Knowledge-based designing method of surgical instruments for hip surgery

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1. Introduction

Each year more than 500,000 arthroplasties are performed in the world to recover hip joint functions of individuals [1, 2], and each year this number is increased because of the ageing of population in developed countries. Only in Europe the market of hip prosthesis is 380,000 units and 760 million € per year in Europe, and it is expected that the rate of last years will be increased for next decades [2]. Total hip replacement (THR) consists in the hip joint substitution by both a femoral component (femoral head and stem) and by acetabular component. During last decades, biomechanics, surgeons and hip prosthesis companies have focused their efforts on improving the patients’ quality of life by improving the prosthesis clinical behavior and consequently making the prosthesis life longer. Nevertheless much lower effort has been applied to the development of the associated instruments. One of the most important objective of the ENHIP (Ergonomic Instruments Development for Hip Surgery) project was to develop “Better surgical instruments, which will allow surgeons to reduce time required for surgery and to improve working conditions of surgeons by a reduction of physical effort required, and the consequent effect in the on health expenditure reduction”.

2. Methods

The method consisting of the following stages was used in the project:
- an assessment of existing tools: questionnaire inquiry of existing tools, photo and video recording of hip alloplasty, computer modelling of surgical tool and surgeons anthropometric features (Fig. 1), computer visualization of recorded activities, ergonomic evaluation of activities, analysis of tools design features,
- tools improvement: modelling of design features, testing the virtual prototypes (Fig. 2), Rapid Prototyping, assessment of material prototypes.

Activity realized in a sitting position by the female surgeon of anthropometric features was analyzed.

Fig. 1 Photo-recording of activity realized in a sitting position during the surgical operation when using Rongeur a), and computer models of the surgeon, patient and tool b).

Results obtained from FEM dynamical analysis: map of reduced stresses (a), diagram of contact force between hammer and the Rasp Impactor during “driving in”, using of the Rasp Impactor – Hammer (b), diagram of acceleration in a direction perpendicular to the surface of grasping part of vibrating Rasp Impactor (c).
3. Results

Ergonomics analyses were carried out both experimentally and in a virtual environment. Experimental tests were conducted with using a synthetic model of lower limb. Conditions, in which the tests were carried out were reconstructed in a virtual environment. The following conclusions were drawn on the basis of numerical analyses:

- asymmetric load has no impact on increase of the Rasp Impactor effort,
- reduced masses of the Rasp Impactor improve its functionality for the ergonomic criterion.

4. Discussion

Nowadays, the SMEs follow the trend opened by multinational companies and they concentrate their efforts in what they are more competitive. For a single SME it is very difficult to innovate due to the lack of resources and personnel dedicated to R&D activities. This can be solved by collaborating with RTD Centers that can support and transfer knowledge to SMEs thanks to their facilities and high skilled personnel. To attack so huge market by one single SME is not easy. Only the establishment of cooperation with other companies can guarantee a prominent position and reach greater market share avoiding isolated national efforts.

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References