Lower-Limb Deficiencies and Amputations in Children

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Abstract

Important differences exist in the management of child and adult amputees. Many factors, including the etiology of childhood limb deficiencies, expected skeletal growth, functional demand on the locomotor system and prosthesis, appositional bone stump overgrowth, and psychological challenges, make caring for these young patients particularly challenging. Adherence to the general principles of childhood amputation surgery will typically guide one to the optimal functional result. These principles can be summarized as follows: (1) Preserve length. (2) Preserve important growth plates. (3) Perform disarticulation rather than transosseous amputation whenever possible. (4) Preserve the knee joint whenever possible. (5) Stabilize and normalize the proximal portion of the limb. (6) Be prepared to deal with issues in addition to limb deficiency in children with other clinically important conditions. A large proportion of young amputees undergo a Syme disarticulation, modified Boyd amputation, or knee disarticulation. A modified Van Nes rotationplasty procedure is also useful in this age group. All these provide the child with a weight-bearing stump with good growth potential and no complications due to bone overgrowth. Appropriate timing of amputation procedures and prosthetic fittings is essential to maximize functional benefit to the patient.

J Am Acad Orthop Surg 1998;6:358-367

Many medical articles dealing with children begin with the statement that "children are not small adults." This is also very much the case in the realm of pediatric amputations and limb deficiencies. This fact has been well recognized among pediatric orthopaedic surgeons, prosthetists, and therapists with a large pediatric practice. In recognition of the unique features of this group of patients, the Association of Children's Prosthetic-Orthotic Clinics was founded in 1948, with the goal of advancing knowledge about the treatment of children with limb deficiencies. This multidisciplinary organization encompasses all the medical disciplines associated with the treatment of limb-deficient children. It is largely the experience of the present and former participants in that organization that forms the basis of this article.

Comparison of Children and Adults With Lower-Limb Deficiencies

Children with limb deficiencies differ from adults with such deficiencies in a number of respects:

(1) In the adult population, dysvascular amputations predominate over those necessitated by trauma or tumor. In children, dysvascular amputations are rare. Most children seen in pediatric amputee clinics have a congenital deficiency. Infection, trauma, and neoplasms are also relatively frequent indications for amputation.

(2) In children, the residual limb continues to grow until skeletal maturity. The expected growth must be taken into consideration when planning surgical procedures on the affected limb, and any deviation due to injury or damage to the relevant growth plates must be accommodated.

(3) Appositional bone overgrowth at the end of the stump is a phenomenon encountered only in growing children.

(4) The expected mechanical and functional demand on the residual extremity and prosthesis and the general level of physical activity are very different in adult and nonadult amputees.

(5) The psychological challenges related to limb loss and frequently to an underlying condition (e.g., a congenital anomaly or malignant tumor) as well, together with peer-group integration pressures, are very different in the pediatric age group than in adults. Furthermore,

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these psychological factors vary even within the pediatric age group (e.g., young children versus adolescents), affecting their social development.

(6) Amputations due to multiple limb deficiencies are more common in the pediatric practice. This fact is closely related to the etiologic differences between children and adults, as congenital deficiencies, trauma, and purpura fulminans (all common causes of limb deficiencies in children) frequently involve more than one limb.[1]

(7) Phantom pain is a relatively common phenomenon in adults, but is virtually unknown in young children and occurs only infrequently in adolescents, and even then is only rarely significant.

Classification of Pediatric Limb Deficiencies

According to Etiology

Congenital

In the Western world, most childhood amputations are necessitated by a congenital disorder. Affected children are born with part or all of a limb missing or with a limb abnormality that is best managed by partial amputation and prosthetic restoration.

Posttraumatic

Large numbers of children lose their limbs due to vehicular accidents, electrical burns, thermal burns, lawnmower accidents, and other preventable encounters with dangerous equipment and machinery. Here the role of the medical profession is twofold—to provide medical treatment and to take an active part in promoting the prevention of these injuries.

Fortunately, amputations due to injuries from exploding land mines and other military equipment are rare in North America. However, in many parts of the world such injuries are among the leading causes of traumatic amputations.

Post–Tumor Resection

The peak incidence for many primary bone tumors, other than those of hematopoietic origin, is in the first and second decades of life. The advent of limb-sparing surgery for malignant bone and soft-tissue neoplasms has considerably lessened the number of these patients but has introduced some new challenges related to innovative, unconventional techniques of limb salvage.[2,3]

Infectious

Children with limb loss due to systemic septicemia, usually due to meningococcal infection, are becoming an important patient population in most pediatric amputee clinics, particularly in the clinics that are attached to large teaching centers with pediatric intensive care units. Many children who once would have died of such a devastating infection now survive in spite of multiorgan failure, as a result of aggressive resuscitation with the use of modern pharmaceuticals and technology. Unfortunately, these children are frequently left with severe multiple-limb deficiencies.

