases did the duplicated thumbs seem to have independent motor function. The collateral ligaments had normal attachments to their respective components. There was no apparent laxity of the collateral ligaments which would contribute to the angular deformity. Consequently, angular deformity could not be corrected by tightening of the collateral ligaments. If duplication began at a joint, the joint was enlarged with angulation of the joint. The epiphyses were perpendicular to the respective bone, but were tilted from the long axis of the thumb to the same degree that the joint was angulated. When there was duplication at the metacarpal level, the thenar muscles inserted on the radial component, regardless of the degree of duplication of the metacarpal. The adductor muscles usually inserted into the ulnar component.

Timing of operation

The hand develops function as follows: grip and grasp at 4 to 7 months; thumb and index finger function at 10 to 12 months; voluntary release at 15 to 18 months; and a functional pattern at 2 to 3 years of age. It is preferable to operate on these patients when they are 3 years of age. Since coordinated function of the thumb does not appear until a child is 2 to 3 years of age, waiting until the patient is 3 years of age will not alter the function of the reconstructed thumb, and at this age the structures are larger, surgery is technically easier, and the patient can follow instructions in the postoperative rehabilitation period.

Treatment

Surgical treatment is based on the anatomical variation—level of involvement and the degree of involve-
Basically, treatment consists of removal of the functional part and reconstruction of the remaining components. If function of the two components is equal, then the appearance is considered. Transposition of one digit to another may be required when there is a mixed quality of duplication. The various tissues must be dealt with independently. Skin coverage has not been a problem. The skin may be dealt with by making the incision in the recommended incisional line along the lateral aspect of the thumb, using a Z-plasty, or by using a skin flap. Flexor and extensor tendons should be centralized. This may be done by transposition of the tendon, reconstruction of the tendons after redundant portions are removed, or by centralization which may occur when osteotomies are done to align the joints and phalanges. If the tendons are not centralized, the joints are pulled in an abnormal direction and a dynamic force is created which may cause subsequent deformity. Collateral ligaments attached to their corresponding phalanges need to be transferred to the remaining phalanx to provide joint stability. The alignment of joints and the angular deformity of the phalanges, with their corresponding epiphyses, is corrected by wedge osteotomies proximal to the deformity. If this is not done, the joints function in an improper axis, and with epiphyseal growth, the angular deformity is accentuated. When duplication occurs at a joint, the head of the proximal phalanx or metacarpal is enlarged to accommodate the double articulation. A partial excision of the bone may be done to reduce the bulk. When there is duplication of the proximal phalanx or any part of the metacarpal, most of the intrinsic muscles attach to the radial component. These muscles must be transferred to the remaining component to provide proper function and strength.

Examples of treatment

Example I: Symmetrical duplication of the distal phalanges (Fig. 1). Bilhout-Cloquet procedure, consisting of a central wedge resection of distal phalanges, has been described by Barsky. This procedure is indicated with the symmetrically duplicated distal phalanges. The technique presents several problems. It is difficult to take out sufficient bone to reduce the thumb to the normal size. The base of the proximal phalanx is broad. Approximating the distal phalanges is difficult because of the broad head of the proximal phalanx and the tightening of the collateral ligaments as the
phalanges are approximated. This could not be accomplished by transfixed K-wire and required circumferential suture around the distal phalanges. The articular surface of the distal phalanges was involved, which required accurate approximation. The epiphyses of the distal phalanges also needed to be accurately reduced to avoid growth disturbance. The nail bed required accurate repair to reduce the size of the anticipated cleft of the nail. This procedure appears simple upon initial evaluation, but it is not an easy procedure.

**Example II: Asymmetrical duplication of the distal phalanx (Fig. 2).** This deformity requires removal of the less functional component, which is usually the radial one. The collateral ligament should be transferred to the remaining phalanx. The flexor and extensor tendons should be centralized. The angular deformity of the interphalangeal joint and distal phalanx is corrected with an osteotomy of the distal end of the proximal phalanx. Fixation is obtained by using a K-wire. With correction of the angular deformity, the flexor and extensor tendons probably will be moved into the longitudinal axis of the thumb, eliminating the need for transposition of the tendons.

