

# Biomechanical study of cervical arthroplasty prostheses: influence of positioning and implant height

Institut Pprime / CHU de Poitiers

---

## Supervision

- **Supervisor** Tanguy Vendevre, PU-PH, CHU de Poitiers
  - **Co-supervisor:** François Zot, MCU, Université de Poitiers
- 

## Context

Cervical arthroplasty is increasingly used as a surgical solution for treating degenerative cervical spine pathologies, particularly as an alternative to arthrodesis. By preserving segmental mobility, it reduces adjacent segment degeneration and improves patients' quality of life. However, reported clinical outcomes remain heterogeneous. This variability is largely explained by differences in implant positioning and height selection, two essential parameters for ensuring stability, natural kinematics of the operated segment, and prosthesis longevity.

Poor anteroposterior or mediolateral orientation, as well as inadequate implant height, can lead to biomechanical imbalances, overloading of neighbouring structures (adjacent discs, facet joints, ligaments), and premature device wear. Understanding these phenomena requires a coupled approach between numerical modelling and experimentation, integrating anatomical variability and physiological mechanical conditions specific to each patient.

This project builds on work conducted within the PEM team at the Institut Pprime on lumbar and thoracolumbar spine modelling, and on the established collaboration with the orthopaedic surgery department at CHU de Poitiers. The objective is to transpose this expertise to the cervical spine, which is more mobile and subject to complex loading conditions.

## Objectives and Scientific Approach

The general objective of this thesis is to evaluate the influence of cervical prosthesis positioning and height on the biomechanical behaviour of the operated segment. To achieve this, an integrated approach coupling finite element numerical modelling and experimentation on anatomical specimens will be developed.

Initially, patient-specific finite element models will be developed from medical imaging (CT, MRI). These models will include bony structures (cervical vertebrae), intervertebral discs, ligaments, and articular cartilages, in order to faithfully reproduce the mechanics of the healthy cervical spine. Arthroplasty prosthesis implantation will then be simulated by systematically varying positioning

parameters (anteroposterior, mediolateral) and implant height. These variations will enable analysis of their impact on stress distribution, intervertebral mobility, and interactions between different articular structures.

Subsequently, results from simulations will be compared with experimental tests performed on human spinal segments. These tests will be conducted in partnership with the Anatomy Laboratory (ABS Lab) of the University of Poitiers, using adapted mechanical setups reproducing physiological conditions of flexion, extension, and rotation. Measurement methods developed by the PEM team (marker tracking, digital image correlation) will be implemented to analyse the obtained data. This experimental approach will validate numerical models and refine biological tissue behaviour laws.

Finally, parametric and statistical analysis will be conducted to identify the most favourable geometric and mechanical configurations for implant stability and durability. These results will lead to concrete recommendations on surgical positioning and, potentially, to improvement directions for prosthesis design.

### **Expected Impact**

The impact of this work is multifaceted. Scientifically, the thesis will contribute to better understanding the biomechanical behaviour of the operated cervical spine and interactions between the implant and surrounding tissues. Clinically, it will provide quantitative elements for optimising prosthesis positioning, reducing mechanical complications, and improving long-term functional outcomes. Ultimately, the developed models could be integrated into personalised surgical planning assistance tools, thus promoting the dissemination of a predictive and individualized approach to spinal surgery.

### **Scientific Environment and Partnerships**

The thesis will take place in a highly interdisciplinary and collaborative environment. The CHU de Poitiers, through the orthopaedic surgery department, will provide clinical expertise, access to operative data, and implant devices. The Institut Pprime (UPR 3346 CNRS – University of Poitiers – ISAE-ENSMA) will ensure the development and validation of finite element models, as well as mechanical analyses. The Anatomy Laboratory (ABS Lab) will contribute to the experimental part on human specimens, within an ethical and technical framework adapted to this type of study.

The research environment thus offers the doctoral candidate a unique complementarity between clinical expertise, advanced numerical modelling, and biomechanical experimentation.