Dysvascular

Dysvascular amputation is uncommon in the pediatric age group. This type of amputation is usually related to a thrombotic or embolic phenomenon secondary to an underlying medical condition. It may also be related to a surgical procedure performed on the heart or great vessels or as a complication of vascular access procedures in neonates.[4]

Neurogenic

Included in this category are limb deficiencies due to (1) amputations required to treat ulcers or infections in insensate feet and (2) knee disarticulations performed in some cases of sacral agenesis.

According to the Level and Type of Limb Deficiency

Acquired Lower-Limb Deficiency

Acquired lower-limb deficiency is classified the same in children as in adults. Joint disarticulation, above- and below-knee amputations, and (more frequently in children) Syme and Boyd amputations are used.

Congenital Lower-Limb Deficiency

The tissue absence or deficiency in the congenital etiology group is frequently quite complex in nature, commonly affecting the whole limb to a variable degree. It is not within the intended scope of this article to provide detailed descriptions of the various types of congenital limb deficiencies and the controversies surrounding them. Only a brief overview will be presented.

Traditionally, a number of names with Greek or Latin roots have been used to describe these conditions. Many of these terms are not particularly accurate or specific. Nevertheless, their use persists, and one should be versed in at least the more common terms, such as fibular hemimelia, tibial hemimelia, and phocomelia (from the Greek word *phoke*, meaning "seal").

A more accurate and scientific attempt at classification has been made by Frantz and O'Rahilly.[5] They distinguish between transverse deficiency, in which the distal part of the extremity is lost but the proximal part is relatively normal, and longitudinal deficiency, which involves the limb asymmetrically, with structures on only one side of the limb being affected. Longitudinal deficiencies are classified according to which part of the extremity was involved: preaxial

(tibial-side deficiency), postaxial (fibular-side deficiency), and central (lobster-claw deficiency). Longitudinal deficiencies are further described by designating the affected bones and specifying either partial or total involvement.

More recently, combined international efforts have led to the establishment of a classification endorsed by the International Organization for Standardization and the International Society for Prosthetics and Orthotics, the so-called ISO-ISPO classification of congenital limb deficiency.[6] This classification also uses the principle of transverse versus longitudinal deficiency. The description of a transverse deficiency includes the segment at which the limb terminates (e.g., a congenital below-knee amputation at the midpoint of the tibia would be described as a "transverse deficiency leg middle third"). In the case of a longitudinal deficiency, the affected bones are named in proximal-to-distal sequence, specifying whether the deficit is partial or total (e.g., a type I tibial hemimelia with a hypoplastic first ray would be described as "longitudinal deficiency tibia total, ray 1 partial"). Any bone not named is assumed to be present in relatively normal form. Many longitudinal deficiencies play an important part in amputation surgery because they require surgical amputation of at least part of the affected extremity to obtain the most functional limb.[7]

General Principles of Lower-Limb Amputation Surgery in Children

The primary goal in the management of limb-deficient children is to maximize function. One should always think about what can be done to make the child's limb as functional as possible. It is useful to develop an approach based on the following general principles: (1) Preserve length. (2) Preserve important growth plates. (3) Perform disarticulation, rather than transosseous amputation, whenever possible. (4) Preserve the knee joint whenever possible. (5) Stabilize and normalize the proximal portion of the limb. (6) Be prepared to deal with other issues in addition to limb deficiency.

Preservation of Bone Length

Bone length can be preserved even with less than ideal soft-tissue coverage. Skin grafts, rotational flaps, and free-tissue transfer can be utilized to obtain satisfactory soft-tissue coverage. To preserve length in a child frequently means not only saving as much bone length as possible but also preserving functional growth plates.[8]

Preservation of Important Growth Plates

When treating very young children, the contribution of epiphyseal growth to the overall length of the extremity or an amputation stump can be very important, particularly in the case of growth plates around the knee. Standard above-knee amputation in an infant with loss of the distal femoral physis will produce an extremely short stump at skeletal maturity, and will likely require a hip disarticulation–like prosthetic fitting. The same argument can be made regarding the proximal tibial plate if any hope of functional below-knee fitting is to be entertained in the future.

