

Thumb Duplication: Concepts and Techniques

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Within the Oberg, Manske, Tonkin (OMT) classification, thumb duplications are a failure of formation and/or differentiation affecting the radial-ulnar axis of the hand plate. The Wassel description of seven types of thumb duplication provides a good structure from which an approach to management is based. The aim of surgical reconstruction is to obtain a stable, mobile thumb of adequate size and appropriate shape. The most common form of reconstruction is removal of the lesser digit and reconstruction of the dominant digit. Surgical techniques address the problems of deviation, instability and lack of size. The disadvantages of the Bilhaut-Cloquet procedure, these being joint stiffness and a nail ridge, may be lesser concerns when reconstruction of one digit will not create a satisfactory thumb of adequate mobility, stability, alignment and size. Complicated problems of triphalangism, triplication, ulnar dimelia and the rare circumstance in which neither of the duplicated thumbs may be adequately reconstructed present specific challenges which demand alternative techniques.

Keywords: *Thumb duplication, Classification, Assessment, Reconstruction*

Thumb duplication is classified within the International Federation of Societies for Surgery of the Hand (IFSSH)/Swanson classification of congenital anomalies of the hand and upper limb as a “duplication” (group 3).¹⁾ Included are radial polydactyly, central polydactyly, ulnar polydactyly and proximal duplications such as ulnar dimelia. Although groups 1 and 2, “failure of formation” and “failure of differentiation”, give some imprecise suggestion as to the cause of a particular anomaly, other groups of this classification, “duplication”, “overgrowth”, “undergrowth” and “constriction ring syndrome” (and perhaps also that of “generalised skeletal anomalies”) are purely descriptive. Our increasing understanding of the molecular biology of limb growth and patterning demands a reappraisal of the classification of congenital limb anomalies, one that reflects this current knowledge. The Oberg, Manske, Tonkin (OMT) classification implicates the axis of formation and differentiation which is primarily involved in the development of the

anomaly (Table 1).²⁾ It recognises that formation and differentiation occur together, not as separate independent processes, and directs us to the site of insult in the developing limb bud. It also indicates whether the anomaly involves the whole of the upper limb or the hand alone.

It is beyond the scope of this article to explore in detail the genetic pathways and the disruptions within these which lead to thumb duplication. However, application of the principles upon which the OMT classification is based provides some understanding of how anomalies of development and patterning occur. Thumb duplications are a failure of formation and/or differentiation affecting the radial/ulnar axis of the hand plate. The primary signal centre involved is the zone of polarising activity (ZPA) in the posterior part of the developing limb bud. Sonic Hedgehog protein, which is expressed in the ZPA, plays a major role in determining radial-ulnar characteristics. Abnormal expression of other morphogens such as Hox genes, Bone Morphogenetic protein and Gli-3 are involved in the development of thumb duplications.

The Wassel description of seven types of thumb duplication is that which is most familiar to congenital hand surgeons (Fig. 1).³⁾ It is based on the level of the skeleton at which the duplication occurs and is simple. It provides no information as to which thumb is dominant, whether there

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Table 1. The OMT Classification of Hand and Upper Limb Anomalies

Malformations	
Failure of axis formation/differentiation: entire upper limb	
Proximal-distal outgrowth	Brachymelia with brachydactyly Symbrachydactyly Transverse deficiency Intersegmental deficiency
Radial-ulnar (anteroposterior) axis	Radial longitudinal deficiency Ulnar longitudinal deficiency Ulnar dimelia Radioulnar synostosis Humero-radial synostosis
Dorsal-ventral axis	Nail-patella syndrome
Failure of axis formation/differentiation: handplate	
Radial-ulnar (anteroposterior) axis	Radial polydactyly Triphalangeal thumb Ulnar polydactyly
Dorsal-ventral axis	Dorsal dimelia (palmar nail) Hypoplastic/aplastic nail
Failure of handplate formation/differentiation: unspecified axis	
Soft tissue	Syndactyly Camptodactyly
Skeletal deficiency	Brachydactyly Clinodactyly Kirner's deformity Metacarpal and carpal synostoses
Complex	Cleft hand Synpolydactyly Apert hand
Deformations	
Constriction ring sequence	
Arthrogryposis	
Trigger digits	
Not otherwise specified	
Dysplasias	
Hypertrophy	
Macroductyly	
Upper limb	
Upper limb and macroductyly	
Tumorous conditions	

is convergence and/or divergence at any particular joint level, the stability of joints, nor the presence of soft tissue anomalies. Triphalangism is clumsily placed separately in type VII, although it may accompany skeletal anomalies which differ from that classically depicted in Wassel's type VII. It may be preferable to describe the duplication according to its skeletal level (types I to VI) and add "accompanied by triphalangism in the radial and/or ulnar thumb", as appropriate. A basic flaw in the Wassel classification is that this it is based on an assessment of the skeleton, the true nature of which may not be radiologically apparent in the skeletally immature. For instance, a type I duplication may be classified as a type II until ossification of a basal cartilaginous connection becomes apparent. It is often not possible to define the status of physes and epiphyses. Nevertheless, the Wassel terminology provides quite a good structure from which one may approach the management of a thumb duplication. The more experienced surgeon will have an understanding of the anomalies that are likely to be associated with each type and which may require attention during reconstruction, just as an understanding of "camptodactyly" infers the presence of specific anatomical anomalies which accompany that diagnosis.

PREOPERATIVE ASSESSMENT

The aim of surgical reconstruction is to obtain a stable, mobile thumb of adequate size and appropriate shape. Stability and size relate to strength, both for grip and pinch. Thumb mobility is largely dependant upon the integrity of the carpometacarpal (CMC) joint, usually normal in Wassel types I to IV, but possibly with varying degrees of maldevelopment or underdevelopment in types V and VI. Mobility at the metacarpophalangeal (MCP) and interphalangeal (IP) joints, although necessary for normal thumb function, is perhaps not as important. The range of normal MCP joint motion is variable, both in the amount of flexion and the presence or absence of hyperextension. Loss of IP joint flexion impairs tip pinch, but children compensate effectively without appreciating any loss of function. When the surgeon is confronted with a conflict between stability and mobility, it is reasonable to accept a decrease in distal joint motion to obtain joint stability, if the CMC joint is intact. Finally, the shape of the thumb relates to aesthetics and is important.

