STRUCTURAL HEALTH MONITORING APPLIED ON ORTHOPAEDIC IMPLANTS

L.C. Pastrav[1], S. Leuridan[2], J. Roosen[3], Q. Goossens[1], M. Mulier[3], W. Desmet[4], K. Denis[1], J. Vander Sloten[2]

[1]KU Leuven Campus Group T, Health Engineering, Leuven, Belgium
leonard.pastrav@kuleuven.be, quentin.goossens@kuleuven.be, kathleen.denis@kuleuven.be
[2]KU Leuven, Biomechanics Section, Leuven, Belgium
steven.leuridan@kuleuven.be, jos.vandersloten@kuleuven.be
[3]University Hospitals KU Leuven, Department of Orthopaedics, Pellenberg, Belgium
jorg.roosen@med.kuleuven.be
[4]KU Leuven, PMA Section, Leuven, Belgium
wim.desmet@kuleuven.be

Abstract: *Based on the structural health monitoring paradigm, a series of research studies conducted at the Catholic University of Leuven, Belgium analysed the stability of orthopaedic implants. Vibrational methods were applied on hip, knee and shoulder implants in various fixation conditions. The results show that vibration analysis is a promising tool able to help surgeons in assessing the stability of bone-implant structures.*

Keywords: *biomechanics, implants, orthopaedics, stability, vibration*

1. Introduction

A large number of artificial orthopaedic joints are implanted every year in the world (i.e. more than one million total hip replacements) and the rate of success is strongly dependent on the mechanical stability of the implant-bone structure [1, 2]. Therefore, the assessment of the stability of orthopaedic implants is a hot research topic for clinicians, implant designers, and implant manufacturers.

Structural Health Monitoring (SHM) is defined as the process of implementing a damage detection strategy for engineering structures based on vibration or acoustic techniques. The SHM statistical pattern recognition paradigm, consists of four steps that need to be taken to achieve such a successful implementation: (a) operational evaluation; (b) data acquisition, fusion and cleansing; (c) feature extraction and information condensation and (d) statistical model development for feature discrimination [3]. Successfully used to detect damages in bridges, aircraft, oil ridges and large buildings [4], SHM techniques also hold promise in the field of biomechanics.

The first report of the use of vibration analysis in Orthopaedics was in 1932 by Lippmann who used auscultatory percussion for the examination of clavicle fractures [5].

More sophisticated methods have been successfully used to determine bone mechanical properties [6, 7] and to monitor fracture healing [8, 9].

Vibration analysis is also a promising method to assess the integrity of implant-bone systems. Vibrational techniques have shown their merit in the detection of loosening [10] of total hip replacement systems. Several features based on the vibration output have been used in the detection of late and early loosening, such as harmonic distortions [10] or resonance frequency shifts [11]. As an alternative to measuring the vibration response using