Chapter 10
A Particle Swarm Optimization-Based Approach for Finding Reliability in a Total Hip Prosthesis

Bouakkar Loubna
1 Research Laboratory in Production (LRP), University of Batna 2, Batna, Algeria

Ameddah Hacene
https://orcid.org/0000-0003-2572-7372
2 Laboratory of Innovation in Construction, Eco-Design, and Seismic Engineering (LICEGS), University of Batna 2, Batna, Algeria

Mazouz Hammoudi
University of Batna 2, Batna, Algeria

ABSTRACT

Nowadays, we assist the global extension of reliability optimization problems from the design phase of systems and sub-systems to the design and operational phases, not only of systems and sub-systems, but also of bio functionality design. This chapter investigates the relative performances of particle swarm optimization (PSO) variants when used to find reliability in the total hip prosthesis by finding the maximization of jumping distance (JD) to avoid dislocation and the minimization of system's stability to offer mobility. Statistical analysis of different cases of head diameters of 22, 28, 36, 40 mm has been conducted to survey the convergence and relative performances of the main PSO variants when applied to solve reliability in the total hip prosthesis.

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INTRODUCTION

The normal human hip joint has treated as a ball and socket joint in the biomechanical research areas, with the center of rotation defined as the center of hip joint and allows a wide range of motions, resulting in three directions of movement: flexion/ extension, abduction/adduction and intra-extra rotation. This hip joint supports the body during human activities and is responsible for the distribution body weight. Hip dysfunction can occur at different times in a person's life, this problem has been studied by several researchers, among others (Ray Marks et al, 2003), who mentioned several reasons for hip dysfunction of which fractures of the neck and trochanteric regions of the femur.

Total hip replacement (THR) has been developed in an effort to improve mobility, enhance the overall quality of life and improve the function of damaged joints. Researchers seek to extend the validity and reliability of hip implants, where there are many risks that affect the reliability of hip implants, such as instability, dislocation and that remains the second most common reason for revision surgery after aseptic loosening. The main directions of dislocation are posteriorly (flexion/ extension – internal rotation / external rotation – adduction/ adduction) movements.

The most famous factors influence the dislocation as:

- Patient characteristics of such as a history of spinal fusion, inflammatory arthritis (E.B. Gausden and all, 2018), patients with fixed spinopelvic alignment from standing to sitting position (C.I. Esposito and all, 2018), was identified as independent risk factors for dislocations.
- The surgical technique such as the wrong positioning of the cup in total hip arthroplasty during surgery can be a risk factors for dislocations (T. Scheerlinck, 2014).
- The prosthesis design's factors are numerous; several studies have been carried out to avoid dislocations.

Laura Ezquerra, Maria Paz Quilez(2017); who generated a parametric three-dimensional finite element (FE) model capable of predicting the dislocation stability for various positions of the prosthetic neck, head, and cup under various activities. In their study, three femoral head sizes (28, 32, and 36 mm) were simulated and nine acetabular placement positions: abduction angles (25°, 40° and 60°) combined with anteversion angles (0°, 15° and 25°) were analyzed. They evaluated the range of motion (ROM) and maximum resisting moment (RM) until dislocation; they found the safe zone of movement for impingement and dislocation avoidance in total hip replacement: an abduction angle of 40°–60° and anteversion angle of 15°– 25°. It is particularly important that the anteversion angle does not fall to 10°-15°. The

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