These components of thumb function demand attention when planning surgical reconstruction. It may be obvious to the casual eye that one thumb is the dominant thumb. However, there may be deficiencies of the thumb to be retained. The parents are warned that surgery may

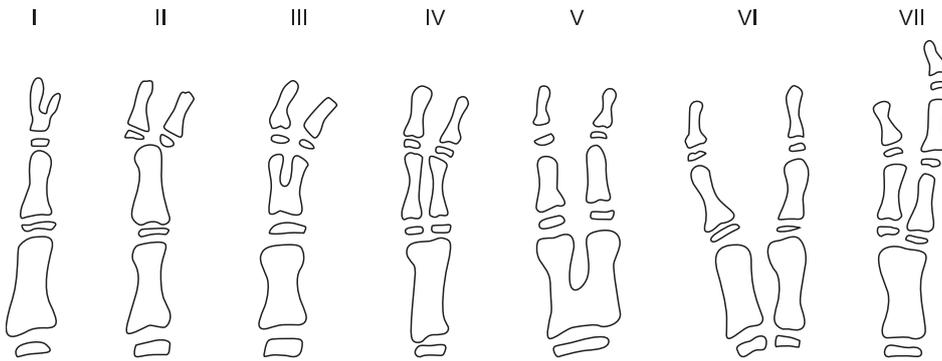


Fig. 1. The Wassel classification of thumb duplication. Reprinted with permission from Springer-Verlag.³⁾



Fig. 2. Appearance of the dominant thumb when the examiner's hand conceals the radial duplicate.

involve the reconstruction of the dominant thumb, not simply removal of the smaller digit, usually the radial. A comparison with the normal thumb of the opposite hand will demonstrate that the thumb to be retained is smaller and may lack certain anatomical components. For these reasons, some prefer the description “split” thumb to that of thumb duplication.⁴⁾ If the examiner places his or her thumb over each of the duplicate parts in turn, the appearance following ablation of the lesser thumb may be simulated. This may reassure surgeon and parent of an acceptable aesthetic outcome and warn of any need to attend to angular deformities and lack of bulk (Fig. 2).

The clinical assessment addresses the soft tissue bulk and shape, the integrity of the nail folds, collateral ligament stability in radial and ulnar deviation, and hypermobility, particularly in the hyperextension plane of both IP and MCP joints. Global instability of either or both will severely compromise function. It is often a consequence of extrinsic tendon anomalies of flexor pollicis longus (FPL) and the extensors, with abnormalities of origin and insertion applying deforming forces across unstable, hypoplastic joints. Divergence of proximal phalanges at MCP joint level and convergence at IP joint level are common in Wassel type IV duplications, particularly when the thumbs are of equivalent size. These pose difficult problems for the

reconstructive surgeon. The principle is to complete the reconstruction of the retained thumb at the time of the removal of the smaller digit, attending to all anatomical anomalies which may compromise optimal function, particularly those which lead to the complications of instability and deviation.

Simple radiological examination is usually adequate in obtaining the additional information necessary for surgical planning. A true posterior-anterior and a true lateral view of each of the duplicate thumbs may be difficult to obtain in some presentations. Their relevance must accompany the findings of the clinical examination. An X-ray of the opposite thumb is beneficial in comparing bone size and shape and assists in assessing joint deformity. A magnetic resonance imaging better delineates intra-articular cartilage structure. This investigation or an ultrasound may assist in the assessment of soft tissue anomalies, but neither are routinely employed. It is rare indeed to consider a necessity for vascular studies.

Armed with the information obtained from a precise clinical examination and the radiological appearance, the surgeon will decide the ideal reconstruction of the dominant thumb, incorporating elements of the thumb to be discarded, as appropriate. Uncommonly, one is confronted with a circumstance in which neither thumb is of

adequate size, stability, mobility and appearance to allow a satisfactory reconstruction. The classical Bilhaut-Cloquet procedure combines equal longitudinal components of each thumb to achieve greater size and stability, albeit it at the cost of loss of some mobility.⁵⁾ Modifications of the Bilhaut-Cloquet procedure utilise less or more of each thumb. However, to retain the integrity of the eponymous terminology, longitudinal parts of the skeleton of each thumb must be combined. Of course, other combinations, such as an acral transposition (on top plasty), may be employed to obtain an optimal result, but these are not examples of the Bilhaut-Cloquet method.

Perhaps the most difficult decision confronting the surgeon and parents when choosing the optimal form of reconstruction, is posed by the circumstance in which both thumbs are hypoplastic, without a satisfactory CMC joint at the base of either. No reconstruction is ideal. Pre-operative discussion and planning must consider the possibility of multiple surgeries and the likelihood of inferior thumb function. These concerns also become apparent when one is dealing with unusual problems involving thumb triphalangism, thumb triplication and the mirror hand, all examples of complicated polydactyly. Alternative surgical techniques may be helpful in obtaining the desired outcome of a stable, mobile thumb of adequate size and shape with as few surgical interventions as possible.

SURGICAL TECHNIQUES

Floating Thumb

If the skin bridge of a floating thumb is less than 4 mm in width it is my practice to excise this in the neonatal period if the parents so wish. Often the parents are concerned that the digit is vulnerable to injury. The child is wrapped in a blanket and held gently on the lap of a nurse. A fine 27 gauge needle is used to infiltrate local anaesthetic at the base of the skin bridge. A vascular clip or a suture may be placed around the base as close as possible to its origin and the digit is removed with a blade. The vascular clip or suture will fall off at two weeks or thereabouts. If performed precisely, the nubbin is minimal and hopefully will not require revision surgery at a later time.

If the skin bridge measures more than 4 mm, a formal excision and suture under general anaesthetic is delayed until after 3 months of age when general anaesthesia, conducted by a paediatric anaesthetist, is reasonable.

Removal and Reconstruction

This is the most common procedure for the management of thumb duplication. However, the complexity of the reconstruction will depend upon the status of the dominant thumb. Simple excision is indicated when there is no bony connection with the digit to be retained and the joints of this digit are stable. I prefer a formal dorsal or palmar based v-shaped flap rather than a racquet incision. The latter leaves a longitudinal incision which becomes

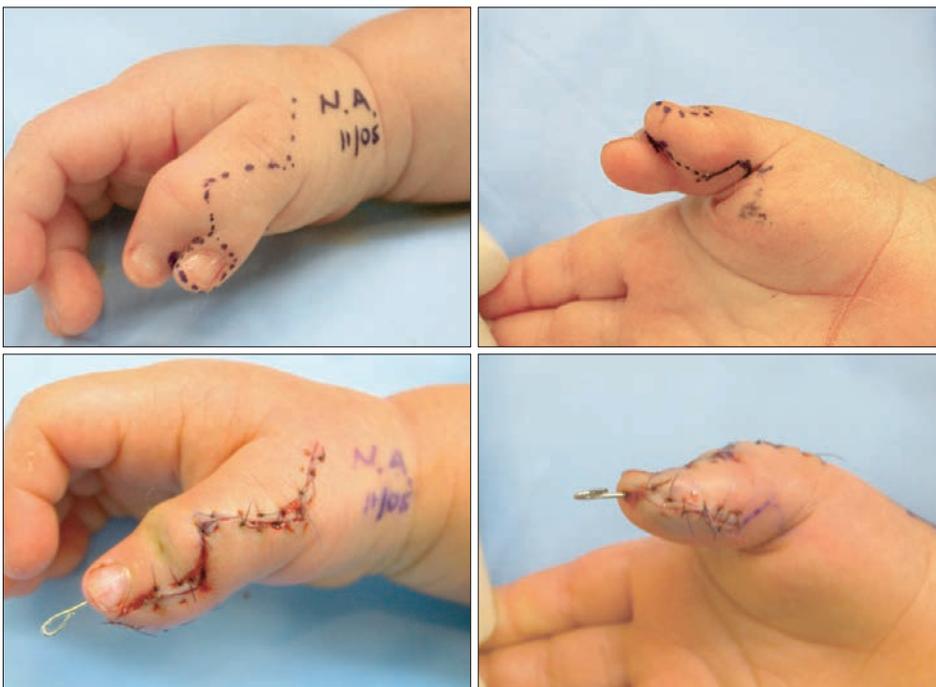


Fig. 3. Elevation of a neurovascular island flap from the radial aspect of the radial thumb to improve the contour of the reconstructed thumb.

