MINI-SYMPOSIUM: CHILDREN’S ORTHOPAEDIC SURGERY

(iii) Congenital hand anomalies

A.C. Watts, G. Hooper*

The Hand Unit, St John’s Hospital, Howden Road West, Livingston, West Lothian EH54 6PP, UK

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Summary
This is a review of congenital anomalies of the hand, taking into account the development of the upper limb, the known aetiological factors and classification of these disorders. The principles of their management are described.

Introduction
Congenital upper limb anomalies are second only to congenital cardiac abnormalities in frequency and account for 10% of all malformations at birth. Congenital abnormalities may arise either from primary structural defects due to localized developmental failure or secondary changes after normal development has begun. A number of different classification systems have been proposed but the most widely known and that adopted in modified form by the international federation of societies for surgery of the hand (IFSSH) and the American society for surgery of the hand (ASSH) is the Swanson classification1 (Table 1). The aim of this classification is to use simple terms to describe the appearances, avoiding words based on Latin and Greek, or eponyms, which may be misunderstood or difficult to translate into other languages. This has not been entirely achieved, as will be apparent from the terms used in this article. It implies nothing about the causes of any anomaly. Most but not all anomalies can be classified using this system.2,3 It should be borne in mind that different types of anomaly can occur in the same limb, making classification difficult.

Embryology
The limb bud develops around 26 days after fertilization. At 52–53 days the embryo is 22–24 mm in length (crown-rump length) and the fingers are entirely separate. Eight weeks after fertilization all the limb structures are present. This period of embryogenesis when rapid development of the limb is occurring is when most congenital upper limb abnormalities occur. The fetal period that follows sees differentiation, maturation and enlargement of existing structures.

The limb develops in a proximal to distal direction. Cells from the lateral plate mesoderm (which become bone, cartilage and tendon) and somatic mesoderm (which become muscle, nerve and vascular structures) migrate into the overlying ectoderm to form the limb bud. Three signalling centres control development: the apical ectodermal ridge (AER) regulates proximodistal development, the zone of polarizing activity (ZPA) radioulnar development and an ectodermal signalling centre regulates dorsoventral development (differentiation of dorsum of finger with nail, and ventral surface with pulp). There is increasing
knowledge of how these signalling centres control cellular differentiation and positioning by growth factors and gene expression.

Congenital anomalies may be isolated (confined to the upper limb, possibly bilateral) or part of a malformation syndrome, with several congenital abnormalities affecting different systems, for example the heart and renal systems. Malformation syndromes are presumably the result of some process affecting several developing systems at the same time.

Aetiology

The precise aetiology of congenital upper limb anomalies is largely unknown. Some have a clear genetic pattern, which may be autosomal, recessive or sex-linked, but others are sporadic and non-hereditary. An apparently sporadic anomaly with no family history may be the result of new mutation. A clinical geneticist should assess all families in which there is a child with a congenital anomaly.

Physical and chemical agents acting on the developing embryo may cause non-hereditary anomalies. Relatively few such factors have been identified, the most well-known being the drug thalidomide. The former diagnostic process of chorionic villus sampling was also associated with limb abnormalities. It is possible that the quoted incidences may change if antenatal diagnosis by ultrasound is followed by termination or better maternal health changes the risks of embryogenesis. These factors will only be apparent from long-term studies.

Excluding stillbirths the overall prevalence is 11.4–19.7 per 10 000 live births. Little variation has been shown between different population groups in the prevalence of most anomalies but ring constriction syndrome was found to be 4–6 times more common in Japan than in Edinburgh and ulnar polydactyly is known to be more common amongst Afro-Americans. Male children are more commonly affected than female with a reported ratio of 3:2 for all categories of abnormality other than generalized skeletal abnormalities. There is a reported increase in prevalence with increasing maternal age: for mothers over the age of 40 years the prevalence ratio is twice that for mothers under 30 years.

Between 5% and 20% of upper limb anomalies are associated with an identifiable syndrome. Bilateral anomalies occur in half of the cases and the majority are of the same type in each hand. Multiple upper limb anomalies occurring in the same individual are reported to occur in 17% of cases.

Failures of differentiation and duplications are the most common anomalies. Polydactyly is the most common individual diagnosis. Failure of formation is the next most common category with both transverse and longitudinal defects occurring equally. Radial ray deficiency is the most common single diagnosis in this category.

