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Review article

Amputation and prosthesis fitting in paediatric patients

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ABSTRACT

Amputation of a limb is always perceived as a catastrophe. The principles underlying creation of a stump adapted to modern prosthetic fittings must be fully understood and the patient managed by a multidisciplinary team. In paediatric patients, preserving residual limb length is a crucial point that should be assessed according to the expected growth potential. Advances in prosthetic fittings have led to changes in the overall concept of socket design, which seeks to achieve three objectives: to maximise the weight-bearing surface area, to eliminate friction of the skin on the socket, and to eliminate lever-arm effects. The introduction on the market of new materials has contributed substantially to advances in prosthetic fittings. These advances require the use of new criteria for stump quality and optimisation, which exert a considerable influence on prosthesis function. Prosthetic fitting and specific management of psychological and social problems are provided during an inpatient stay in a physical medicine department, by a team of physicians, other healthcare professionals, social workers, and educators. Three-dimensional imaging and gait analysis provide valuable information.

1. Introduction

Amputation of a limb during childhood is a rare event that is consistently perceived as a catastrophe, first by the family and later on by the child. The principles required to create a stump capable of accepting a function-restoring prosthesis must therefore be fully understood. The patient must be managed by a multidisciplinary team of professionals who work closely together. Although the paediatric orthopaedic surgeon is the first to intervene, an essential step – ideally taken before the amputation – is an in-depth discussion with a highly skilled orthopaedic prosthetist and with the staff of the physical and rehabilitation medicine (PRM) department who will be in charge of the patient during the adaptation phase. Multidisciplinary teamwork is required for stump wound care, selecting and fitting the prosthesis, and providing social support. Later on, the orthopaedic surgeon and other members of the multidisciplinary team must work together to monitor the patient's morphostatic development and growth, as well as to make decisions about changing the prosthesis. Unfortunately, amputation is often required as an emergency procedure. Therefore, every surgeon should know how to fashion a serviceable stump.

Considerable advances have been made in the field of limb prostheses. New materials have been introduced and new prosthetic designs created to improve performance. These changes mandate a reappraisal of the principles underlying amputation surgery. The review presented herein is based on recent technical progress in prosthesis development and on its implications for selecting the surgical technique and providing PRM management, with the assistance of new tools such as three-dimensional lower-limb imaging (EOS®) and quantitative gait analysis (QGA). Only surgical lower-limb amputations, for any reason, are discussed here.

2. Background

Amputation may be required in different indications:

- trauma: examples include crush injury to the limb due to a vehicle or injury by a farming machine or lawnmower (Fig. 1). The level of the amputation varies. The crucial point is adjustment to the level of the initial lesion;
- infection: *Purpura fulminans* with bloodstream infection is the most severe form (Fig. 2). This life-threatening condition requires emergency treatment and carries a high risk of amputation. In patients with gas gangrene, amputation is a life-saving procedure. In the event of infection, the amputation level should be determined with care, to obtain a cut in healthy tissue while preserving sufficient length of the residual limb. Failure to create a sufficiently wide safety margin between the initial site of

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Fig. 1. Lawnmower injuries.

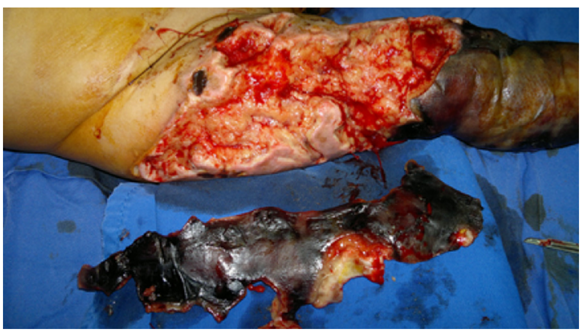

Fig. 2. *Purpura fulminans*.

infection and the level of amputation puts the patient at risk for recurrent infection;
- tumours (Fig. 3): this cause has become less common. Keeping a sufficiently wide safety margin between the tumour and the suprajacent cut is mandatory but may limit the length of the residual limb;
- congenital abnormalities: an example is congenital pseudarthrosis of the tibia. Amputation may be the only option in these conditions;
- vascular abnormalities: compromise of the vascular supply is rare in children. The main causes are iatrogenic vascular injury due to extravasation of contrast medium or drugs into the perivascular or subcutaneous compartment. Thrombosis is less common (Fig. 4). Amputation may be inevitable.

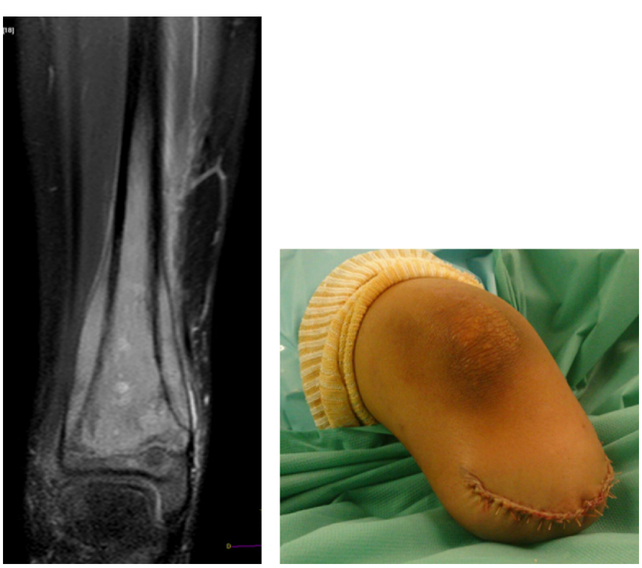

Fig. 3. Osteosarcoma of the distal third of the tibia in a 5-year-old.

Congenital amputation, or limb agenesis, requires a highly specific management strategy that does not involve surgery. This condition is not discussed here.

3. General principles of paediatric amputation surgery

Most of the amputation techniques used for adults are also suitable for paediatric patients. Attention should be given to the growth potential of the stump, which varies with the amputation level. Adaptation is best in the youngest children. The objective is prompt wound healing followed by fitting with an appropriate prosthesis that will allow the patient to resume near-normal activities.

Krajbich listed the general principles of childhood amputation surgery [1]:

- preserve limb length;
- preserve growth plates;
- prefer disarticulation over transosseous amputation;
- preserve the knee joint whenever possible;
- stabilise and normalise the proximal portion of the limb;
- direct appropriate attention to the patient's general health and to clinical conditions other than the amputation.

Preserving length is crucial in paediatric patients. Because the distal growth plate contributes 75% of longitudinal femoral growth, transfemoral amputation results in a very short final stump. Transtibial amputation preserves the growth plate but can result in bone overgrowth at the transected end, which may continue until growth is complete, often requiring trimming on one or two occasions. The fibula grows faster than the tibia and becomes prominent. Another possible complication in children after transfemoral or transtibial amputation is formation at the bone end of a sharp spur that gradually penetrates the overlying soft tissues. The best means of preventing this complication is tibiofemoral synostosis or typical osteomyoplasty [2]. When the fibula is absent, a number of techniques can be used, including extensive bone grafting, which carries a major risk of resorption; use of bone cement to fashion a champagne cork-shaped end; or stump capping using the inverted fibula, with the fibula diaphysis press-fit into the medullary canal and the head located distally, where it produces a pleasantly rounded stump end [3].

In every case, revision surgery may prove necessary, particularly to correct growth disorders. The child and parents should be informed of this possibility.