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Lower Limb Prosthesis After Amputation the End or the Beginning of Treatment

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Abstract

Sports and exercise are beneficial in terms of physical and psychological wellbeing of not only able-bodied but also for disabled ones. This notion is supported by the fact that sports became an integral component of rehabilitation in a center at the Stoke Mandeville Hospital after World War II that eventually gave birth to the Paralympic Games. The ultimate desire of amputees to partake in high activity sports led to the development of sports specific prosthesis with greater functional advantage over nonspecific ones. But the amputees tend to develop several skin and musculoskeletal complications ascribed to socket prosthesis which can be overcome by osseointegrated implants at the expense of high incidence of superficial infections about the stoma. Further, robotic technology is bringing revolution in the field of prostheses.

Keywords: Amputation; Lower-limb; Prosthesis; Sports; Osseointegration; Complications; Robotic

Introduction

Since the ancient times, amputation or surgical removal of limbs due to trauma, infections, congenital defects and peripheral arterial disease, have been performed [1]. One of the earliest examples of amputation of a large toe and usage of prosthetic toe carved from wood, stem from ancient Egypt in 15th century. Though a necessary procedure for survival, it was once considered as one of the most gruesome procedures known to surgery [2]. The effect of amputation on the afterlife of amputee led to the development of most primitive prosthetics, that were made to camouflage the visible deformities rather than to restore function, to the present sophisticated ones that are functionally compatible with one's own limbs [3]. The amputees in general have poor physical health because of the two, surgical procedure itself and the medical condition for which it was performed [4]. On the top of that, limb amputation brings about great anxiety and depression amongst the amputees and they are considered as a separate group of individuals that need special care and facilities [5]. The participation in sports and exercise not only maintain the physical health and psychological wellbeing of amputees but also enhance confidence and coping behavior. With better counselling and rehabilitation of amputees, the number of individuals with limb amputations is increasing and more of them are recruited to participate in a wide range of activities including recreational sports. While the goal of rehabilitation in athlete amputees is to foster rapid return to selected sports, the goals in non-athletic amputees could be either just rapid recovery of daily activities or to engage them in recreational activities and sports so as to enhance the rapid recovery of their physical as well as mental fitness [6].

Man's determination to do better has transformed the function of lower limb prosthesis from restoring daily life activities to tremendous performance of athletic amputees in competitive sports close to their non-disabled counterparts. The birth of disability sport took place after Second World War when Dr. Ludwig Guttmann founded a center for those who sustained spinal cord injuries. The rehabilitation process for these patients incorporated competitive sports and this integration eventually influenced the development of Paralympic Games [7].

Lower limb amputation can be described as below knee (trans-tibial) and above knee (trans-femoral). In the last decade, the craving amongst amputees for participation in sports culminated in development of stronger, lighter weight prosthesis that made lower limb amputees to accomplish high physical demands and to return near to their premorbid functional level. The modern lower limb prosthesis is essentially comprised of; Liner, Socket, Pylon and Foot. Liner, which could be either silicone gel or silicone elastomer, that cover the residual limb, reduce tension and shear and provide greater comfort by reducing skin abrasions. Socket, which receives the liner and the limb, is fundamental to achieve satisfactory load transmission between the stump and prosthesis. The socket is then connected to the pylon simulating the limb which is then connected to foot that is variable according to the needs of individual [1].

The evolution of knee prosthesis for above knee amputees initiated with the development of Stabilized Knee Prosthesis after Second World War, then carbon fiber prosthetic in 1980s and ultimately the Microprocessor Prosthetic Knee (MPK) in 1990s. MPKs draw input from different types of sensor that monitor position, velocity, forces and moments during ambulation. For trans-femoral amputees, with high level of activity, Power Knee was designed which generates active power at the knee joint [7]. Similarly, the development of prosthetic feet passed through phases of progressive advancement. It commenced with Seattle foot in 1981 which was introduced as first energy storing prosthetic foot, then Terry Fox design for trans-femoral amputees, then Flexfoot which was inspired by the legs of "Cheetah" animal and finally the Proprio foot (Ossur) in 2006 introduced as the first microprocessor prosthetic foot [8].

Prosthesis doesn't bring an end to the treatment of amputees. The skin prosthesis intimate interface is subjected to numerous stresses. Stump Edema Syndrome in its beginning is relatively innocuous but when persistent, due to poorly fitted prosthesis, may lead to ulceration of the skin. The friction generated as a consequence of rubbing of skin against the socket terminate in lichenification of the skin which may progress to verruciform hyperplasia (a precursor of carcinoma). Skin reacts to the warmth developing inside the socket (due to tight fitting) by perspiration and as air can't circulate freely, this increased humidity provokes bacterial infections and dermatophytosis. Infection with Staphylococcus aureus can lead to folliculitis, furunculosis, cellulitis and occasionally intertrigo in the folds of skin at the stump end. Allergic contact dermatitis may occur which is attributed to prolonged sensitization from the chemical compounds like lanolin found in skin moisturizers used by amputee himself or on prescription to take care of skin or from the agents used in manufacture of the socket itself or from the liner. Furthermore, trans-femoral amputees are typically prone to the development of epidermoid cysts in the skin of inguinal fold and adductor region of thigh. Thanks to the continued friction and unnatural forces generated from the use of from the prosthesis that the keratin and upper epidermal layers invaginate within the dermis thereby mimicking "foreign body" and eliciting nonspecific inflammation that may become complicated by secondary bacterial infection [9]. The most common orthopedic complications are in long-term users are osteopenia and osteoporosis in the amputed side hip, early onset osteoarthritis of hip and knee of the sound side, scoliosis and low back pain [10].

Prosthesis skin interface complications not only lead to poor quality of life among amputees but also to reduced joint movements, proprioception and poor fitting of prosthesis as well. The only approach to abolish skin problems in the stump is to directly connect the limb prosthesis to the bone of stump transcutaneously, a process known as Osseointegration. Bony anchored prosthesis offers several potential benefits including improved quality of life, increased range of motion at hip joint improved walking ability and prosthetic use, enhances osseoperception and near normal hip abductor strength. The most common complication of these osseointegrated implants is superficial infection at the skin penetrating site [11]. Further, these are restricted in certain conditions, as they are not indicated for trans-tibial amputees with an ultra-short stump and preexistent ipsilateral knee osteoarthritis [12].

Robotic prosthesis, another great innovation, is restoring lost functions more efficiently than the passive prostheses and further trials are being conducted to control the movements with the brain [13]. Therefore, to conclude, an amputee who uses prosthesis for the rest of his life was once subjected to lifelong morbidities ascribed to various complications of this artificial limb but now man's curiosity to get better and better is refining the outcomes of prosthetic use after amputation surgery.

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