a deforming force if there is any deviation with growth. Alternatively, the surgeon may prefer to perform a z-plasty to break up this longitudinal scar. If there is any concavity across the radial aspect of the thumb to be retained, usually the ulnar thumb, then a neurovascular island flap raised from the thumb to be discarded can fill this concavity very nicely (Fig. 3). The neurovascular island flap may also be used to supplement the nail fold and pulp. When raising the flap, it should be extended as far as possible on to the pulp so that it then can be advanced distally at the recipient site for better inset and contour. The level of inset distally will be determined by the anatomical characteristics of the reconstructed thumb. A too bulky contour is not aesthetically pleasing. The fibrous septae within the pulp need to be released so that the flap may be inset evenly.

For more complex duplications, the problems facing the reconstructive surgeon are those of deviation and instability at MCP and IP joints. These must be addressed if the outcome is to be optimal and secondary surgery is to be avoided. The causes are multifactorial: bone shape; joint underdevelopment and incongruity; abnormal tendon insertions, in particular the extrinsic extensors and FPL; and inadequacy or absence of collateral ligaments. These are best exemplified in the zig-zag deformities found in the common Wassel type IV thumb duplication when the thumbs are of near equal size (Fig. 4). The same principles and techniques apply to these problems when encountered in any of the other Wassel types, but it is illustrative to de-

tail the techniques used when all elements listed above are deficient in a type IV deformity.³⁻¹²⁾

I prefer zig-zag incisions, often incorporating a neurovascular island flap from the radial thumb, which is to be discarded. The dissection is in a plane deep to the extensor and flexor tendons which are divided at their insertions. The proximal and distal phalanges are removed along with the nail and nail fold. All other tissues, including tendons, are retained. A Beaver blade is helpful to maintain periosteum from the level of the diaphysis of the proximal phalanx, incorporating the MCP joint radial collateral ligament and a capsular-periosteal flap along the radial border of the metacarpal, keeping this flap as broad as possible, one-third to one-half of the circumference of the metacarpal (Fig. 5).¹³⁾ It is easy to perform this dissection on too deep a plane, elevating cartilage from the epiphysis of the proximal phalanx or from the metacarpal head. This should be removed from the capsular-periosteal flap so that an irritating lump does not develop with growth. Any IP soft tissue connection between the bases of the two proximal phalanges is retained, maintaining its attachment at the base of the proximal phalanx of the ulnar thumb. These tissues are used for reconstruction of the MCP joint radial collateral ligament.

The articulation of the MCP joint is inspected. Any ulnar deviation of the proximal phalanx will need to be corrected. Proximal traction is applied to the tissue attached to the radial aspect of the base of the proximal pha-



Fig. 4. Wassel type IV thumb duplication with divergence of proximal phalanges and convergence of distal phalanges.

lanx to correct the longitudinal alignment of the thumb. Stability and movement in the flexion-extension plane are assessed. A little sculpting of the metacarpal head with a Beaver blade may be necessary to improve congruency. A longitudinal metacarpal osteotomy removes that part of the metacarpal head which was articulating with the radial thumb (Fig. 5). Care must be taken that the proximal extent of this osteotomy is not directed too proximally or too far ulnarwards. The attachment of the capsular-periosteal flap proximally is maintained. If axial alignment at the MCP joint cannot be re-established, then a closing wedge osteotomy, based radially at the head-neck junction of the metacarpal, will be necessary. The osteotomy is not performed at this stage of the procedure, as the instability created increases the technical difficulty of reconstruction of distal aspects of the thumb.

Following removal of the radial thumb, the extensor and flexor mechanisms are evaluated. The thenar musculature is often included in the capsular-periosteal flap, without separation from its attachment to the MCP joint radial collateral ligament. The bifurcation of the common FPL tendon is usually distal to the level of the MCP joint. In these instances, the alignment of the tendon is radial to the longitudinal axis of the ulnar thumb at the level of the MCP joint, with an eccentric insertion to the radial side of the base of the distal phalanx (Fig. 6). There is bowstringing in two planes - radially and palmarly - with incompetence of the pulley mechanism. Similarly, the long extensor often inserts radially on the dorsal lip of the distal phalanx. The insertion of extensor pollicis brevis is often anomalous

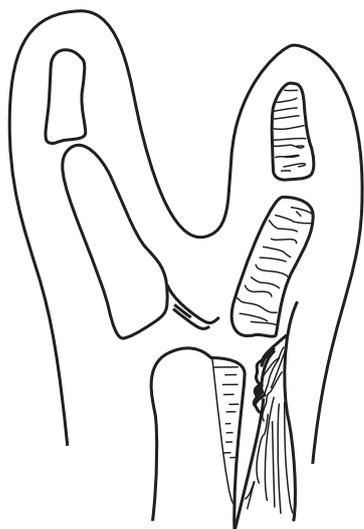


Fig. 5. Diagram of capsular-periosteal flap for metacarpophalangeal joint radial collateral ligament reconstruction; and longitudinal osteotomy to remove redundant articular surface of the metacarpal head.

and there may be connections between either or both extensors and FPL - pollex abductor (Fig. 7). These extrinsic tendons create a deforming force across the cavity of the ulnar thumb on its radial side. IP joint flexion is impaired, with deviation into the radial plane, and there is instability at the IP joint. If the deformity can be passively corrected, retaining reasonable congruency of the IP joint, soft tissue procedures will achieve good alignment. If not, a closing wedge osteotomy, based on the ulnar side at the head-neck junction of the proximal phalanx, is indicated. The clinical and radiological preoperative assessments and the intra-operative assessment will have determined the necessity or

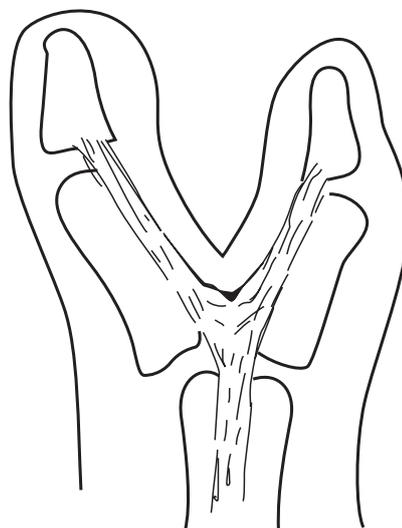


Fig. 6. Distal bifurcation of the flexor pollicis longus with eccentric insertions into the terminal phalanges.