The rate of mortality is high. Eighteen per cent die before the age of 6 years due to other congenital disorders.

Failure of formation

In transverse absence all proximal structures including nerves, arteries and tendons will be present. In longitudinal absence lateral structures are absent or deficient. The aetiology of transverse absence is multifactorial but experimentally removal of the AER during embryogenesis results in a truncated limb similar to that seen in congenital amputations. Interca11 defects, in which the proximal and distal parts of the limb are present but an intermediate segment is missing, probably do not exist.

Transverse absence

Transverse absence, incorrectly known as congenital amputation and also incorrectly attributed at times to constriction bands, occurs when the limb fails to form below a certain level. The most common level is the proximal forearm (more often on the left side), followed by transmetacarpal, distal forearm and transhumeral. The anomaly is usually unilateral and is classified according to the last remaining bone segment. Finger nubbins may be present at the distal end. Developmentally the child is usually normal but may not crawl.

Prostheses are more likely to be accepted if introduced before the age of 2 years. Initially the child is given a passive hand, but may start to use an active device between the age of 2 and 3. Active devices may be cable operated or myoelectric. The latter may be perceived as superior but they are heavy and need a lot of maintenance. Despite the

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total difference in control mechanism, most children can use both types, although sufficient muscle bulk to generate a control signal is necessary to use a myoelectric arm.

**Longitudinal absence**

**Radial hypo- and aplasia**
Radial deficiency includes a spectrum of anomalies affecting the radial side of the forearm and hand, including the thumb, which may be normal or hypoplastic. In radial absence (Fig. 1) the forearm is usually very short, the wrist unstable and the digits have reduced range of movement and power. It is an uncommon anomaly but is the most common longitudinal deficiency. There is a strong association with congenital syndromes, some of which may be life-threatening, such as the vertebral anomalies, anal atresia, cardiac anomalies, tracheoesophageal fistula, renal anomalies, limb anomalies syndrome (VACTERL), Holt-Oram syndrome (cardiac septal defects and limb anomalies), thrombocytopenia, anaemia, absent radius (TAR), Fanconi anaemia and chromosomal anomalies such as trisomy 13 and 18. The condition is often bilateral.

Function may be severely affected especially where the deformity is bilateral. The primary issues are thumb hypoplasia, wrist instability and inequality of the forearm bones. The aim of surgery is to obtain carpal centralization and stabilization on the end of the ulna and thumb reconstruction by pollicization may be required. External fixators are often used to stretch the soft tissue structures on the radial side of the wrist prior to centralisation. Recurrence of deformity and stiffness have been reported in long-term follow-up studies. Surgery should not be undertaken in the presence of severe major organ defects due to the risks of anaesthesia, and when active elbow flexion is absent.

**Ulnar deficiency**
This is much less common than radial deficiency with an incidence of one in 100 000 live births. It is most commonly unilateral and does not have the same systemic associations as radial deficiency. The entire upper limb may be hypoplastic with a malformed or fused elbow joint. The hand and carpus are always affected with absent ulnar digits in 90%, syndactyly in a third and thumb abnormalities in 70%.

Severe bowing of the radius may result in a bizarre appearance and marked malposition of the hand. The aim of surgery is to enable the child to bring the hand to the mouth. Resection of the fibrocartilaginous anlage of the distal ulna, once considered mandatory, has been shown to be unnecessary in most cases, although it may still be required if the radius is extremely bowed and corrective radial osteotomy is necessary. Humeral osteotomy may be indicated if the arm is internally rotated, and closing wedge osteotomy can be employed to place the elbow in a more flexed position. Surgical correction of associated digital anomalies can improve hand function.

**Cleft hand**
True cleft hand (stigmatizing terms such as "lobster-claw hand" should be avoided) is manifest by a central V-shaped absence, which may be associated with absence of one or more digits. It is commonly inherited as an autosomal dominant trait, sometimes leading to local lusters of cases in affected families. It may also occur in a number of syndromes. The aetiology is thought to be a wedge-shaped defect of the apical ectoderm of the limb bud. It may be unilateral or bilateral and may involve the feet.

Cleft hand produces a particular challenge because function may be good but the appearance may be socially unacceptable. Those with a family history are more likely to accept an observational approach. Early surgery should be aimed at preventing worsening of the deformity, for example by removing a transverse bone, which will widen the cleft as it grows (Fig. 2). Other surgery can be delayed until the child is older, with emphasis placed on reconstruction of the first web space and closure of the cleft.