Disarticulation Rather Than Transosseous Amputation

Adherence to this principle preserves the distal growth plate, prevents stump overgrowth, and improves prosthetic suspension. Stump overgrowth (a unique condition of the immature skeleton) is a poorly understood pathophysiologic phenomenon of appositional bone growth at the level of transected bone. It can produce sharp pointed spikes, which can be the source of a number of complications, such as residual limb pain, bursa formation, and erosion of the overlying soft tissue leading to complete erosion through the skin (Fig. 1).

Bone overgrowth in the stump is by far the most common complication of transosseous amputation in children and one that is very difficult to treat.[9,10] Various techniques have been proposed to deal with this phenomenon; however, none has gained universal acceptance. Soft-tissue reconstructions (involving the use of muscle, periosteum, and fascia), distal stump osteotomies, use of metal and plastic plugs, and iliac-crest bone graft (including the apophysis) all have their proponents; however, universal acceptance is lacking, either because of failure to decrease the incidence of the condition or the concurrent morbidity of the procedure. Careful attention to prosthetic socket fitting to minimize residual limb problems from overgrowth and judicious surgical revision of the distal part of the stump are always recommended. Frequent revisions are to be avoided.

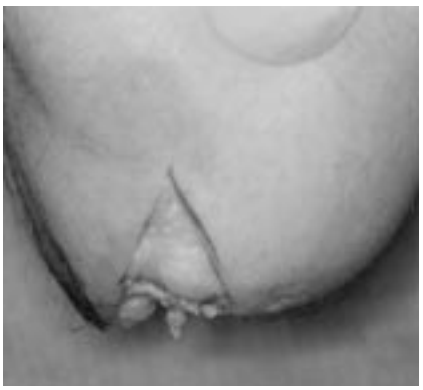


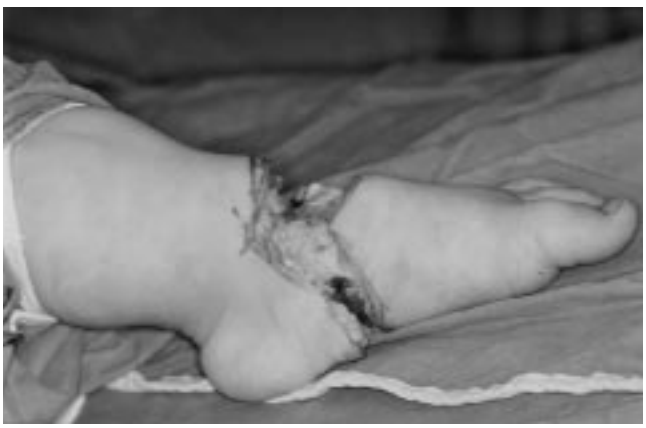
Fig. 1 A sharp spike of bone overgrowth eroded through the skin, necessitating stump revision.

The only certain prevention of bone overgrowth in the residual limb is to avoid transosseous amputation. No overgrowth phenomena occur in the bone end covered by articular cartilage. An advantage of disarticulation is the production of a good, at least partially weight-bearing limb end, with articular cartilage providing some cushioning. The widening of the distal part of the bone (epiphysis and metaphysis) also provides better socket suspension, allowing more vigorous activity without fear of losing the prosthesis or requiring additional suspension gear. These advantages far outweigh the potential disadvantage that the stump might be too long. The length of the stump can be controlled relatively easily in the growing child by carefully timed epiphysiodesis; in skeletally mature patients, intercalary bone shortening is more appropriate. This technique of joint disarticulation and intercalary femoral shortening should probably be used more often in the young adult population as well.

In view of these considerations, it is not surprising that knee disarticulation—and, in particular, Syme amputation (ankle disarticulation)—is the most common amputation procedure used in children. Syme amputation in children is truly an ankle disarticulation, with no surgical resection of any of the distal tibia or fibula (Fig. 2). This procedure is very useful in many childhood conditions, including longitudinal deficiencies such as the various types of fibular and tibial hemimelia (Figs. 3 and 4). Syme disarticulation in children results in a very functional weight-bearing residual limb essentially free of long-term complications.