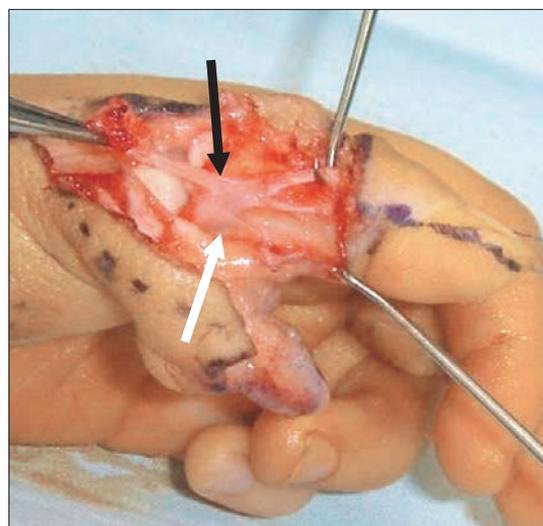


Fig. 7. Connections between the flexor pollicis longus (white arrow) and the extrinsic extensors (black arrow).

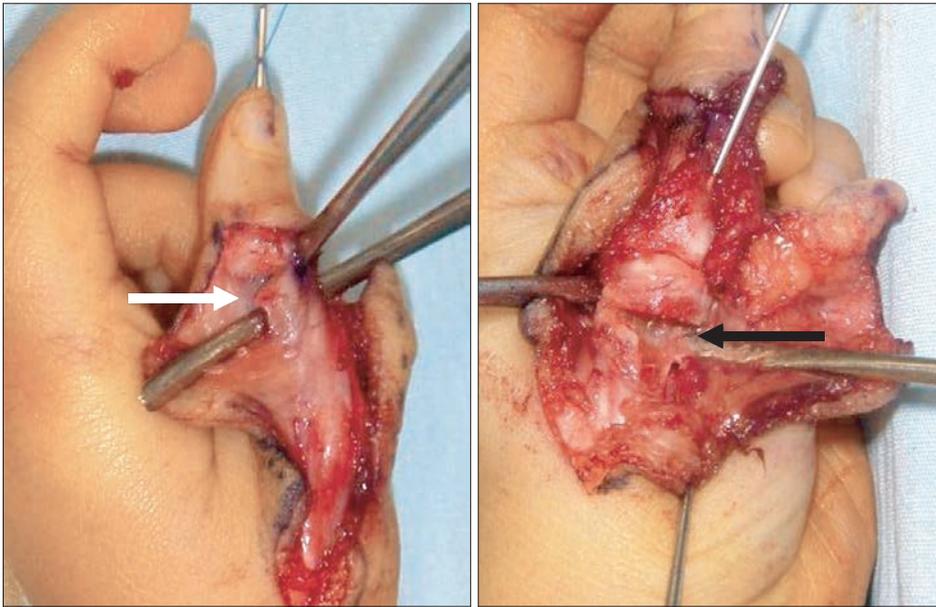


Fig. 8. Corrective osteotomies at the neck of the proximal phalanx (white arrow) and the neck of the metacarpal (black arrow).

otherwise for these rather difficult osteotomies - the bones are small and there are no second chances if errors are made. The following description assumes all components contributing to malalignment and instability require attention.

The radial insertion of the long extensor tendon (one-third to one-half width) is elevated and mobilised proximally to the level of the MCP joint, for future re-insertion on the ulnar side of the base of the distal phalanx. The aberrant insertion of FPL is dealt with in the same manner. Prior to this, the FPL of the discarded thumb is dissected proximally, well into the common FPL, so that a strip of tendon can be harvested and used for pulley reconstruction. There may also be redundant extensor tendon which can be used for such a reconstruction, but the surgeon should avoid compromising the integrity of the extensor tendon reconstruction of the retained thumb.

The osteotomies are now performed. Ideally, I try to gain access to the IP joint and pass an 0.7 mm K-wire antegrade through the terminal phalanx. The K-wire is then driven retrograde across the IP joint, having reduced the joint into its optimal position. It is an error to too aggressively correct deviation at the level of the IP joint, as the deformity will simply recur following removal of the K-wire. The wire does not pass across the intended osteotomy site at the head-neck junction of the proximal phalanx, but stabilises the joint to allow better control during the osteotomy. I use a Beaver blade to create the closing wedge osteotomy, based on the ulnar side. A small saw may be utilised in bigger bones. The assumption is that, when the K-wire is removed, the IP joint position will be retained.



Fig. 9. Tendon realignment and pulley reconstruction.

The osteotomy can then be planned to address the true deformity. The K-wire is then driven proximally across the osteotomy site into the proximal part of the proximal phalanx. If I am lucky, the same K-wire can be used to fix the MCP joint, in its reduced and stable position, prior to creating the closing wedge osteotomy based on the radial side of the metacarpal at the head-neck junction. After the second osteotomy is performed the wire is driven into the metacarpal base. Usually, a second K-wire is necessary to perform the stabilisation of the MCP joint and the metacarpal osteotomy, unless one has been particularly fortunate in obtaining perfect axial alignment of the first

K-wire in all planes (Fig. 8).

Attention is then turned to the soft tissues. I use a 5-0 Ticron on a small taper needle to reinsert the components of the extensor and flexor tendons which have been previously mobilised (Fig. 9). These are attached to the ulnar side of the insertion of both extrinsic tendons and to the base of the terminal phalanx. If instability of the ulnar collateral ligament of the IP joint is present, my method of reconstruction is to raise a longitudinal strip of the palmar plate (about 2 mm in width), dividing it proximally and retaining its attachment distally. This is transposed dorsally to the head-neck junction of the proximal phalanx, distal to the osteotomy site, and is sutured through bone with a 5-0 Ticron suture.

The pulley system is incompetent. I simply use part of the flexor or extensor as a circumferential pulley around

the proximal phalanx, sutured to itself (Fig. 9).

These procedures - flexor and extensor tendon reinsertion, bone realignment, joint and pulley reconstruction - result in a significant decrease in motion in IP joint flexion and, occasionally, a mild extension lag. However, in such difficult reconstructions, I consider that axial alignment and stability are more important than IP joint motion.

