State of the art and future of bone repair

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The fracture of bone results in a local discontinuity of bone stiffness with consequent loss of mechanical function of bone and injured limb. The function of bone is to provide protection and support for soft organs and to allow locomotion as well as other mechanical functions. Fracture healing i.e. the restoration of original integrity of bone, requires restoration of the anatomy and solid, stiff and strong, union of the fracture. Nature is able to provide quite reliably the solid union but in most cases the anatomy as a prerequisite to optimal function is not restored without medical treatment.

The medical treatment of fractures consists of a two step procedure: restoration of the anatomy (reduction) and maintenance (stabilization) of the anatomical position of the fracture fragments while enabling and supporting solid bridging. The early treatment with external splints made of wood, plaster and plastic was sufficient only for inherently stable fractures or where only bending deformity had to be corrected. The problem is that for avoiding twisting and shortening the neighbouring articulations needed be fixed in deflection. The resulting immobilization of the articulations and with it the one of the soft tissues resulted in heavy trophic damage with pain, swelling and patchy bone loss.

The surgical treatment of fractures had initially a unique goal: restoration of anatomy, enabling function of the articulations to avoid the damage mentioned above, the "fracture disease". For this purpose the surgical intervention aimed at precise reduction and complete immobilization of the fracture mostly achieved by application of compression between the fracture surfaces. The trade in for the optimal function and fascinating histological healing was the comparably slow restoration of the strength of bone. The stabilizing implants had to be left in place for up to two years while the treatment with e.g. plaster cast resulted in solid union within two months. Our observations question whether "primary healing" is a healing process or a side effect of removal of necrotic bone.

In the past decades a basic change of the technology has taken place: the degree of immobilization is adapted to still allow immediate function but to enable the repair tissues to detect the presence of the fracture. This is achieved by using a more deformable splinting technology. The amount of dynamic displacement at the fracture site or better relative deformation (strain dL/L) cannot be greater than the elongation at rupture of the repair tissue and needs to be enough great to still allow the detection and mechanobiological stimulation. An intriguing observation of R. Hente, Davos was that not only the amount of strain but as well its repetition rate is critical.

The future challenges: while it is difficult, not to say impossible, to predict the future one can still define the needs of achievement i.e. today's problems. The complications of today's treatment, still infections and refractures and some unexplained slow and painful healing rates will have to be addressed. Avoiding fashionable trends especially those based on "what the bone wants to do" requires a better understanding of the complex processes of bone fracture repair. Here we expect help from molecular biology the required methods of standardized fracture fixation in the mouse are now available.

To allow to proceed with innovative research we need to understand that innovation is rarely if at all the result of research as a service. The leading innovations are rather the result of the unexpected. Thus the crude statement "If you follow the flock, you risk to step in their waste" is a guide to lateral thinking and reconsideration of research management alike. We must be open to the unexpected finding and minimize daily overhead.

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