Chapter 18
Prosthetic and Orthotic Devices

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ABSTRACT

Prostheses and orthoses are devices intended to improve motor function in amputated patients or patients with different kinds of motor disorders, respectively. Thanks to a multidisciplinary approach that has evolved along the years, prosthetics and orthotics are really two disciplines in which biomechanical and clinical aspects are integrated and take advantage of new materials and technologies. Artificial limb components, limb supporting braces, and many other devices are already available, and can provide effective solutions for locomotion, upper limb function, and posture. Within a clinical/theoretical framework, this chapter addresses the main principles of application and the technical issues related to the use of prostheses and orthoses. These include among others, problems of manufacturing, adaptation to the patient, functional assessment, and the role of advanced technologies. The aforementioned concepts are all to be considered if the objective is to obtain good functional results and to improve the quality of life of disabled people.

18.1.CHAPTER OBJECTIVES

Prosthetics and Orthotics are two different disciplines that have as a common objective the recovery of human function through the use of special devices called, respectively, Prostheses and Orthoses. The main objectives of this chapter are: i) to review the basic knowledge about prosthetic and orthotic devices with reference to one of the main application areas, that is motor rehabilitation; ii) to provide information about their characteristics and main component, namely the biomechanical principles related to designing and fitting these devices to patients, and, iii) to address the new advances being derived from the advent of new materials and technologies. The state-of-the-art includes basic concepts and applications that have evolved in the last sixty years, starting from the boost of investment and research that has come after the Second World War. Recent improvements are the result of an increased awareness of the problems of disability and handicap; they are continually improving quality of life and autonomy in persons with special needs.

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18.2. INTRODUCTION

Subjects affected by motor disabilities require specific orthopedic devices to recover a function and perform a physical activity. Lower limb amputees require an artificial limb to replace the missing body parts in order to walk; upper limb amputees need an artificial hand to grasp objects. These are examples of substitutive devices called prostheses. Whereas, people who have the anatomical integrity of their limbs, but have lost the ability to control their function appropriately because of weakness or deficit in the neuromotor control system, may be aided by external devices that help the insufficient organ to work more properly. Such devices are called orthopedic orthoses. Supplying these devices to patients is a delicate and complicated task that requires the integrated cooperation of a team of several professionals, commonly formed of: physicians, physical therapists, orthotist and prosthetist, occupational therapist, and possibly a psychologist for what concerns the many psychological aspects related to the new condition of daily living of the patient. The Prosthetics and Orthotics field has increasingly become an area in which not only the patient-related aspects are faced, but also where new materials and new technologies are tested and find application, and where new concepts related to function and to manufacturing processes are implemented. For this reason, the role of biomedical engineers has become increasingly important as well in this field. In fact, the interplay of medical and technological aspects, leading to products that have to be tightly connected to human beings and have to solve special functional needs, can only be faced by a professional who has a strong engineering background and has acquired a considerable knowledge and sensitivity of clinical terminology and problems.

18.3. A COMPREHENSIVE DEFINITION OF PROSTHETIC AND ORTHOTIC DEVICES

Among the broad variety of devices that can help the recovering of a physiological function in people affected by motor disabilities are the ones that deal with the musculoskeletal system and which are called orthopedic prostheses and orthoses. A commonly accepted definition of prosthesis and orthosis is the following: "*An orthopedic prosthesis is an internal or external device that replaces lost parts or functions of the neuro-skeletomotor system. In contrast, an orthopedic orthosis is a device that augments a function of the skeletomotor system by controlling motion or altering the shape of body tissue*" (Lord & Turner-Smith, 2000). Basically, an orthopedic prosthesis substitutes an anatomical part, while an orthosis helps an existing organ to perform better and to overcome its deficiency. Although the concept of prosthesis and orthosis includes devices that could be applied internally or externally to the human body, usually the term '*prosthetics and orthotics*' refers to the discipline dealing with external appliances. These are, for instance, prostheses for amputees and orthoses for limbs and rachis, and not the artificial joints that are implanted inside the body and constitute a specific area called '*joint prosthetics*' or '*endoprosthetics*'.

People in need for orthotic and prosthetic services present a variety of impairments. Those receiving orthotic services include people with brain injuries, spinal cord injuries, cerebral palsy, stroke and burns, among others. Prosthetic services are provided to people with congenital limb deficiencies or amputations.