Preservation of the Knee Joint

Many studies considering gait analysis, metabolic energy consumption during gait, and functional evaluation of amputees clearly show the importance of the active knee joint in the biomechanics of lower limb function.[11] Therefore, every effort should be made to preserve a functional knee joint in patients with transverse and longitudinal deficiencies. Even a very short proximal tibial fragment in a child can ultimately become a useful below-knee amputation stump, either through natural growth (if the proximal growth plate is preserved) or by surgical lengthening procedures in combination with innovative modern prosthetic fitting. In patients with some longitudinal deficiencies, such as those due to proximal femoral focal deficiency (PFFD) (Fig. 5) or type I or type II tibial hemimelia, unconventional reconstructive procedures can be employed to obtain a functional knee-like joint substitute. In the case of PFFD, the Van Nes rotationplasty (also known as tibial rotationplasty or Borggreve rotationplasty) is most commonly used. This procedure substitutes the ipsilateral ankle joint, turned 180 degrees at the level of the opposite normal knee, for an absent or abnormal knee joint (Fig. 6). The distal part of the extremity is then



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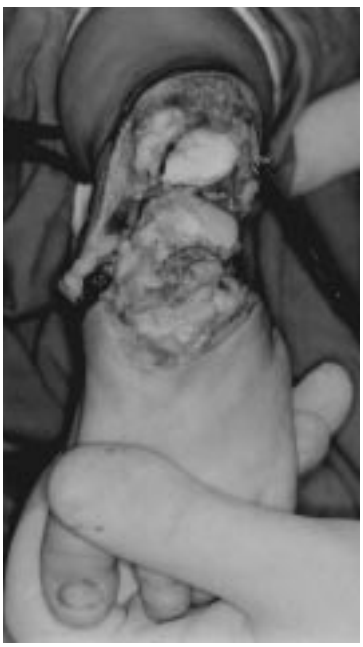

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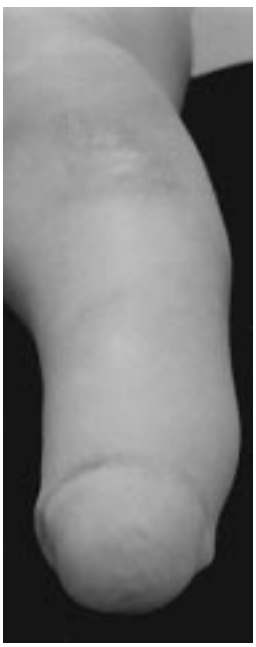

C

Fig. 2 Syme amputation in a child with fibular hemimelia. **A,** Skin and soft-tissue incision. **B,** Ankle-joint disarticulation. Note the absence of the lateral malleolus. **C,** Healed stump, with the heel pad providing a weight-bearing terminal surface.

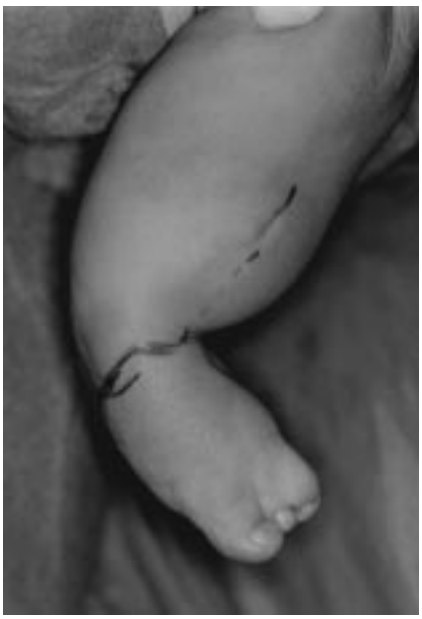

Fig. 3 Type II fibular hemimelia. Syme amputation was combined with tibial osteotomy to correct anterior tibial bowing, which is frequently associated with the severe form of fibular hemimelia.

restored with use of a joint prosthesis. Below-knee amputation–like function can be achieved.[12,13]

In the patient with tibial hemimelia and a functioning quadriceps

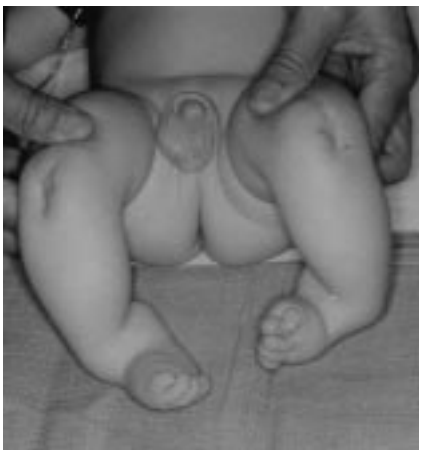

Fig. 4 Bilateral type II tibial hemimelia. The patient was treated with bilateral Syme amputation and tibiofibular synostosis.

mechanism, the so-called Brown procedure, in which the proximal fibula is used to reconstruct the knee, has been utilized by some surgeons with a measure of success.[14-16] In the absence of active quadriceps function, knee disarticulation remains the procedure of choice.

