J.F. Silva Gomes
Shaker A. Meguid
Editors

RECENT ADVANCES IN MECHANICS AND MATERIALS IN DESIGN

Proceedings of the 6th International Conference on Mechanics and Materials in Design, P. Delgada, Portugal, 26-30 July 2015

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About the Book:

During the last few decades the development of computer based techniques, as well as new experimental methods, nanotechnologies and nanomaterials, among many other material technological advances, added new dimension and perspectives to mechanical design and manufacturing of engineering systems, structures and components. Different tools are now available to optimize any engineering solution, and we must continue our efforts to develop and use superior materials, apply reliable analytical and numerical techniques and validate these with sound experimental methods.

This volume contains the extended Abstracts of papers accepted for presentation in the *M2D2015 - 6th International Conference on Mechanics and Materials in Design* held in Ponta Delgada/Portugal, 26-30 July 2015. The book is complemented by an accompanying CD-ROM containing the full length papers.

M2D2015 is part of a prestigious series of conferences that was initiated in 1996, in Toronto (Canada), coordinated by the International Scientific Committee on Mechanics and Materials in Design. The conference attracted over 320 participants with 423 accepted submissions from 42 different countries around the world. These papers were presented in July 26-30, 2015 in the magnificent city of Ponta Delgada-Azores, Portugal. The conference themes, which address novel and advanced topics in Mechanics and Materials in Design, focused on analytical and numerical tools at all scales, testing and diagnostics, surface and interface engineering, tribology, mechanical design and prototyping, modes of failure, composite and engineered materials, biomechanics, energy and thermo-fluid systems, impact and crashworthiness and case studies.

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M2D2015

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EDITORS' PREFACE

M2D2015 is the sixth international gathering of a prestigious series of conferences coordinated by the International Scientific Committee of Mechanics and Materials in Design. This series of conferences are wholy devoted to advances in mechanics, materials, structural integrity and design. M2D2015 is sponsored by the University of Porto, the University of Toronto and the University of Azores. The conference attracted over 320 participants with 423 accepted submissions from 42 countries out of 620 submissions. These papers were presented in July 26-30, 2015 in the magnificent city of Ponta Delgada, Azores. The conference themes which address novel and advanced topics in Mechanics and Materials in Design focused on analytical and numerical tools at all scales, testing and diagnostics, surface and interface engineering, tribology, mechanical design and prototyping, modes of failure, composite and engineered materials, biomechanics, energy and thermo-fluid systems, impact and crashworthiness and case studies.

We believe that the meeting offered our delegates a forum for the dissemination of their recent work in mechanics and materials and their applications in engineering design, fostered research that integrates mechanics and materials in the design process, and promoted exchange of ideas and international co-operation among scientists and engineers in this important field of engineering.

We are particularly indebted to the authors and special guests for their presentations. Each of the more than 420 contributions offered opportunities for thorough discussions with the authors. Particularly, we acknowledge the excellent contributions of the participants, their innovative ideas and research directions, the novel modeling and simulation techniques, and the invaluable critical comments. We are also indebted to the outstanding keynote speakers who highlighted the conference themes with their contributions and covered the main topics of the conference. We also take this opportunity to thank the members of the International Scientific Committee and the reviewers for their time, effort and helpful suggestions.

We offer our sincere gratitude to the symposia organisers for their efforts and valuable contributions to the success of the event, and the local organising committee for attending to the conference demands and delegates needs.

All in all, M2D2015 was a great success and the credit must go to all the participants for their significant contributions and lively discussions, the keynote speakers for bridging the gap between the different disciplines and the organizing committee for an absolutely superb organization of the meeting in this magnificent city. To all of you, we offer our gratitude.

Given the rapidity with which science is advancing in all areas of mechanics and materials, the next conference in this series (Integrity, Reliability and Failure - IRF 2016) will take place in Porto, Portugal in July 2016. Undoubtedly, we expect IRF2016 to be as stimulating and interesting as M2D2015, as evidenced by the excellent contributions offered in this current event. We look forward to seeing all of you in Porto in 2016.

