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Editorial

Enhancement of Fracture Healing☆

Fracture healing is a perfectly orchestrated process between biomechanics and biology [1,2] resulting in the formation and reorganization of bone tissue [3]. The functions of bone are reconstituted to provide mechanical stability, transfer load and momentum transfer and protect inner organs [4]. However, in some occasions the orchestra instruments become out of tune and healing of the fracture is delayed or even fails. Delayed unions and non-unions occur in only few patients [5,6] but they have rather severe implications. If bone union is delayed, patients remain limited in their function. They often suffer from ongoing pain, being unable to weight-bear or to return to their usual activity levels. Persistent non-unions commonly require additional surgery which not infrequently is associated with further complications and reoccurring surgical interventions. Finally, non-unions have a significant financial impact associated with the direct costs of surgical and non-surgical interventions and indirect costs of productivity loss [7,8].

Consequently, any measure to prevent the delay or even the failure of fracture healing would have immediate benefit for individual patients as well as for health economics. The Orthopaedic Trauma Care Foundation (OTCF) – a global network of surgeons and scientist, dedicated to the advancement of osteosynthesis and trauma care – recognized the urgent need to tackle this problem. In November 2019 the OTCF invited an expert panel to meet in Prague, Czech Republic for a discussion on this hot topic. The expert panel consisted of 24 surgeons, clinical and basic scientists who attended the workshop and contributed to this Injury Supplement on the “Enhancement of fracture healing”. The topics in this supplement include: (1) Clinical outcome of fracture healing and fracture healing models, (2) bone grafts and substitutes, (3) cellular and molecular based therapies, (4) surgical therapies and (5) physical therapies for the enhancement of healing.

The clinical factors to be considered for improving the healing process are based on the basic principles of fracture treatment [9]. Insufficient fracture fixation is an inherent and surprisingly frequent risk factor for healing delays. Thus, surgical fixation of the non-union creates close proximity of the fracture ends, restores anatomical orientation and reduces mechanical strain to promote the healing process. Additionally**,** a large number of patient related risk factors exist, which have been identified to impede the healing process [10]. The resulting implications strongly depend on the anatomical location and thus require careful consideration by the surgeon. While some of these risk factors might be modifiable, there are circumstances that require the surgical fixation to be augmented by enhancing therapies. A frequently applied fracture enhancement methodology is the implantation of bone grafts [11]. This supplement will critically discuss the pros and cons of bone grafts and provide an overview on other available bone substitutes and osteobiologics. The appropriate use of bone substitutes or osteobiologics may enhance healing but it needs to be carefully considered when to use them, what osteobiologics are currently available, and how to best employ them. Furthermore, the development of tissue engineering techniques for the augmentation is a very heavily researched area and this supplement will also present some of the synthetic graft substitutes we can expect to see in the future and how they will aid patients with non-unions.

Molecular and cellular based methodologies to augment the armamentarium of fracture management have long been researched [12,13,14], and are used sporadically in patients. However, there are new promising strategies and refined therapies which may have the potential to resolve this quandary. This supplement will provide updates on the use of clinically available therapies including bone morphogenetic proteins, parathyroid hormone and platelet rich plasma but also on some newer and promising targets like the WNT signaling pathway.

The probably most heavily investigated area of fracture healing enhancement is the variety of physical signals which have been suggested to affect the fracture healing process. Without any doubt the mechanical environment plays a central role for successful fracture healing. The local strain at the fracture site provides the required mechanical signals for the control of molecular and cellular downstream processes which are responsible for revascularization, tissue formation and differentiation. If the required signals are not provided by weight bearing activities of the patient, there are various possibilities to induce mechanical stimulation through vibration, ultrasound or shockwaves. This supplement will review the role of mechanical signals and will appraise the various methods which are clinically available for physical enhancement of fracture healing.

Finally, of outmost importance is the timely detection of success or failure of the healing process and tools to monitor its progression. While traditional imaging methodologies remain the most readily available tools [15], there are other promising technologies under development. These new technologies are mainly imaging based and this supplement will review computed tomography, magnetic resonance imaging, nuclear imaging and ultrasound imaging. But also smart implant technologies will be available in the near future that directly assess the local deformation at the fracture site and will provide direct information on the growth and maturation of newly formed bone tissue.

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