These unconventional procedures require the expertise and experience of both the surgical and the prosthetic team. The final outcome, particularly in the case of rotationplasty, can be a knee-like joint with near-normal function.

Stabilization and Normalization of the Proximal Portion of the Limb

Many children who undergo amputation because of a congenital condition have either a longitudinal deficiency affecting more proximal parts of the limb or a transverse deficiency with some additional abnormality in the proximal part of the limb. For the optimal functional result, additional surgical procedures or prosthetic modifications may be required. This is particularly so in the case of hip-joint and rotational-, coronal-, or sagittal-plane malalignments. Similar measures may be necessary to prevent onset or progression of deformity of the proximal portion of the limb attributable to contractures, muscle paralysis or weakness, spasticity, or asymmetrical growth due to abnormal or only partially functioning growth plates.

Other Issues in Addition to Limb Deficiency

The orthopaedic surgeon may be the first professional knowledgeable about orthopaedic conditions to see a newborn. The limb deficiency could be an isolated lesion or part of a syndrome (either a sporadic occurrence or a genetically inherited condition, such as tibial hemimelia or lobster-claw hand deformity). The parents and other

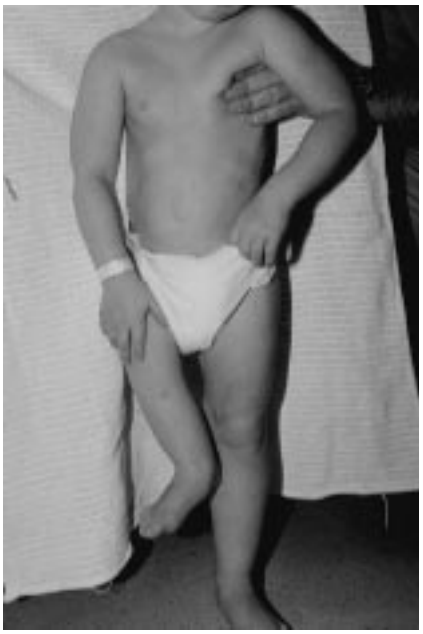

Fig. 5 In this child with PFFD, the ankle of the affected extremity is almost at the level of the contralateral knee. The foot on the affected side is almost normal. This child would be a good candidate for knee fusion and rotationplasty.

family members are frequently desperate for answers regarding immediate treatment and long-term prognosis. The cause of the deformity and the prospect of having another child with a similar defect are concerns. The multidisciplinary approach, including genetic counseling, used in pediatric amputee clinics is essential under these circumstances.

Specific Considerations in Lower-Limb–Deficient Children

Amputations Around the Ankle

Amputation around the ankle warrants specific attention. Two types of amputations are commonly used for this purpose: the Syme ankle disarticulation (Fig. 3) and the Boyd amputation, in which the ankle is disarticulated but the os

calcis is preserved for surgical arthrodesis onto the distal end of the tibia. Boyd amputation virtually ensures a stable heel pad and a good weight-bearing stump.[17] Both procedures have their proponents, and in many institutions they are used interchangeably. The most common use of the Syme or Boyd amputation is for congenital longitudinal deficiencies. Many cases of longitudinal fibular[4] and tibial deficiencies (Fig. 4) and PFFD (Fig. 5) are best treated by these procedures, usually because of severe shortening of the extremity, foot deformity, and ankle and joint instabilities and deformities.[18-23]

Another situation in which the Syme or Boyd procedure can be very useful is in the treatment of congenital tibial pseudarthrosis. In some children, amputation is the final operation for this difficult condition, in spite of the availability of modern surgical techniques, such as vascularized-bone transplantation and use of an Ilizarov-type circular external fixator to obtain union. A Syme or Boyd amputation (not a below-knee amputation) will give these children a good weight-bearing stump in spite of the persistent pseudarthrosis. The child will almost immediately have a very functional extremity, prosthetically equal in length to the opposite member, and can usually participate unrestricted in physical activities with peers for the first time. The pseudarthrosis site is well controlled by the prosthetic socket; in some instances, union eventually occurs.[24,25]

Syme disarticulation is also useful in cases of acquired limb loss, such as foot trauma (common in lawnmower accidents) and loss due to purpura fulminans. The procedure is particularly appropriate in the treatment of the latter condition, as injury to the proximal growth plates by the same pathologic process is quite common.

