

Finite element analysis of the remodeling of a metatarsal after head arthroplasty

Yohann Couqueberg^{*1,2,3a}, Valérie Berry-Kromer^{1,2b} and Céline Bouby^{1,2c}

¹Université de Lorraine, LEMTA, UMR 7563, Vandoeuvre-lès-Nancy, 54500 France

²CNRS, LEMTA, UMR 7563, Vandoeuvre-lès-Nancy, 54500, France

³NOVASTEP, Espace Performance III, Bâtiment P, 35760 Saint-Grégoire, France

Abstract:

Nowadays, metatarsophalangeal arthroplasty for patients with severe Hallux Rigidus shows good clinical outcomes with a pain relief and a restoration of joint mobility. However, many complications or failures discredit this surgery compared to other surgeries with better outcomes, especially arthrodesis (Brewster (2010)). In a way to reduce the failure rate coupled with the procedure, we developed a subject-specific Finite Element analysis coupled with a bone remodeling law with the aim to determine the density distribution in a metatarsal after an arthroplasty. In this study, hypothesis concerning bone remodeling are the following:

- Use of a purely mechanical remodeling law developed by Weinans et al. (1992) using the strain energy as remodeling stimulus;
- Use of a metatarsal model created through a dedicated Matlab program from CT-scans of patients;
- Use of loading conditions which represent daily activities such as walking or climbing stairs;
- Use of tribological properties between bone and prosthesis close to actual conditions.

The goal of this communication is to describe the primary outcomes of bone remodeling on metatarsal bone with the description of the influence of different factors listed above on final density distribution. This study serves as a premise for the development of a reliable surgical tool with the aim at helping to prevent complications or failures of the surgery. It could allow the improvement of the design of new prostheses.

Keywords: Metatarsophalangeal arthroplasty, bone remodeling, finite element analysis

References

- Brewster, M. (2010). Does Total Joint Replacement or Arthrodesis of the First Metatarsophalangeal Joint Yield Better Functional Results? A Systematic Review of the Literature. *The Journal of Foot and Ankle Surgery*, **49**, 546-552.
- Weinans, H., Huiskes, R. & Grootenboer, H. J. (1992). The behavior of adaptive bone-remodeling simulation models. *Journal of Biomechanics*, **25**, 1425-1441.