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Medical & Technical Aspects of Implant Research & Developmen

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1. Jan Barcik (AO Research Institute) *Modulation of fracture mechanical conditions and feedback approach to determine the optimal healing environment, PhD thesis*

Bone fracture healing by callus formation offers the patient the ability to resume regular activities sooner than with regular therapy, however current methods lack adequate monitoring. The present work develops an active fixation system for *in vivo* investigations with continuous monitoring. The developed fixator was managed well by the tested animals and there were no signs of osteonecrosis after the surgeries.

2. Prof. Marc Balligand (University of Liège) *Unexpected implant failures after long bone fractures treatment in dogs: cases, reports and failures analysis*

Implant failure can occur as a result of unexpected callus formation if the fracture is near a joint, where there's a lot of mobility. Implants with one plate on the compressive side can fail if the plate is too rigid or because of bad contact. Measurements of the level of forces needed to bend the plates indicate that muscle force was the main factor.

3. Prof. Dian Enchev (UMHATEM Pirogov) *How to solve problematic bone fractures – with augmented fixation or using new implants?*

Implant design has improved greatly over the years, especially the Locking Compression Plates (LCP). Currently there are 2 ways to fix problematic bone fractures: IMOS with variety of plates and screws or with endosteal augmentation. The latter method is a useful tool in the surgeon's hands offering variety of techniques like augmentation with fibula, structural graft, PMMA and calcium phosphate. However this flexibility comes at a higher cost and risk of infection that is attributed to the longer operating time.

4. Prof. Martin Stoddart (AO Research Institute) *Mechanically induced chondrogenesis*

Chondrogenesis is the process by which cartilage is formed. It is known that motion produces callus and mechanics alone can run this process. In the study a multiaxial bioreactor is used that can simulate all the movements in a joint. The bioreactor system allows for the application of shear, compression or

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a combination of both stimuli. It was demonstrated that a combination of shear and compression is able to induce chondrogenic differentiation due to activation of TGFβ.

5. Prof. Boyko Gueorguiev (AO Research Institute) *Digitally-enhanced implant research and development*

Current implant design is working on producing implants inseparable from the bone that offer real time fracture monitoring. Using the FE model the fracture can be simulated and the optimal screw orientation can be calculated.

A Fracture Monitoring System is in development that could provide real time information (unlike X-ray data) through a chip on the plate of the implant. The compiled information from the chip would be easily accessible through a laptop or a smartphone. Development of laboratory equipment simulations for surgical training is in progress.

6. Dr. Stoyan Ivanov (Medical University Varna) *Added value of using 3D printed models in understanding complex fractures*

Complex fractures are difficult to characterize and analyze. 3D has been increasingly utilized in the preparative planning and implant design. It offers full visualization of the fracture which results in a better fixation and less operative time. Although 3D visualization is a useful tool in the surgeon's hands it is more time consuming, expensive and the accuracy of the medical print is highly influenced by the scan parameters.

7. Dr. Preslav Penev *Ankle stability after total talus replacement*

The talus is linking the lower leg to the foot. Clinical problem is that fracture often leads to osteonecrosis and there's no good answer to this problem. The only treatment includes removal of the talus and filling the gap. Total talar replacement with 3D printed part is discussed with a focus to answer the question: when is it necessary to have ligaments stabilization?

8. Prof. Hristo Skulev (Institute of Metal Science) *Coatings for better osseointegration, virus and bacterial protection*

Various coatings and surface treatments for titanium and titanium alloy substrates are discussed. Surface modification is conducted on titanium implants with electrochemical and plasma coating techniques with a focus on achieving better biocompatibility. Alternating layer coatings ("sandwich coatings") are demonstrated with SEM surface topography pictures.

9. Prof. Rositza Dimitrova (Institute of Metal Science) *Fractography of some orthopaedic plates*

A fractographic analysis is conducted on orthopaedic plates subjected to fatigue tests. SEM fractographs are reviewed for all of the plates and micro-hardness (HV) is measured. All plates microstructure consists of austenite grains with deformation twins and slip bands. Non-metallic inclusions in the plates contain single globular oxides and silicates with sizes up to 20 μm. All plates were fractured as a consequence of fatigue tests and fatigue striations are found on fracture surfaces on all plates.

10. Boris Yanachkov (Institute of Metal Science) *Options for mechanical and electrochemical testing of metallic and nonmetallic materials*

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Different methods for testing and characterization of materials are discussed with a focus on materials for implant development. Materials corrosion resistance can be tested on a specialized salt fog machine. Analysis can be conducted in a variety of specialized laboratories that all have EU accreditation.

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