The MCP joint radial collateral ligament is then reconstructed using the capsular-periosteal flaps that have been elevated previously (Fig. 10). Local tissue is generally adequate. The capsular-periosteal flap attached to the metacarpal is sutured into the epiphysis at the radial base of the proximal phalanx or into tissue attached to it. The physis is avoided. I also place a suture just distal to the metacarpal osteotomy to make certain that the capsular-

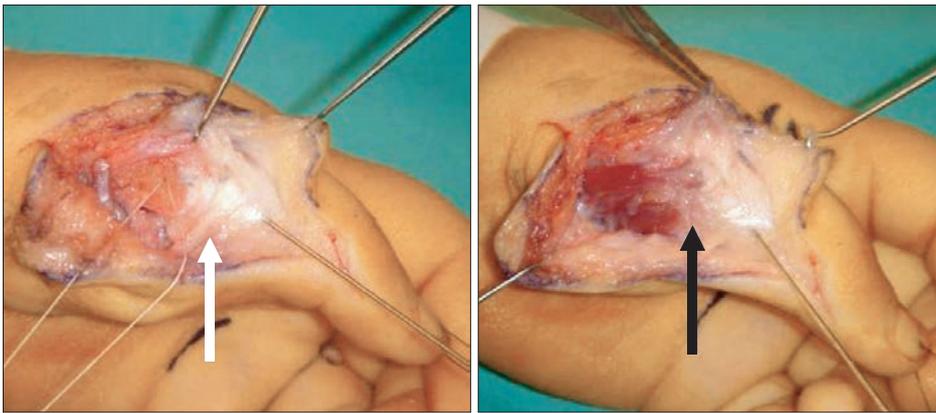


Fig. 10. Reconstruction of the metacarpophalangeal joint radial collateral ligament with a capsular-periosteal flap. Soft tissue from the base of the proximal phalanx is sutured to the metacarpal neck (white arrow). Radial collateral ligament and thenar musculature is oversewn into the ligament reconstruction (black arrow).

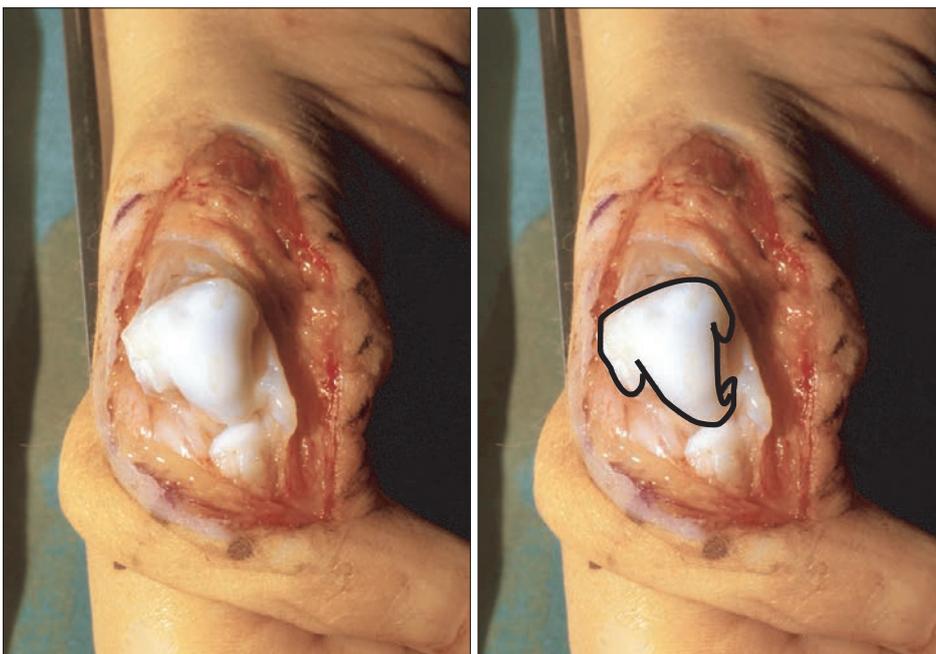


Fig. 11. The "elephant trunk" sign of global metacarpophalangeal joint instability.

periosteal flap is adherent at the new origin of the radial collateral ligament. Occasionally, this ligament reconstruction demands reinforcement. I elevate a longitudinal piece of the palmar plate in the manner described for the IP joint, transposing the proximal aspect to the metacarpal head where it is sutured.

Global instability of the MCP joint presents a difficult problem. In this instance, the MCP joint is severely hypoplastic and unstable in all directions. Viewed end-on, the metacarpal head does not flare but narrows on its palmar side - the "elephant trunk" sign (Fig. 11). The proximal phalanx articulation is flat. I attempt to avoid a MCP joint chondrodesis or arthrodesis. This is the one procedure that may be performed at a later stage, if absolutely necessary. The soft tissue reconstruction is in three planes. Instability in hyperextension can be overcome by advancing the volar plate proximally, stitching it to bone at the metacarpal head-neck junction. There may be adequate local tissue on the ulnar side to reconstruct an ulnar collateral ligament. Alternatively, the ulnar part of the volar plate may be divided longitudinally for reconstruction of an MCP joint ulnar collateral ligament. The surgeon will

need to decide which components of the instability are best suited to reconstruction with the palmar plate and which with other local tissue.

The thenar musculature may have been incorporated in the radial collateral ligament reconstruction. If not, it can be oversewn into it. If there is ulnar collateral ligament instability, one must be careful about reattaching it under tension distal to the MCP joint on the radial side, as this may act as a deforming force. Similarly, it is not ideal to suture it to the extensor tendon mechanism and increase any previous tendency of the extensor tendon to sublux radially.

After releasing the tourniquet, the flaps are inset with 6-0 Vicryl Rapide sutures. I maintain the thumb in a plaster for five weeks. The K-wire(s) is removed following radiological assessment of osteotomy union. A removable splint protects axial alignment, allowing the child increasing periods of time out of the splint for gentle active and passive flexion and extension exercises. Aggressive therapy is unnecessary. The child's spontaneous activities are usually satisfactory. The parents may need to attend to the wounds through bathing, massage, and the use of Coban

