Evaluation of a new modular system for personalised corrective surgery

Laura Revol, Aurelie Levillain, Yoann Lafon, Thierry Barrière, Nathalie Boudeau, Alexandre Gilbin, Benjamin Billotet

Advances in Bone and Orthopedics

Proceedings of BONITOS 13 June 2025 version

Dr. Laurent Pujo-Menjouet, University of Lyon, France
Dr. Helene Follet, French Institute of Health and Medical Research, France - French-speaking Society of Biomechanics Representative
Dr. Aurélie Levillain, University of Lyon, France
Dr. Jean-Philippe Berteau, College of Staten Island, USA
Dr Michael Chiacchiero, College of Staten Island, USA
Dr Amanda Rotondo, College of Staten Island, USA - New York Chapter of the American Physical Therapy Association Representative

Evaluation of a new modular system for personalised corrective surgery

Revol Laura * [1,2,3], Aurelie Levillain [1], Yoann Lafon [1], Thierry BarriÃ¨re [2], Nathalie Boudeau [2], Alexandre Gilbin [2], Benjamin Billottet [3]

[1] Universite Claude Bernard Lyon 1 - Faculte des sciences – Universite Claude Bernard Lyon 1 – 4 rue Victor Grignard - 69100 Villeurbanne, France
[2] Franche-Comte Ã‰lectronique Mecanique, Thermique et Optique - Sciences et Technologies (UMR 6174) – Universite de Technologie de Belfort-Montbeliard, Ecole Nationale Superieure de Mecanique et des Microtechniques, Centre National de la Recherche Scientifique, Universite de Franche-Comte, Centre National de la Recherche Scientifique : UMR6174, Universite de Technologie de Belfort-Montbeliard : UMR6174 – 32 avenue de l'Observatoire 25044 BESANCON CEDEX, France
[3] ennoia – ennoÃ¯a – 18 rue Alain Savary, France

Corrective surgery of angular limb deformities in veterinary surgery requires accurate identification of the deformity and surgical technique for optimal recovery (1). Patient-specific instruments are widely used in human surgery and have recently been introduced in veterinary surgery (2). These methods significantly improve surgery accuracy, reduce operating time and accelerate recovery (2). However, their high cost, due to significant design preparation and production expenses, limits their use in clinical practice.
To optimize the manufacturing process, combined modular bone plates have been proposed in the literature (3). The assembly system is the critical part and can alter the mechanical behaviour and the fatigue strength. In a previous study, we demonstrated that similar mechanical properties and fatigue life can be maintained compared to standard plates. However, the study focused on the mechanical characterization of the modular system only using the ASTM F382-24 standard to analyse the impact of the assembly system, without considering the clinical environment.

The aim of this study is to evaluate the feasibility of using such a system under biomechanical considerations. The combined system will be screwed on a synthetic tube and subjected to compressive loading. Experimental and numerical analyses will be carried out to evaluate its performance.

Due to the complexity of direct comparisons with data from the literature, the mechanical properties of the proposed system were compared to a reference plate with identical dimensions. The plates were fixed on synthetic tubes (Sawbones4th generation, Vashon, WA, USA). Quasi-static compression tests (ElectroPuls E1000) were first conducted on six plates from each group (reference and prototype). Digital Image Correlation (DIC) was performed using two cameras (Nova R4-4K) to measure axial displacement and deflection. The experimental displacement was then compared with numerical displacements obtained from SolidWorks Simulation. Then cyclic tests were conducted on five combined systems. Each test was conducted to reach 180000 cycles with a maximal force of 200N (60% of the 30Kg dog body weight). The number of cycles was recorded at failure if it occurs before the end of the cyclic test.

*Speaker

In conclusion, the proposed method provides an evaluation of the new system and a comparison with numerical simulations, which may subsequently be used to evaluate different configurations or sizes.

1. Armond CCD, Lewis DD, Kim SE, Biedrzycki AH. Accuracy of virtual surgical planning and custom three-dimensionally printed osteotomy and reduction guides for acute uni- and bi-apical correction of antebrachial deformities in dogs. *Journal of the American Veterinary Medical Association*. 2022

2. Carwardine DR, Gosling MJ, Burton NJ, O'Malley FL, Parsons KJ. Three-Dimensional-Printed Patient-Specific Osteotomy Guides, Repositioning Guides and Titanium Plates for Acute Correction of Antebrachial Limb Deformities in Dogs. *Vet Comp Orthop Traumatol*. 2021

3. Revol L, Gilbin A, Levillain A, et al. Mechanical investigation of assembled osteosynthesis plates: experimental and numerical approaches. *Multidisciplinary Biomechanics Journal*. Published online October 2024.

Keywords: osteosynthesis plate, numerical simulations, experimental tests, veterinary surgery