Rehabilitation and prosthetics post-amputation

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Abstract

It is paramount that surgeons performing amputations have an understanding of the rehabilitation pathway and the prosthetic options for their patients following the amputation procedure. Some surgeons consider an amputation a failure of their previous treatment, but for their patients, it is the beginning of their rehabilitation. In limb loss, the rehabilitation pathway could start antenatally or at the pre-amputation consultation, but input continues for the life of the patient. An integrated pathway between the surgical and rehabilitation teams for patients, from the consideration of option of amputation, through surgical treatment and pre-prosthetic rehabilitation, to provision of a definitive prosthesis and achievement of their ultimate goals is essential. This article aims to provide an introduction to current practice in amputee rehabilitation. We will cover rehabilitation in upper and lower limb loss and describe the input of the multidisciplinary team led by the rehabilitation medicine consultant and indicate where future advances will be made.

Keywords amputation; lower limb; phantom limb pain; prosthesis; prosthetics; rehabilitation; stump; upper limb

Introduction

Amputation of a limb is a life-changing operation that results in profound alterations in the physical and psychological welfare of the patient. In the past, an amputation was considered by some surgeons to indicate a failure of treatment, particularly for malunion of fractures. However, to patients, amputation is the start of their rehabilitation process meaning that for the first time they will be free of pain and able to aim for improved function.

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Each year in the UK approximately 16 000 patients undergo a limb amputation.[1] Globally, amputation is one of the most common contributors to disability, with 30 million people worldwide living with limb loss.[2] A rehabilitation pathway after amputation, with appropriate provision of prosthetics, offer opportunities for people to re-build their lives, regain independence and dignity, and resume former activities.[3]

Most lower limb amputations performed in the UK are for peripheral arterial disease, complications of diabetes mellitus, or a combination of both. Amputees are typically older, with several co-morbidities, including osteoarthritis in the remaining lower limb joints. Whilst the goal of most lower limb amputees is to walk, 20% of transtibial and 60% of transfemoral amputees will never walk again. As life expectancy improves, the prevalence of amputees unable to walk will increase – this includes those whose amputation occurred at a younger age due to trauma, but for whom aging impacts on their ability to mobilize. Inability to walk is associated with decreased ability to exercise, increased susceptibility to further comorbidity, reduced independence and lower quality of life. There are also impacts on health and social services with consequent increases in costs.

Trauma is the second leading cause of lower limb amputation, and the leading cause of upper limb amputation.[4] Upper limb amputations are a much smaller proportion of the total number of amputations in the UK, and worldwide, but as they generally occur in adults of working age, have a disproportionate impact on function and quality of life due to their effect on the ability of the patient to do bimanual tasks. They also result in an increased incidence of overuse injuries of the contralateral limb.

Amputations are described by the anatomical level of the bone or joint transected at the time of surgery. Therefore, for example, the two most common lower limb amputations are referred to as transtibial and transfemoral. A knee disarticulation refers to an amputation through the knee. The terms 'below knee', 'above knee' and similar are inaccurate and misleading and should not be used in modern clinical practice.

Amputee rehabilitation services are provided by 44 NHS centres in the UK. Each provides input to patients who are being considered for amputation, or are recently amputated, and they all provide lifelong follow-up to all amputees. Most are co-located with other rehabilitation services, as patients' needs are often multifactorial. Although all deliver general amputee rehabilitation services, the provision of more specialist equipment, such as highly specialized upper limb prosthetics and microprocessor controlled knees, is limited to the larger centres due to the level of expertise required in prescribing these prostheses.

Amputation surgery

Knowledge of the current rehabilitation pathway and prosthetic options can guide the surgeon to fashion a stump that can be used by a patient in function long-term with minimal complications from prosthetic use. This may reduce need for further revision surgery. If there are any concerns about the procedure, the operating surgeon should discuss the patient with the rehabilitation medicine consultant linked to the acute service.

If an elective amputation is a treatment option, patients should be facilitated with a pre-amputation consultation at the

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amputee rehabilitation centre where the pathway can be discussed to aid them in making an informed decision and prepare psychologically. This is the only treatment that has been repeatedly shown to reduce post-amputation pain and phantom limb pain. It is important to manage patients' expectations, starting at this stage, while making them familiar with the challenges of limb loss and prosthetic use, as this will differ depending on their co-morbidities. Furthermore, prehabilitation can be discussed, to reduce surgical risks, enhance postoperative recovery and improve long-term outcomes. Peer support from a suitable and established amputee if appropriate is offered, as is information about patient support charities.

When considering amputation it is important to take into account an individual's prosthetic options and suspension strategies and to contour the bony edges to diminish painful pressure areas during prosthetic use. Various surgical methods can be used while dividing peripheral nerves to prevent or delay neuroma formation.