**Symbrachydactyly**
This term is discussed here as it occurs in the literature and causes confusion. The use of the Greek-based term symbrachydactyly goes against the principle of simple language in the IFSSH classification but it perhaps illustrates one of the difficulties of that classification, at least for certain disorders. Symbrachydactyly has been used to describe a spectrum of distal hand deformities, usually occurring unilaterally, which are all thought to result from a sporadic failure of mesenchymal differentiation. The 4 types are seen as: (1) short stiff fingers and a normal thumb;
(2) absence of the central 3 fingers and relatively normal thumb and little finger; (3) absence of all fingers with preservation of the thumb; and (4) transverse absence of all digits at the metacarpal level. However, types 2, 3 and 4 differ from true transverse absences in that there are digital nubbins that bear nail remnants. Using the IFSSH classification these abnormalities would be classified respectively as: (1) undergrowth; (2) terminal central defect; and (3) and (4) as terminal transverse defects. However, it should be remembered that the IFSSH classification is descriptive and does not attempt to ascribe a pathological mechanism to each anomaly, whereas the concept of “symbrychydactyly” is based on a proposed commonly pathological process. A more detailed overview of this topic and other aspects of classification is given in the article by McCarroll.3

**Failure of differentiation**

**Radioulnar synostosis**

This is not of course a congenital hand disorder but is mentioned here because of the effect that it may have on hand function and the fact that it is commonly seen by orthopaedic surgeons. The radius and ulna normally separate late in the first trimester of pregnancy. Failure of this process results in synostosis. This condition may be inherited in an autosomal dominant fashion and is bilateral in 60% of cases. The forearm will be fixed in pronation in most cases. Diagnosis is typically delayed, sometimes until adolescence. Radiographic evidence of a bony bar between radius and ulna confirms the diagnosis. It is usually an isolated anomaly but other musculoskeletal anomalies co-exist in a third of cases.

If the deformity is unilateral surgery may not be required as the child can compensate with shoulder and elbow movement. Surgery is indicated if the forearm is pronated greater than 60°. Derotation osteotomy, which should be combined with slight shortening by bone resection, aims to place the hand in neutral to 15° of pronation in unilateral cases or 10–20° of pronation of the dominant arm and neutral rotation of the non-dominant arm in bilateral cases. The patient must be observed closely post-operatively for compartment syndrome.10

**Carpal coalition**

During the embryonic phase of limb development the carpal bones develop from a cartilaginous condensation. Failure of this cavitatory process results in coalition of the carpal bones. The most commonly fused bones are the lunate and the triquetrum in isolated carpal coalition but it can occur as part of a syndrome. The overall incidence is estimated to be 1 in 1000 of the population but there is increased frequency in females and in those of African descent. This condition is usually asymptomatic and an incidental finding but symptomatic cases have been reported.11

**Camptodactyly**

Camptodactyly is a flexion deformity of the proximal interphalangeal joint that may be progressive and is often fixed. Most cases are sporadic but it may be inherited in an autosomal dominant fashion with variable penetrance. The little finger is most commonly affected. The pathological mechanism has not been defined for all cases but some are associated with anomalous lumbrical insertions, which can be released. Generally speaking the results of surgical treatment are otherwise poor, particularly if the proximal interphalangeal joint is fixed. Conservative treatment with stretching, splints and serial casts can be employed with some success.

**Clinodactyly**

In this condition there is angulation of the digit in the coronal plane distal to the metacarpophalangeal joint. It is associated with many syndromes. The underlying abnormality is in the alignment of the interphalangeal joints due to asymmetrical longitudinal growth. The overall incidence is difficult to ascertain as many cases never present. The most common type shows radial angulation which is often bilateral and is inherited in an autosomal dominant fashion with variable penetrance. Males are more likely to express the phenotype.

The most severe form of growth insult results from the formation of a “delta” phalanx often associated with a C-shaped longitudinal bracketed epiphysis (Fig. 3). Hand function is rarely significantly altered by isolated clinodactyly but intervention may be sought for cosmesis. Indications for surgery are severe deformity with shortening or involvement of the thumb, and moderate deformity with functional impairment. Osteotomy is required to correct the underlying bony abnormality. Opening wedge osteotomy has the advantage of gaining or preserving length. Single stage correction is preferred. An alternative technique, which can only be used when the growth plate is open, is by epiphyseal bracket resection and fat grafting, allowing “catch-up” growth on the side of the concavity.12

**Symphalangism**

This is a curious condition in which an interphalangeal joint, usually the proximal interphalangeal joint in the small finger, fails to form by the usual mechanism of cavitillation of the cartilage between the cartilaginous precursors of the

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Figure 3 Clinodactyly affecting the small finger. Note the longitudinal bracketed epiphysis.
phalanges. It has an autosomal dominant form of inheritance and its interest lies in the fact that the condition has been traced in families for many generations, far longer than any other congenital condition.