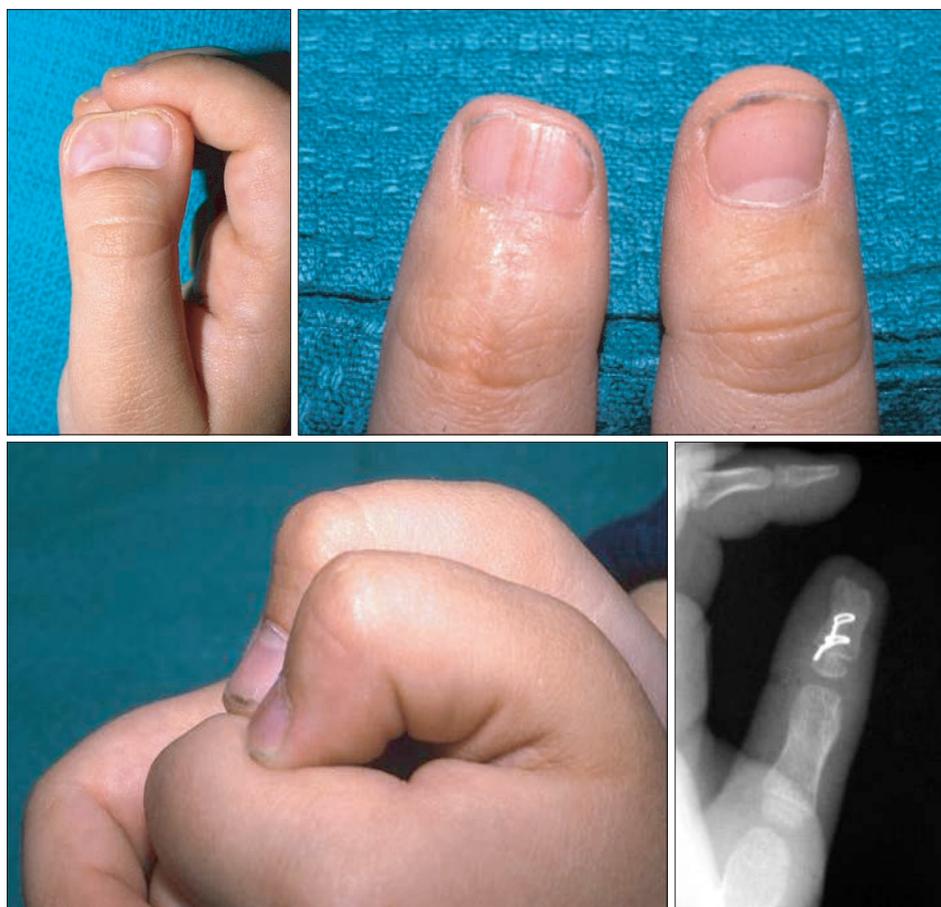


Fig. 12. Preoperative and postoperative views of a Wassel type I with equal size and shape of duplicate parts.

wrapping or silicon if scars tend to any significant hypertrophy.

Such sophisticated and complex reconstructions are not common. Many type IV thumb duplications simply require attention to the MCP joint radial collateral ligament and reshaping of the distal metacarpal and metacarpal head articular surface. However, a failure to recognise other anomalies which require reconstruction will lead to unsatisfactory outcomes and secondary surgery.

Wassel type V duplications often demand a more proximal metacarpal osteotomy to realign the skeleton. Although the MCP joint is intact, radial collateral ligament reinforcement may be necessary. It is rare to perform

reconstructions at CMC joint level, even in type VI duplications, other than perhaps a capsular suture and, on occasions, reattachment of the insertion of abductor pollicis longus. Some unusual cases are discussed in the final sections of this article.

The Bilhaut-Cloquet Procedure

Some see no indication for the classical Bilhaut-Cloquet procedure, stating that the complications of restricted joint motion and nail ridge are unacceptable and that appropriate application of techniques described above obtain good results. This may be so for most type I and type II thumb duplications, for which deviation and instability at the IP joint can usually be managed with these techniques. When

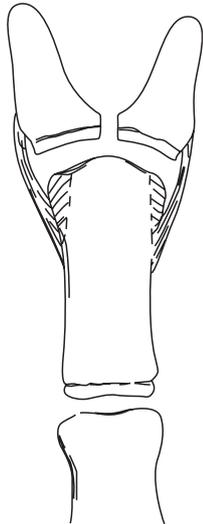


Fig. 13. Diagram of excision of triangular fragments of bone and cartilage from the proximal phalangeal head to decompress the terminal phalangeal reconstruction.



Fig. 15. Two fine interosseous wires are placed at defined distances distal to the physes.

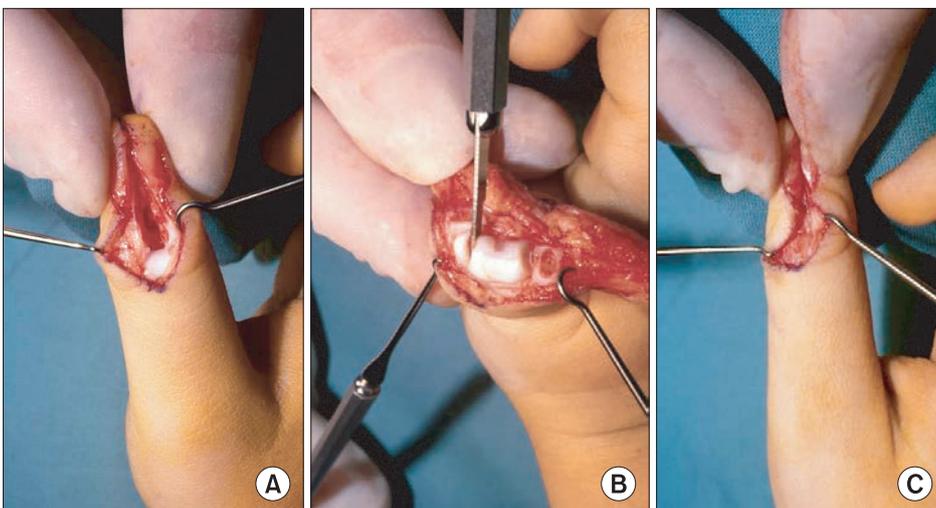


Fig. 14. (A) Inability to appose the two parts of the terminal phalanx along their whole length. (B) Removal of triangular wedge of cartilage and bone from the proximal phalangeal head bilaterally. (C) Easy apposition of terminal phalangeal components.

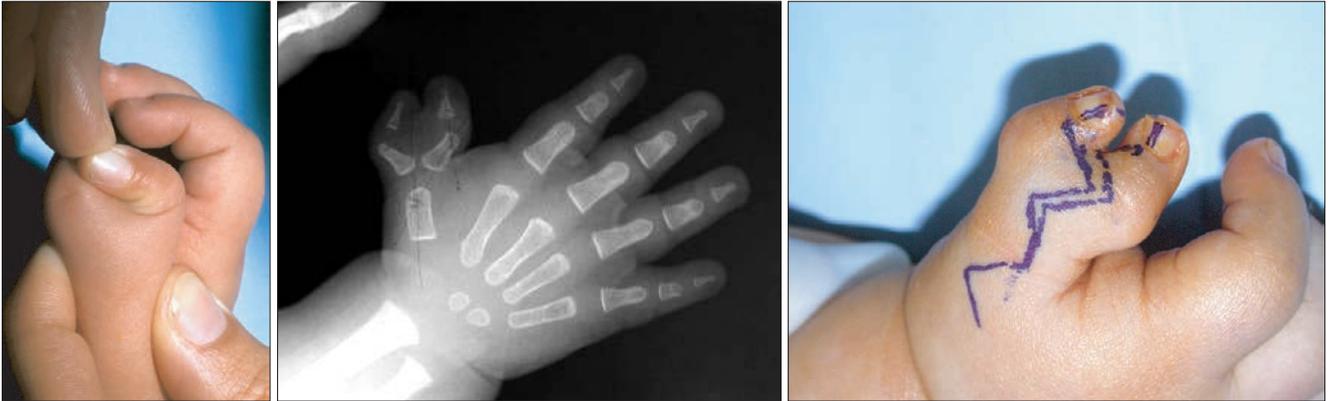


Fig. 16. Significant instability and deviation of a type III thumb duplication.