Shaker A. Meguid and J.F. Silva Gomes
P. Delgada / Azores, July 2015

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PAPER REF: 5355

ADDITIVE MANUFACTURING IN THE DEVELOPMENT OF AN INTRAMEDULLARY NAIL: STUDY OF CLINICAL CASE

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ABSTRACT

The additive manufacturing is currently an indispensable tool in different areas. Its application in orthopaedic area has been essential in the development of surgical procedures, visualization of anatomical structures and especially in the new implants design to improve the conditions for patients' treatment. The present study considered different techniques of additive manufacturing applied in design, diagnosis and planning of a locked intramedullary nail used in the femoral diaphysis fractures (type A). This study was complemented with the follow-up of a surgery case to the femoral diaphysis fracture. It was performed a biomechanical analysis using the finite element method and 3D models through a printing in full colour, allowing to obtain the colour levels related to von Mises stresses. All the studied techniques have proved to be important, since they allow a three-dimensional view of real dimensions of the implant by helping health professionals to do a more accurate and safe surgical planning.

Keywords: additive manufacturing, femur, fracture, locked interlocking nail, finite elements.

INTRODUCTION

In orthopaedic surgery, the femoral diaphysis fractures are among the most common. These surgeries are considered serious injury as result of violent forces. There are different systems of classification which identify the types of fractures that can occur in a particular anatomical region or specific bone. This work was based on the classification system developed by Swiss Group *AO*, which includes the fractures classification of the long bones (Muller et al., 1991). Depending on the type of fracture, it is necessary to understand the best way of treatment to allow the creation of a biological environment that maximizes the normal processes of bone repair. The intramedullary fixation with intramedullary nail is one of the possible treatments for this type of fracture. These implants have a locking system through surgical screws that allow the intramedullary nail remains attached in the bone on the proximal and distal zone. However, the main objective is to design an implant that decreases the rehabilitation time and offers better results for patients. The additive manufacturing coupled to medicine has proven to be a great tool in the improvement and planning of this surgeries.

The main goal of this study is to evaluate the potential of the additive manufacturing technique in design, diagnostic and planning of implants used in femoral diaphysis fractures (type A). The study was complemented with the follow-up of a surgery case to the femoral diaphysis in a specialized Hospital from Brazil (Fernandes, 2013).

METHODOLOGIES OF STUDY

Following the method used in the clinical case, a three-dimensional model of the femur-implant-screws was created with a simple fracture (type A), Fig.1. In this study a numerical analysis was conducted to study the biomechanical effect of the material of the intramedullary nail (stainless steel), the influence on osteosynthesis of the fractured bone and the action on the femoral diaphysis fracture, type A (Fernandes, 2013).

Some additive manufacturing processes (Stereolithography, Fused Deposition Modelling and Three-dimensional Printing Monochromatic and Chromatic) were used to manufacture a locked intramedullary nail and the set femur-implant-screws, with the objective of evaluating the technique of manufacturing for diagnosis and planning of placement of implants.

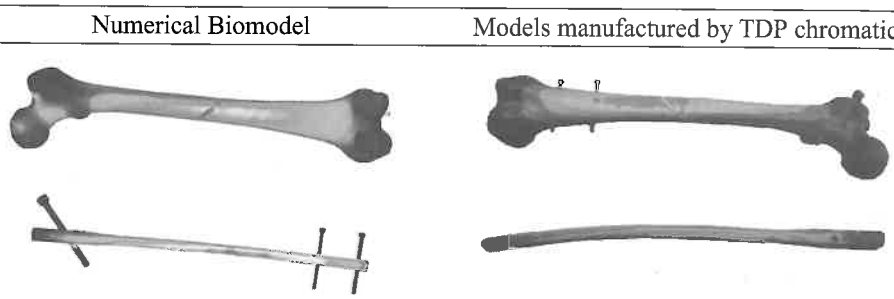

Fig. 1 - Comparison between numerical model and manufactured model by Three-Dimensional Printing.

CONCLUSION

The additive manufacture applied in the medical area has been revealing to be an essential tool for visualization and direct manipulation of prototypes, offering several advantages, such as simulation, surgical planning and exposure of clinical case to the patient. The colour printing of intramedullary nail and femur-implant-screws, allowed the actual view of physical models with the respective colours related to the involved stresses. All the discussed techniques are essential in orthopaedic area by three-dimensional view and real dimensions of the implant and the intended location for the placing, helping health professionals for a more accurate and safe surgical planning.

ACKNOWLEDGMENTS

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