**Flexed Thumbs**

**Congenital trigger thumb**

This is a misnomer. There is no evidence that the thumb is abnormal at birth and the majority of thumbs present with fixed flexion rather than triggering. Bilateral involvement occurs in about a quarter of children. A nodule lying just proximal to the A1 pulley is readily palpable on the tendon of flexor pollicis longus and prevents full excursion of this tendon. The thumb may be passively manipulated into extension, often with a 'pop', and may be splinted in extension. There is debate as to the natural history. It is currently accepted that in those diagnosed before 1 year of age the thumb may be observed with or without splintage up to 3 years of age. The indications for surgery are failure of resolution with conservative management, a child presenting over the age of 2–3 years and the presence of a rigid deformity. The treatment is by surgical release of the A1 pulley under general anaesthesia and with magnification. Care must be taken to avoid injury to the digital nerve. Recurrence is very rare.

**Congenital clasped thumb**

Congenital clasped thumb describes a spectrum of anomalies from minor deficiency of the extensor mechanism to severe abnormality of the thenar muscles, web space and soft tissues. A type I deformity is usually supple with absence or hypoplasia of the extensor mechanism. Type II is complex with additional joint contractures, collateral ligament abnormality, web space contracture or thenar muscle abnormality. A type III anomaly is associated with arthrogryposis or its related syndromes. The diagnosis may be delayed because the newborn typically holds the thumb clenched in the palm. The diagnosis is made by the appearance of a thumb that rests in flexion with extensor lag that is usually at the metacarpophalangeal joint. This indicates hypoplasia of the extensor pollicis brevis muscle. Extension lag at the interphalangeal joint and an adduction deformity of the metacarpal indicate deficiency of extensor pollicis longus and abductor pollicis longus, respectively. The treatment is by splintage in extension to prevent further hypoplasia and allow hypertrophy. The results are good with splintage retained for 2–6 months in cases identified at less than 1 year of age. Surgery is indicated if splintage fails or the child is over the age of 2 years. Mild deformity that is missed may not require treatment, as function may not be affected. Extensor indicis transfer is the operation of choice where this is present.

**Syndactyly**

Syndactyly is a common congenital hand anomaly that occurs when the normal processes of digital separation and web space formation fail to occur. The digits form from condensations of mesoderm within the terminal paddle of the embryonic limb under the control of the AER. Regulated apoptosis occurs from distal to proximal between the digits to form the web-space. Syndactyly is commonly bilateral and a family history is reported in 10–40% of cases. The degree of digital fusion is variable, being described as complete or partial. The fusion may include soft tissue only (simple syndactyly) (Fig. 4) or soft tissue and bony parts (complex syndactyly). Abnormalities of the nails, digital nerves and vessels, and tendons may be seen. Extra digits may be contained within a fused mass of digits in syndactyly. Syndactyly may be isolated, in which case the long/ring finger web space is most commonly affected, or involve several fingers. The tendon mechanisms may be normal, shared or deficient.

Syndactyly results in cosmetic, functional and developmental problems. Tethering of longer digits by the adjacent shorter digit leads to flexion contracture and deviation of the longer digit towards the shorter. In all cases surgery should be considered unless the deformity is minor, other comorbidities prevent intervention or the deformity is so severe that intervention may have a deleterious affect on function. There is debate as to the ideal timing of surgery; the aim should be to complete any corrective procedures by school age. Better outcomes have been shown with surgery after 18 months of age, but some prefer to operate earlier to prevent developmental problems. Staged procedures are indicated when release is required on both sides of a digit to reduce the risk of vascular compromise. Reconstruction is performed primarily by "Z" plasty. A full description of the many different techniques can be found in larger texts.  