**Example III: Duplication at the proximal phalangeal level (Fig. 3).** The radial component usually is not developed as well as the ulnar component. The extensor tendons are duplicated with a common hood. The flexor tendons are duplicated. If there is an angular deformity, there is subluxation of the flexor and extensor tendons. The collateral ligaments attach to the respective proximal phalanx. The intrinsic muscles attach to the radial component. Treatment consists of excising the less dominant thumb, decreasing the size of the distal articular surface of the metacarpal head, transferring the collateral ligament to the remaining phalanx, advancing the intrinsic muscles to the proximal phalanx, and doing an osteotomy of the appropriate bones to correct angular deformity. Immobilization is obtained using a longitudinal K-wire.

**Example IV: Duplication at the metacarpal level (Fig. 4).** The thenar muscles always attach to the radial component regardless of the size of duplication.
require transfer to the remaining component. The other reconstructive techniques already described may be used.

**Example V: Mixed quality of duplication (Fig. 5).**
The radial thumb is crooked and small on the distal end. The base is well developed. Attached to it are the abductor pollicis brevis, the flexor pollicis brevis, the adductor pollicis, and the extensor pollicis brevis. There is good function at the base of the thumb, with very little function of the proximal and distal phalanges. The ulnar component is straight and has full development of the flexor and extensor tendons. The metacarpal is developed incompletely and there is no intrinsic or extrinsic muscle attachment at the base. Reconstruction requires removal of the radial thumb at the metacarpal level and transfer of the ulnar component to the base of the more radial metacarpal. The extensor pollicis brevis, abductor pollicis brevis, flexor pollicis brevis, and adductor pollicis are transferred to the transposed thumb. The flexor and extensor tendons are transferred with the ulnar component.

**Example VI: Inadequate thumb web space (Fig. 6).** The radial component is removed. The thumb web space is inadequate, and reconstruction of the thumb web space is accomplished by sliding a skin flap from the dorsum of the hand into the thumb web space. The adductor muscles and first dorsal interosseous were released. The donor site was closed with a split-thickness graft.

**Complications**

Complications consist of skin contracture, increased angular deformity, unstable joints, and intrinsic weakness. These usually are associated with incomplete cor-
Fig. 3, con't.
Fig. 4. Duplication at the metacarpal level.

resection at the time of operation or with failure of the patient to return for subsequent steps of reconstruction.

In this series there are six patients who need an additional procedure. Three of these need deepening of an inadequate thumb web space. The other three are patients with duplication at the level of the proximal phalanx who need osteotomies of the proximal phalanx to correct the angular deformity of the interphalangeal joint and distal phalanx.

Complications in this series consisted of (1) a stiff, painful interphalangeal joint in one case (An arthrodesis was done, resulting in a stable, painless joint.); (2) stiffness of the interphalangeal joint with adhesion of the extensor tendon and extension contracture of the interphalangeal joint occurred in one case (A tenolysis, a capsulotomy, and a fascial graft were done. These resulted in a painless interphalangeal joint with up to 20° of flexion.); (3) radial deviation of the distal phalanx of 30° in one case (Reefing of the ulnar collateral ligament was done without improvement of the angular deformity. It has been our experience that angular deformities cannot be corrected significantly by tightening of the collateral ligaments and a corrective osteotomy is required.); (4) in one case, a central wedge resection of the distal phalanges resulted in an improved appearance but the thumb was still broad.

Results

In all of our patients, the appearance was improved. The most striking improvement in function and appearance was in the thumbs with the more proximal duplication. There was decreased range of motion of the joints involved in the operation. The average postoperative range of motion of the interphalangeal joints was 0° to 30° of flexion. Opposition was maintained, and after operation function was not impaired. The patient and the patient's parents were pleased with the results.
Summary
Reconstructive surgery of supernumerary thumbs requires a basic knowledge of the abnormal anatomy. If correction is inadequate, deformities can become accentuated by abnormal dynamic forces. The ultimate goal in the treatment of any congenital anomaly of the extremities is restoration of the normal anatomical relationship of the remaining structures to the longitudinal axis.

REFERENCES

(cont'd on p. 116)
Fig. 6. Inadequate thumb web space.

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