Knee Reconstruction With Use of Rotationplasty

The Van Nes rotationplasty (Fig. 6) substitutes a rotated ankle for a knee and is used in children with PFFD who have a good functioning ankle, as well as in some instances of malignant tumor resection about the knee.[26] Originally described by Borggreve in Germany before the Second World War, the procedure was modified for congenital femoral deficiencies by Van Nes.[13] Modern versions of the procedure used for PFFD are usually combined with a knee arthrodesis, with the rotation carried out mostly through the knee.[12,27] Kotz and Salzer[2] described the use of the modified version of the rotationplasty reconstruction after resection of malignant sarcomas of the distal femur. The procedure was further adapted for use after resection of sarcomas in both the proximal tibia and the proximal femur.[28,29] In the latter scenario, the distal femur is fused to the side of

A B

Fig. 6 **A,** A large segment of the thigh can be resected in the modified Van Nes rotationplasty after tumor surgery. **B,** The healed extremity shows a Van Nes ankle-knee at the level of the opposite knee.

the pelvis in 180 degrees of rotation, with the knee functioning as a uniplanar hip joint and the ankle joint substituting for the knee joint.

Van Nes rotationplasty has sometimes been criticized for its cosmetic appearance, but it has consistently been shown to be a functionally excellent reconstruction and to be well accepted by patients from a psychological and cosmetic point of view.[11] The success of this procedure is largely dependent on the experience, knowledge, and teamwork of the surgeon, prosthetist, and physical therapist.[26]

Multiple Limb Deficiencies

Children with multiple limb deficiencies often present a major challenge to the amputation team. Interestingly, there is frequently no need for surgical intervention. In many cases, imperfect feet at the ends of congenitally deficient limbs may be the only prehensile organs the child has.[1] It is often quite amazing to see how dextrous and functional these feet can be for activities such as feeding, writing, drawing, and playing. One must, therefore, resist every temptation to attempt to make these feet better looking at the cost of their becoming stiff and nonfunctional (Fig. 7).

Purpura Fulminans

Probably the most challenging condition seen by the pediatric orthopaedic surgeon in the area of limb deficiency is limb loss due to purpura fulminans, most commonly caused by meningococcal septicemia, but occasionally due to infections caused by other organisms, such as pneumococci. The initial episode frequently brings the patient near death with multiorgan failure requiring vigorous cardiopulmonary resuscitation, renal dialysis, and other supportive measures. The ischemic damage to the extremities eventually leads to dry gangrene. It is not clearly established that early fasciotomy prevents the development of gangrene or other extremity tissue damage. The orthopaedic surgeon is usually consulted after necrosis has already become firmly established. At this point, one should exercise a wait-and-see approach until the child is fully resuscitated and other organ complications have stabilized. The dry gangrene should be allowed to become fully established in the affected part of the extremity, frequently well distal to the area initially thought to be involved. Bone scanning can sometimes be helpful to delineate the level of deep necrosis.[30] The surgeon should proceed with amputation only when the level of deep necrosis is well delineated. It is quite acceptable to amputate distal to the level of the skin gangrene if the deep tissues are healthy and covered by early granulation tissue. Skin grafts can be utilized in such situations (Fig. 8). The exception to this rule is infection in necrotic tissue (wet gangrene); in such a case, early amputation is imperative for successful recovery.

Multiple limb amputations, as difficult as they are, present only part of the picture. Necrosis of proximal tendons (e.g., the patellar and quadriceps tendons) leads to joint malfunction. Ischemic damage to the growth plates leads to complete or partial growth arrest, resulting in cessation of longitudinal growth or angular deformities. It is not unusual for the growth plates to be affected well proximal to the soft-tissue damage or to affect limbs where no soft-tissue damage exists (Fig. 9). Large areas of skin necrosis can make prosthetic fitting challenging. As the level of care in pediatric intensive care units increases, along with the ability to resuscitate very