![Figure 4](a,b) Simple syndactyly between the ring and long fingers.
Skin grafts should be full thickness where possible and should be avoided in the commissure to prevent interdigital contractures and web creep. Outcomes are better for simple syndactyly. Syndactyly may be associated with other deformities, and be a feature of a syndrome, such as Apert syndrome (severe complex syndactyly with bicornal craniosynostosis) or Poland syndrome (simple syndactyly, brachydactyly and absence of the sternocostal portion of pectoralis major), or present in some chromosomal abnormalities.

**Duplication**

The terms radial and ulnar are now preferred to pre-axial and post-axial when describing polydactyly.

**Radial polydactyly**

Polydactyly of the thumb is more common amongst Caucasians and Native Americans and is usually sporadic although a family history is not uncommon. It is classified according to the system of Wassel\(^{14}\) into seven types depending on the degree of duplication and separation of the bony parts (Fig. 5). The most common of these (30–40%) is the type IV duplication, followed by type II.

The condition is not a true duplication as neither digit is as robust as a normal thumb nor do they both contain the usual soft tissue attachments. The thumb should be examined for stability and mobility of joints. One of the duplications will tend to be larger and in surgery for type III and IV duplications the smaller digit may be ablated. Surgery is usually carried out between 6 and 12 months of age before pinch grip develops. The aim is to create a stable functioning thumb and this may require using parts from both digits in reconstruction. Tendons should be centralized on the retained thumb and intrinsic muscles should be transferred from the ablated digit to the one that is retained. Any residual instability or malalignment may progress to the formation of a lateral ’Z’ thumb deformity.\(^{15}\)

**Ulnar polydactyly**

Ulnar side polydactyly is frequently inherited in an autosomal dominant pattern but with variable penetrance. Its prevalence is highest amongst black Americans, and when seen in Caucasians it is suggestive of an underlying syndrome. The accessory digit can either be well-formed (type A) or a rudimentary pedunculated nubbin (type B). A well-formed digit must be surgically removed and this is probably safer than simple ligation for the type B digit.

**Central polydactyly**

Central polydactyly is the occurrence of an accessory digit within the hand but not on the ulnar or radial border. The ring finger is most commonly duplicated followed by the long and lastly the index finger. It has been suggested that central polydactyly is the result of the same mechanisms that produce typical cleft hand deformity, a view supported by the occurrence of typical cleft hand deformity and central polydactyly in identical twins.\(^{16}\) If the accessory digit is fully formed and functional it need not be removed, otherwise ray resection is the treatment of choice. Synpolydactyly is treated by separation of the digits and debulking of the accessory digit. Complete resection is often

![Figure 5 Wassel classification of thumb duplication. Type (I) bifid terminal phalanx, Type (II) duplicate terminal phalanx, Type (III) bifid proximal phalanx, Type (IV) duplicate proximal phalanx, Type (V) bifid metacarpal, Type (VI) duplicate metacarpal and Type (VII) triphalangism.](image)
impossible leading to somewhat disappointing results. If the duplication is complex no treatment may result in a better functional outcome than surgical intervention.

**Overgrowth and undergrowth**

**Macroductyly**

The most common form of macroductyly, a disproporionately enlarged digit, is an isolated deformity associated with lipomatosis of a proximal nerve. The anomaly may be progressive (disproportionate growth) or static (the enlarged digit maintains in the same proportion to the rest of the hand throughout growth). Multiple digital enlargement is more common than single digit, but is usually confined to an area supplied by either the median or ulnar nerves. The index finger and long finger are most commonly involved.

Macroductyly may be present as part of a more widespread anomaly. It is associated with neurofibromatosis, gigantism and other syndromes such as Ollier disease, Maffucci syndrome, Klippel–Trenaunay–Weber syndrome and Proteus syndrome. Treatment is extremely difficult and is aimed at limiting growth or reducing the size of the digit, for example by epiphysiodesis and debulking. Amputation may be necessary in extreme cases.

**Thumb hypoplasia**

The hypoplastic thumb presents as a spectrum of anomaly from a slightly small thumb to complete absence. It is frequently part of a radial deficiency. The modified Blauth classification\(^\text{17}\) is used to guide treatment (Table 2). The status of the intrinsic and extrinsic muscles should be assessed, along with the stability of the MCP and CMC joints. The diagnostic challenge lies in correctly identifying the type II deformity and whether it is a type A or B anomaly. This may require serial examinations before treatment, but may not be distinguishable until the child develops pinch and grasp in the hand. The stable type A thumb will be incorporated into the pinch grip but the unstable type B thumb will be bypassed with pinch grip performed between the index and middle finger.