Planning and the pre-amputation phase

Lower limb amputation: the level of amputation impacts on the patient's predicted mobility and gait performance. A transtibial amputation is the most common level of amputation, comprising 52% of lower limb amputations in the UK each year. The operation carries good prognosis in terms of mobility with 80% of amputees mobilizing with or without walking aids. However, the exact outcome will depend on the patient's general pre-amputation medical state, including the level of mobility. Energy expenditure when walking with a prosthesis increases by between 16% and 28%.[5]

A transfemoral amputation is selected when there is blood supply sufficiently compromised to heal a less extensive amputation or the knee joint cannot be salvaged. The length of the stump in a transfemoral amputation should be planned to leave a clearance of 12 cm above the fulcrum of the contralateral lower limb. This will enable the use of a variety of prosthetic knee components to equalize the knee centres bilaterally, avoiding a leg length discrepancy. The transfemoral level of amputation requires significantly higher energy expenditure on the part of the amputee to walk (varying between 60% and 110%). Therefore, lower levels of activity and mobility would be predicted.

There are a number of other amputation levels that can be considered, but each has very significant drawbacks in terms of allowing the patient to mobilize afterwards, without conferring any advantages. These should only be carried out after a discussion with the rehabilitation team. The partial foot amputation is commonly used in diabetic forefoot disease. This limb deficiency is usually restored with cosmesis using silicone fillers and is managed by a combined orthotics and prosthetic approach as the biomechanics of the foot are severely altered. A Symes's amputation potentially saves limb length and leaves a weight-bearing stump, but severely limits the prosthetic options as the prosthesis is bulky. Heel pad migration in the longer term is a substantial risk.

A knee disarticulation can also give a weight-bearing stump with preservation of thigh muscles and increased lever arm for performing transfers. However, the cosmetic appearance is poor as the socket will be bulky and there will be visible difference in the prosthetic and contralateral knee centres as the knee mechanism will be attached to the end of the long femur. In the Gritti-Stokes procedure the patella may detach causing pain and inability to weight-bear through the stump. Knee disarticulation should only be considered for patients who will not progress to prosthetic provision due to their co-morbidities, for example, pre-existing complete spinal cord injury or severe cardiorespiratory disease that precluded walking prior to amputation.

Hip disarticulation and hemipelvectomy are carried out for very specific indications, usually advanced malignancy, and can result in satisfactory outcomes, but require very specialist rehabilitation input and prosthetic provision.

Bilateral transtibial and transfemoral amputations markedly increase the metabolic demands of walking compared to unilateral amputation and also require specialist rehabilitation input and prosthetic provision in order to maximize potential mobility. The rehabilitation programme for bilateral transfemoral amputees takes up to 18 months.

The stump (sometimes referred to as the residual limb) plays an important role in the transmission of forces from the body to the prosthetic limb. The ideal stump, therefore, should be a suitable length to accommodate the prosthetic equipment with appropriately fashioned soft tissues to accommodate what can, at times, be very high forces — sometimes multiples of the patient's body weight (Figure 1).

The healed stump should be of adequate length to fit the prosthetic with sufficient leverage and stability. Preservation of length in the residual lever arm during surgery can generate greater torque, which in turn can improve functionality in a prosthesis with less pressure on the soft tissue. Torque is equal to the force applied multiplied by distance from the fulcrum.

The correct stump length is important to incorporate the necessary prosthetic components. It is understandable the traumatic stumps may not fulfil the perfect surgical criteria when surgical salvage is attempted, but aiming for a length as optimal as possible is desirable. However, length should not be preserved at all costs as prosthetic components need to be able to fit into the potential space between the end of the stump and where the foot, in the case of the lower limb, or terminal device, in the case of the upper limb, needs to be positioned.

Upper limb amputation: in planning an amputation of the upper limb, the surgeon should consider an appropriate surgical technique, aiming for quick primary healing, satisfactory cosmetic appearance and a good potential for prosthetic use.

Sufficient soft tissue coverage is achieved by a good myodesis or myoplasty in diaphyseal amputation. A myodesis would provide more stability of the musculature, especially in someone considering an upper limb myoelectric prosthesis. A good-quality scar, healed through primary intention, non-adhered, and free from pain will enable the patient to engage in rehabilitation with a prosthesis in a timely manner.

Transected stump muscles atrophy with time, so sufficient muscle should be preserved at the time of surgery. However, excessive redundant soft tissue is a significant problem in donning the prosthetic limb, as well as limiting the modes of suspension of the prosthesis, such as suction suspension. The risk of skin infection is also increased, due to excessive soft tissue invagination.

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