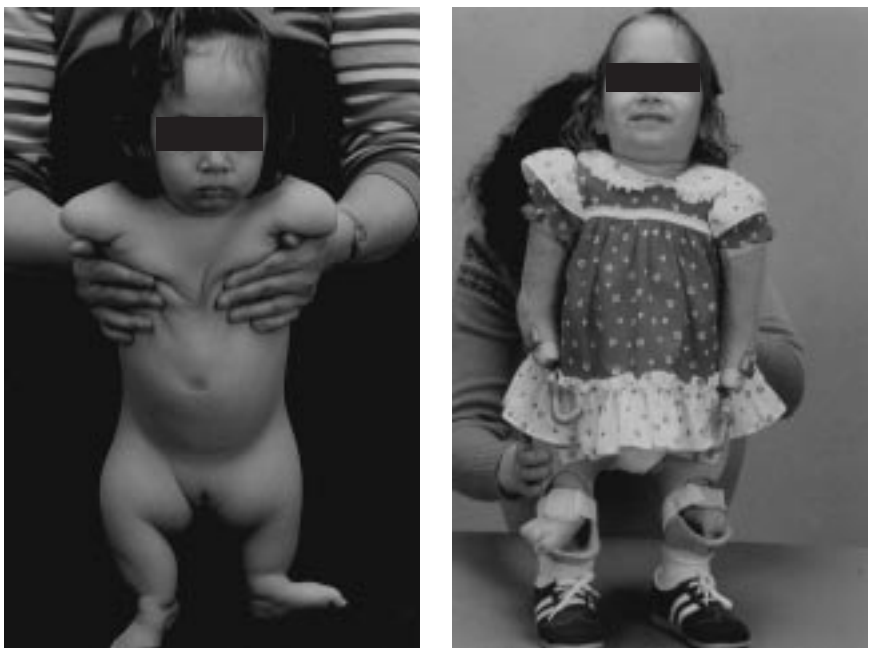

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Fig. 7 **A,** Child with bilateral PFFD and bilateral upper-extremity deficiency (said to be associated with maternal diabetes). **B,** The child's feet are her main prehensile organs, and it was important not to disable them by inappropriate surgery or too-restrictive prosthetic fitting. Upper- and lower-extremity prosthetic devices can make integration into peer activities easier.

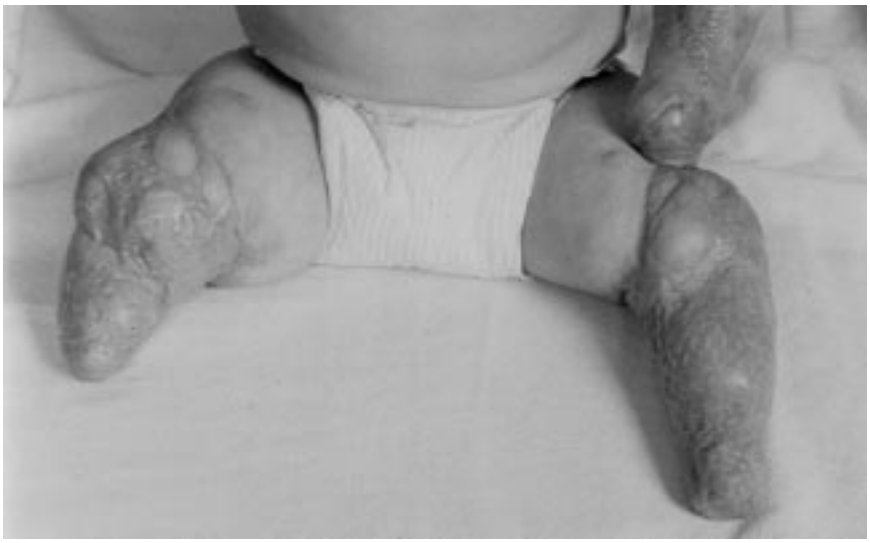

Fig. 8 Multiple limb involvement by purpura fulminans due to meningococcal infection. Skin grafts are frequently needed to obtain adequate soft-tissue coverage.

ill patients, the percentage of children surviving this devastating condition increases as well. However, the price of this success is the larger number of patients in pediatric amputee clinics.

Much is yet to be understood about the pathophysiology of limb necrosis and its prevention and treatment. At this stage, it remains a major challenge to the treatment team from the time of diagnosis onward.

Timing Recommendations

An important aspect specific to the pediatric amputation is the appropriate timing for surgery and subsequent prosthetic fittings.[31] As a rule, one strives for normal functional development, allowing the child to reach developmental landmarks. This generally means fitting a child with a congenital lower-limb deficiency around the time of starting to pull himself or herself up to stand (usually sometime between the ages of 6 and 9 months). When a hip-disarticulation amputation has been performed, a simple extension prosthesis, lightweight with no movable joints other than a locking hip joint, should be used, allowing the child to sit. The child is growing rapidly during this phase, and frequent adjustments to the socket and the length of the prosthesis may be required. No commercial components are needed at this stage, as the child's gait mechanics do not require it.