Type I deformity may require no surgical intervention as function may be good. Pollicization is the treatment of choice for type IIIB, IV and V anomalies. Theoretically pollicization should be done between 6 and 12 months of age, before development of pinch grip, but in practice later operation does not seem to affect the outcome. The functional results are generally good but pinch strength is reduced.\(^\text{18}\) In type II and IIIA deformity the first web space can be widened with Z-plasty and release of the interosseous fascia, and absence of functioning thenar muscles can be circumvented by opposition transfer using abductor digitii minimi or the flexor digitorum superficialis tendon from the ring finger. Extrinsic extensor absence in type IIIA anomaly can be reconstructed with extensor indicis transfer but adequate long flexor reconstruction remains a challenge.

**Brachydactyly**

This term describes a short digit, or ray, in which all the skeletal elements are present but 1 or more are shortened. It may occur in isolation or as part of a syndrome. Similar appearances may be due to injuries resulting in physeal growth arrest (trauma, infection, frostbite). It is a common feature of autosomal dominant skeletal dysplasias such as hereditary multiple exostoses and multiple epiphyseal dysplasia, but is also seen in conditions such as pseudohyoparathyroidism.

The condition is not functionally disabling and treatment is not necessary.

**Constriction ring syndrome**

This is characterized by partial or complete circumferential constrictions around digits or limbs (Fig. 6). The aetiology is unknown and contentious but is currently thought to be related to endogenous mesenchymal degeneration within the developing limb rather than damage by extrinsic amniotic bands. The constriction band results in mechanical
strangulation of the distal appendage. This may be tense with incompressible oedema and occasional nerve palsies. It has been proposed that this condition may result in transverse absence characterized by normal proximal anatomy. The digits may be fused at their distal parts (acro syndactyly).

When the child is born with a congenital amputation due to constriction band syndrome, the condition may be confused with a true transverse deficit. However, in constriction band syndrome there is invariably evidence of skin grooving or other damage in the affected limb or other limbs.

Treatment is aimed at functional and aesthetic improvement. Urgent surgery to salvage a threatened appendage or for nerve decompression may be required. Complete circumferential excision of the band with "Z" plasty is the treatment of choice.

**Generalized abnormalities and syndromes**

The hands may have characteristic shape in many common skeletal dysplasias. For example, in Marfan syndrome the hands are long and thin and in achondroplasia they are short and square. Examples of malformation syndromes have been mentioned elsewhere in the text.

**Miscellaneous disorders**

This group contains those anomalies that cannot readily be classified elsewhere. A couple of examples will be given.

**Madelung deformity**

Madelung deformity is excessive ulnar and palmar angulation of the distal radius. It is often bilateral and more commonly affects girls, usually presenting between 6 and 13 years of age with deformity. It is caused by growth arrest of the ulnar and palmar part of the distal radial growth plate. The ulna is relatively longer than the radius and the lunate is wedge shaped. The appearance is often seen in dyschondrosteosis, a common skeletal dysplasia.

No treatment is required for painless deformity but physiostasis and ligament release can be done in skeletally immature patients to prevent worsening of the deformity. Symptomatic skeletally mature patients may require correction of the deformity with osteotomy and distal ulnar resection or a Sauvé-Kapandji procedure to treat pain arising from the distal radio-ulnar joint.

**Five-fingered hand**

The radial digit is finger-like, with three phalanges, and it lies in the same plane as the other digits. It can be treated by pollicization of the radial digit.

**Principles of surgery**

Surgery is only a part of the management of children with congenital hand anomalies. The aim of surgical treatment is to achieve the maximum function possible for each patient. The psychological and social impact of congenital hand anomalies should not be underestimated and must be addressed in each case. The surgeon should work as part of a team that must include an experienced children’s hand therapist.

Detailed descriptions of surgical procedures are outside the scope of this article. The common procedures involve removal of extra digits, realignment of digits, separation of digits and restoration of a functional thumb by pollicization of a normal digit or toe-to-hand transfer if no other digit is available. It is preferable to complete surgery before normal school age.

Advances in antenatal ultrasound are enabling earlier detection of congenital upper limb deformities. Relton McCarrol in his stimulating review article, has identified in-utero surgery and the use of chromosomal analysis and recombinant DNA technology as future methods for the treatment and prevention of congenital hand anomalies.

**References**