Fig. 17. Bilhaut-Cloquet reconstruction of a type IV thumb duplication with good carpometacarpal and metacarpophalangeal joint motion, restricted interphalangeal joint motion, good size and appearance and minimal ridging.

the nails are combined, the nail fold reconstruction may be a little problematic but must be measured against the nail ridge which is created by removal of central parts of the duplicated thumbs. I have obtained good motion and minimal ridging following the Bilhaut-Cloquet procedure in type I and II thumbs, but only for thumbs of equal size and shape (Fig. 12).¹⁴ If it is to be performed, some tips are helpful. Preoperative planning will determine how much of each thumb is to be removed. The nail bed and terminal phalanx are divided in a step-cut manner, retaining a greater width of nail bed than width of terminal phalanx. This allows easy tension-free coaptation of the nail bed edges once the phalanges are joined together. Extensor and flexor insertions are retained. Elevation of the collateral ligaments from the proximal phalangeal head, with removal of a triangle of articular cartilage and bone bilaterally, allows decompression of the soft tissues such

that the terminal phalanges may be apposed evenly along their whole length (Fig. 13). Without this decompression they tend to meet at either tip or base (Fig. 14). It is vital to match the physes of the two phalanges. The cartilage within the joint can be trimmed with a Beaver blade so that the joint articulation is as congruous as possible. Two fine interosseous wires (30 gauge) are placed at defined distances distal to the physes (Fig. 15). Preliminary drilling with a 0.7 mm K-wire will allow easy passage of the wire suture without splitting the bone. The osteosynthesis must be smooth dorsally with no prominences or ridge. All parts of the nail bed are sutured, including its dorsal component, under magnification with 8-0 Vicryl sutures. Part of the nail is replaced between nail fold and nail bed to prevent formation of a synechia. The extensor tendon is coapted together with 5-0 or 6-0 Vicryl. It is not necessary to re-insert the flexor tendon as long as the integrity of its



Fig. 18. Modified Bilhaut-Cloquet procedure.

insertion has not been compromised.

These principles and techniques may be applied to the one circumstance for which I believe the classical Bilhaut-Cloquet procedure retains a significant role: this being for reconstruction of more proximal thumb duplications when neither thumb distal to the metacarpal is adequate and when the surgeon believes that the reconstructive procedures will not create a satisfactory thumb of adequate mobility, stability, alignment and size (Fig. 16).¹⁵ If I judge that there is a significant risk of instability at MCP and IP joints, that deviation is impossible to avoid, and that the size of the reconstructed thumb will be significantly compromised, then the Bilhaut-Cloquet technique is a good option. Provided that the CMC joint is intact, the

disadvantages of decreased motion distally and a minimal nail ridge are acceptable.

Matching unequal phalangeal elements is the challenge. Transverse osteotomies, as well as longitudinal osteotomies, may be necessary to create parts of equal size. Again, physes must be matched optimally, in both proximal and distal phalanges. Sculpting of the joints may be necessary. Fusion, with shortening of triphalangeal components, when triphalangism is present, adds another challenge to the precision with which the bone reconstruction must be performed. IP joint motion will be minimal. MCP joint motion is usually present but diminished. In my hands, ridging has been present but minimal and entirely acceptable to the patient. The size is matched to the

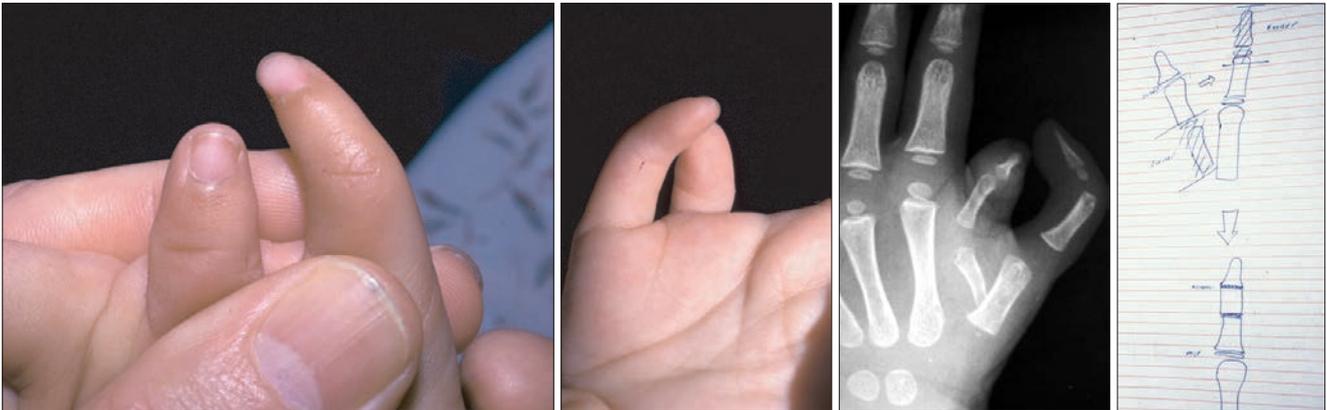


Fig. 19. Preoperative appearance prior to combination of acral transposition of the distal part of the ulnar thumb to the radial thumb with shortening and fusions.



Fig. 20. Postoperative result from the case shown in Fig. 19.

opposite thumb. Stability, strength and appearance provide a superior result to that following the reconstruction of an impossibly hypoplastic and unstable digit (Fig. 17). In my cases, subsequent growth has been maintained without deviation secondary to growth plate tethering.¹⁵⁾

The Modified Bilhaut-Cloquet Procedure

For this term to be valid, some longitudinal components of both thumbs must be combined. Perhaps the most common combination is to use the nail and terminal phalanx of the better thumb, combining this with a part of the terminal phalanx of the lesser thumb (Fig. 18). The difficulty is in matching the small terminal fragment of bone to the dominant terminal phalanx. If the collateral ligament is to

be retained, the component of bone must include epiphysis, physis and a piece of metaphysis. Fixation is difficult. Furthermore, it is not uncommon to include a very small piece of nail bed with this bone fragment, in spite of the best efforts to avoid the inclusion of this. I have had to revise the nail beds of two thumbs suffering this complication.

Acral Transposition

At times, particularly when triphalangism is present, one thumb may be adequate proximally but the other thumb may contain a superior nail and pulp. Acral transposition (on-top plasty) is effective in combining the better parts of both thumbs (Figs. 19 and 20). This may be combined



Fig. 21. Preoperative appearance and X-ray of a thumb duplication.



Fig. 22. Postoperative appearance and X-ray following pollicisation of the dominant digit in the case shown in Fig. 21.

