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Review Article

Expandable endoprosthesis for growing patients—Reliability and research

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ABSTRACT

Nowadays expandable endoprosthesis for growing children is an alternative to amputation in the course of surgical treatment. Modern non-invasive endoprosthesis gives the possibility of elongation without a surgical operation. In the paper, the results of research with the application of computer technique in geometrical modelling are presented, as well as the design and manufacture in processing the medical images and experimental studies during an initial estimation of a new expandable prosthesis construction for growing patients, which will lead to the preparation for production and implantation processes in Poland.

1. Introduction

People at any age can be stricken by cancerous diseases. Among those diseases that afflict younger patients – kids, there are bone tumours, which are usually localized near the knee joint [1,9,13,14]. Due to the fact that a contemporary treatment can be applied, cancerous disease is not a death sentence any more. In order to overwhelm the cancerous disease the sarcoma-stricken knee joint is extracted from the body and replaced with prosthesis. Not only is such a prosthesis to restore the functionality of the limb but it also gives the possibility of extending its length while the patient is growing [6,2,11]. It gives better quality of life and high emotional satisfaction [4].

We have two kinds of expandable endoprosthesis: invasive and non-invasive ones. A surgical operation is necessary to elongate an invasive endoprosthesis. A non-invasive endoprosthesis is elongated without a surgical operation by using a special mechanism. A high social rank, better and better treatment results and the development of the techniques triggered research on a newer construction of an expandable prosthesis including such one which makes lengthening possible without surgery [3,5].

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2. Methods

2.1. Construction of expandable endoprosthesis

Bone sarcomas are usually localized near the knee joint. In one of treatment steps the tumour is removed and endoprosthesis is placed in a free space. The role of tumour expandable endoprosthesis is not only to complete the skeletal system, but as that patient is still growing, to complete the length of the implanted leg, that has not the possibility to reach the right growth [9]. The presented endoprosthesis is composed of a knee module, an expandable module, and a power and control module (Fig. 1).

It is a hybrid endoprosthesis because the elongation of an expandable module is carried out by a screw mechanism non-invasively or optionally invasively. The first aim is to make it possible to use the screw mechanism which is connected with a motoreducer powered by an electromagnetic field and controlled in a radio path. In any other way, a non-invasive procedure could not be applied; the elongation is carried out by a special chuck inserted to an endoprosthesis through a small incision in a patient's leg.

The supply and control system is composed of two moduli: an external one which is situated out of a patient's body, and an internal one which is situated in the endoprosthesis, inside the body. The electric energy which is generated in the external modulus is changed into an electromagnetic field which is sent by a transmitter to a receiver in the internal system. The receiver changes the electromagnetic signal into electric current which supplies a motoreducer.

The supply of the motoreducer which realizes the extending (the elongation) of the endoprosthesis is to take place by means of so called free-accessible energy, which means on the basis of the power transmission in electric coupled circuits from the external device (the transmitter) to the implanted circuit (the receiver) (Fig. 2).

2.2. Prototype manufacturing

The CAD/CAM/CAE systems of design supporting and manufacturing, which have been generally used since the eighties, enable to limit the time consuming work on new products, which also requires smaller cost, because a lot of trials and experiments on new products can be realized virtually by their means. In spite of the noticeable easiness and acceleration of work with the use of these systems, it is not possible to eliminate in their initial phase the manufacturing of a prototype, which is necessary to check the initial project assumption; because the manufactured prototype as a physical model of the product in its initial development phase allows to identify the probable incorrect or wrong assumptions or decisions, and then to eliminate them or to change them.

The rapid and cheap manufacturing of the prototype, which in the initial development phase is a unit product, is made possible by the application of generative techniques, that is a technique of rapid prototyping (RP) and a technique of rapid tooling (RT). The basic aim of the application of these

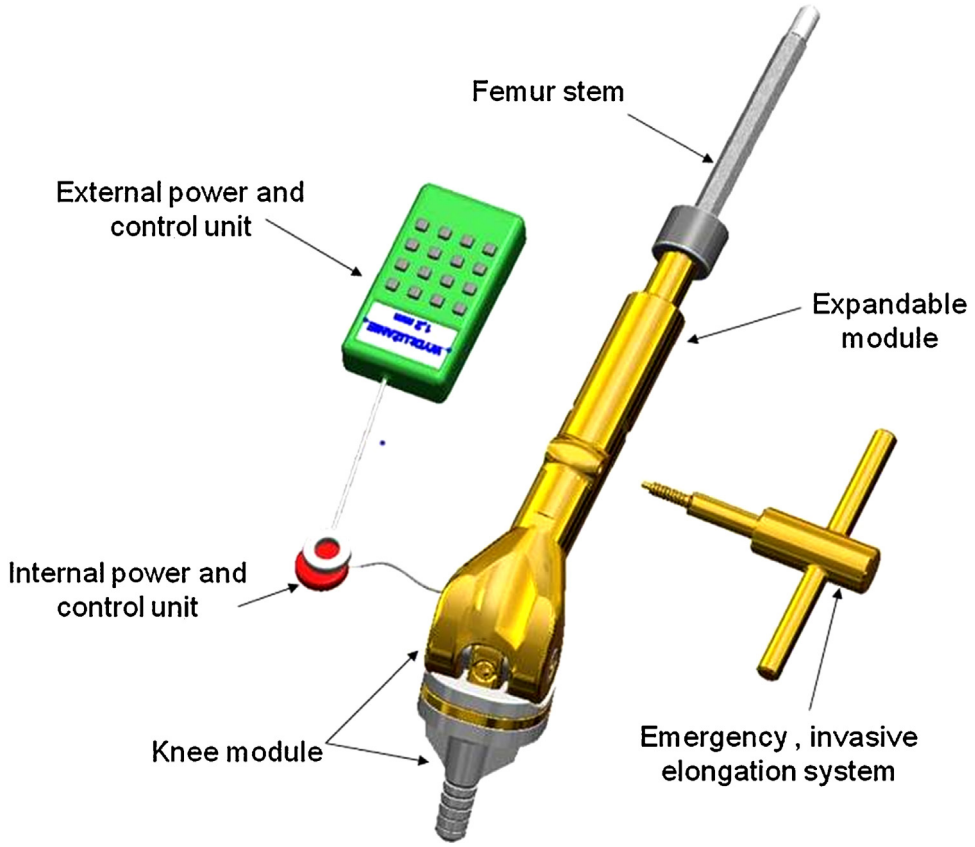

Fig. 1 – Model of hybrid expandable endoprosthesis.