The decision regarding the treatment of longitudinal deficiency should also be made at this time. If it is decided to go ahead with amputation and prosthetic restoration, the procedure is best carried out between the ages of 8 and 12 months. This allows the child to start walking on the prosthetic limb at the appropriate age. Tibial and fibular deficiencies can be managed in the same manner. In the case of tibial hemimelia, magnetic resonance imaging is frequently helpful in assessing the presence of cartilaginous anlage in the proximal tibia, establishing the presence of the patella and the quadriceps and patellar tendons, deciding on the level of the amputation (e.g., Syme amputation versus knee disarticulation), and evaluating the feasibility of proximal reconstruction. When limb lengthening is deemed feasible, the child can be fitted with a simple extension prosthesis that accommodates the limb in a custom-made unconventional socket until such time as a leg-equalization procedure can be undertaken.

At the age of approximately 3 years, the prosthetic fitting becomes more sophisticated. A functional knee is added to the prosthesis for children with amputations through or proximal to the knee, and a standard solid ankle–cushion heel (SACH) prosthetic foot is used

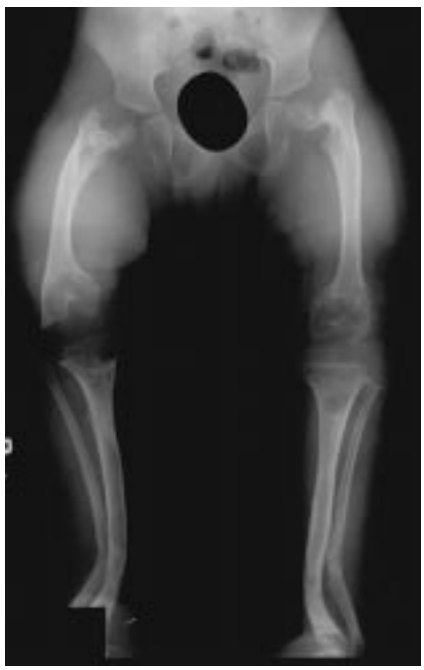

Fig. 9 Radiograph of the lower extremities of a 6-year-old child whose major growth plates had all been virtually destroyed by meningococcemia. Bilateral partial foot and hand amputations were performed, and quadriceps mechanism disruption was also present on the left. The discrepancy in the length of the tibias and femurs is due to a tibia-lengthening procedure. The patient subsequently underwent amputation revision to a bilateral Syme disarticulation.

as a weight-bearing terminal component. Socket design and type frequently become more complex to accommodate individual needs.

In late childhood and adolescence, the full impact of modern prosthetic technology comes into play. The latest designs in energy-saving feet, socket fabrications, prosthetic components, and prosthetic cosmetics are utilized to provide the patient with the best, most functional limb possible. Many children are very active, participating in physical and contact sports. These activities can produce tremendous wear-and-tear stresses on both the residual limb and the prosthetic components. It is not unusual for a child to require more than one prosthesis. Some of these are custom-designed for a specific activity (e.g., skiing or bicycling). Many children with unconventional amputation stumps require all the creative imagination of the treatment team to accommodate their needs for a specific activity.

In the case of PFFD, surgical conversion should be performed between the ages of 2½ and 3 years. A knee arthrodesis combined with a Syme or Boyd amputation is recommended in the case of a nonfunctional deformed foot and ankle. A knee arthrodesis combined with a Van Nes rotationplasty is appropriate for children with a good foot and ankle. This last procedure is a modification of a technique described by Torode and Gillespie, in which the rotation is achieved through the knee after arthodesis by means of release and reattachment of all the tendons and muscles crossing the knee joint, such that in the end they pull in a straight line.[12,27] This eliminates the tendency of the limb to derotate with time. After the osteotomy heals (6 to 8 weeks), the child is fitted with a rotationplasty prosthesis with lockable external knee hinges, and gait-training therapy sessions are commenced.

Summary

The challenges in the treatment of limb-deficient children are unlike those found in the adult population. In children with congenital disorders as well as those who undergo amputation because of acquired conditions, having an unconventional residual limb places a large demand on both the limb and the prosthesis. For the child with a normal life expectancy, long-term durability expectations for the prosthetic device and the residual limb are important considerations.

Making the right decisions, particularly surgical decisions, early in the course of treatment has an impact felt throughout the child's life. Application of the basic principles of childhood amputation surgery, together with imagination tempered by the combined experience of the entire treatment team, can usually produce very satisfactory functional limb restoration. The successful integration of the child into his or her peer group is frequently achieved, allowing for a successful transition into productive adulthood.[32]

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