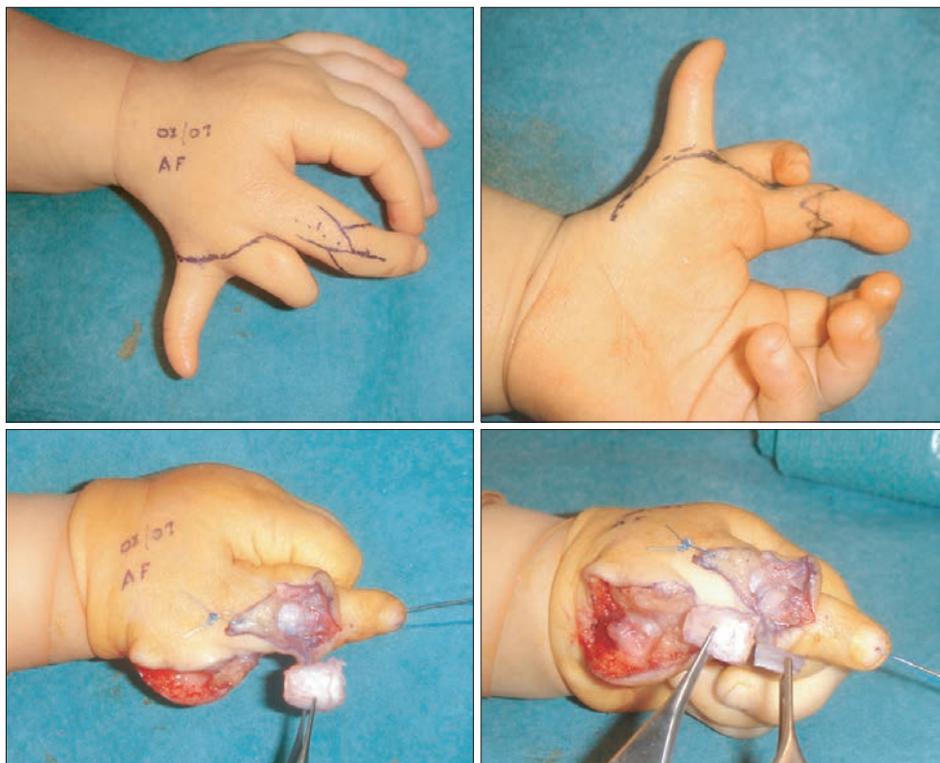


Fig. 23. Shortening, rotational metacarpal osteotomy and interphalangeal fusion with first web reconstruction of the optimal digit in a case of bilateral thumb triplication.

with a modified Bilhuat-Cloquet procedure.

Triphalangism, Triplication and Ulnar Dimelia

The techniques outlined above apply. The surgeon must pursue a reconstruction which provides an adequate CMC joint, which supports a stable skeleton distally, and achieves a thumb which has optimal mobility and adequate size and shape. The assessment must determine which digit, or which combination of digits, will provide the best thumb. The formula to success lies in the creation of an adequate CMC joint. The best digit is chosen for thumb reconstruction. In some circumstances, this digit has the skeleton of a finger, or a transitional metacarpal with proximal and distal physes. If the metacarpal characteristics are those of a finger, I prefer a formal pollicisation as the ideal method of obtaining an adequate CMC joint, as in reconstruction of the five-fingered hand (Figs. 21 and 22). Alternatively, in true thumb triphalangism, when the metacarpal is that of a thumb, the CMC joint may be retained and the reconstruction is performed distally, with shortening and repositioning osteotomies, a joint fusion, a first web plasty and sometimes an opposition transfer (Figs. 23 and 24).

Two Inadequate Thumbs

It is rare to be confronted with a circumstance in which



Fig. 24. Postoperative appearance from the case shown in Fig. 23.

the CMC joints of both thumbs are inadequate. However, when this is combined with severe distal hypoplasia and instability, it is possible that no reconstruction will achieve a useful thumb (Fig. 25). Although it is difficult for many to accept a reduction from six digits to four, both thumbs are useless. I advise removal and a pollicisation of the index finger for optimal function and appearance.

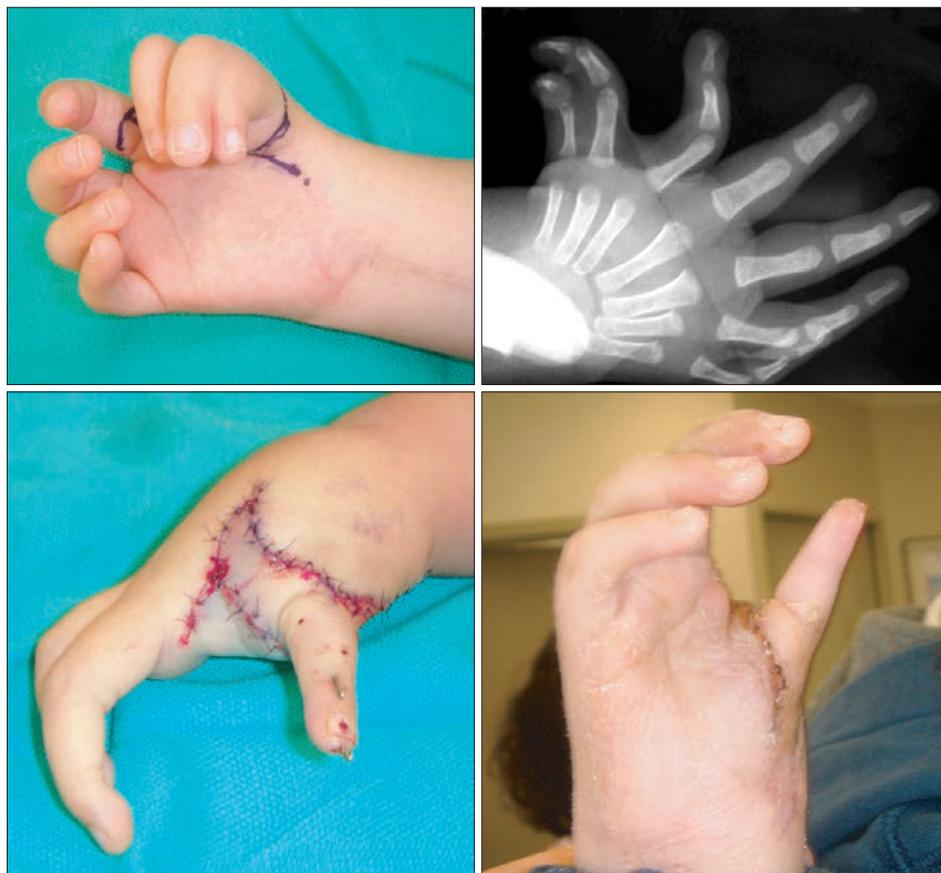


Fig. 25. Pre- and postoperative appearance in a case of ulnar dimelia in which optimal appearance and function were obtained by reducing the number of digits to four.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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