Spine Biomechanics

Stresses and Strains

Degeneration of the Intervertebral Disc and Facet Joints

The degeneration of the intervertebral disc and the facet joints is one major reason for specific low back pain which can be induced, among other factors, by inappropriate mechanical stresses and overloading. It is still a matter of debate which structure is affected first by degenerative processes and whether a correlation exists between both. This knowledge, however, is crucial for the choice of appropriate treatment strategies. It provides basic know-how to optimize the development of spinal implants and helps to take a decision regarding the indication of fusion or motion-preserving implants.

Mechanobiology for Spinal Fusion

The main goal of our research in this area is to investigate the mechanical regulation of lumbar spinal fusion following spondylodesis. For this purpose, finite element models of lumbar motion segments will be developed, that incorporate the mechanical and biological factors influencing the fusion process.

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Spinal motion and spinal loads lead to stresses and strains of spinal structures. It is known that mechanical stimuli (stress, strain, or liquid streams) as well as electrical streaming potentials affect cell metabolism. Too much or too little stress can cause degeneration or injury and thus again be a trigger of back pain.

It is still not known how these three parameters motion, load, stress and strain interact. The spine biomechanics team of the Julius Wolff Institute explored the interaction of these three worlds, to better understand the mechanical causes for the emergence of back pain and be able to develop together with our clinical partners strategies for the prevention and treatment of spinal diseases.

Chronic low back pain is a significant public health problem in industrialized societies. The intact spine carries the upper body and external loads, allows motion in a physiological range and protects the spinal cord. These different demands necessitate a high degree of complexity with various sources for disorders and pain.

The source of pain may be the muscles, the facet joints, the intervertebral discs, or the ligaments. High loads, prolonged postures, and whole body vibration have been identified as trigger for back pain. Thus, investigating shape and motion of the spine and the loads acting on and in the spine are crucial tasks when studying back pain which is not caused solely by socio-psychological factors.
Spinal Motion

Motion is propagated again and again as an activity for the prevention or treatment of back pain. However, it lacks a database for a basic understanding of spinal movements in everyday life, in order to answer the question about the right dose of exercise. The reliable assessment of these data is difficult and their interpretation complex. Furthermore, functional diagnostics are missing for differentiating subjects with and without low back pain in order to increase the efficiency of preventive intervention programs.

Spinal Loads

We now know that back pain is partly due to an overloading of the spine, particularly due to specific activities in competitive sports or even when lifting heavy loads at work. However, a complete direct measurement of spinal loading is not possible until now. Indirect measurements give information such as the change in height after the change of body position, the intra-abdominal pressure, the intradiscal pressure, electromyographic signals from muscles and the loading of implants to stabilize the spine. Results of in vivo load measurements are available in our database OrthoLoad (www.orthoload.com). Because measuring methods have proven to be extremely difficult, we also use mathematical models. After appropriate validity check this can provide information on forces acting in different spinal regions and adjacent muscles.

Stresses and Strains

Movements, like waist inclination, and loads, such as wearing a shopping bag, cause stresses and strains in tissues. The right dose is of great importance. Excessive stress and strain can damage structures, causing cracks or bring discs to prolapse. Low stresses and strains lead to degradation of bone and soft tissue mass, which results in an increased risk of fractures. To date, we know very little about dose-response relationships. It is certain that the correct dose is very individual and age and sex dependent.

The research in spine biomechanics at the Julius Wolff Institute is engaged in such a dose-response relationship in the field of inter-corporeal fusion, new implant techniques, regenerative processes and the degeneration process.

Functional Diagnostics

The goal is the development and validation of functional diagnostics (indices for the evaluation of back-spine shape and motility as well as the core stability) for differentiating subjects with and without low back pain in order to increase the efficiency of preventive intervention programs.

Workplace Evaluation

The aim is to test our developed diagnostic methods and intervention programs under everyday conditions in the corporate world in various industries.