Biomechanics Based Materials and Applications in Orthopedic Clinic

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Abstract. Biomechanics, as an interdisciplinary science, is a combination of physics and biological systems. This technology has widespread applications in medicine because it can help us understand how living organisms respond to both intrinsic and extrinsic mechanical stimuli. This article is mainly to show how the biomechanics is better used in the clinical aspect of orthopedics, to help us to better understand the relationship between the structure and function of human bones, and to provide new ideas for disease diagnosis, treatment plan selection and rehabilitation engineering. By collecting some literature and analyzing the literature, we find out the difficulties we may face in the present clinical stage. The application of biomechanics in the skeletal system is from the micro cellular level to the macroscopic overall bone structure, which is crucial to understanding bone health, disease and repair mechanism. This article will explore the application of biomechanics in the skeletal system, including bone mechanical properties, fracture repair, joint replacement, and motion biomechanics.

Keywords: Biomechanics; Orthopedics clinical; Bio-material.

1. Introduction

Biomechanics are also widely used in medicine, because biomechanics can be used to study not only tiny cellular molecules, but also complex patterns of human movement. Skeletal system is an important supporting structure of human movement and organ protection, due to the complexity of the human body, prompted the rapid development of biomechanics, cell biomechanics, bone biomechanics, tissue biomechanics, cardiovascular and cerebrovascular biomechanics, and many other branch research, effectively help improve orthopaedic clinical technology. In recent years, with advances in research methods and techniques, biomechanics play a central role in the study of the skeletal system. It can help us to understand the function of normal bones, and can also provide a scientific basis for the diagnosis and treatment of orthopedic diseases. With the development of biomaterials science and the advancement of computational simulation techniques, the increasing application of biomechanics in skeletal systems has brought many new possibilities in clinical medicine. At present, there are still many difficulties to overcome in orthopedic clinical technology. At the same time, not only because of external reasons, but also with the age, many functions of the bones will be weakened. Sometimes, so it is necessary to analyze the advantages of biomechanics in solving this problem. However, the idea of applying biomechanics in orthopedic clinical aspects still has many difficulties to overcome. In practice, due to the complexity of the human organs during movement, so cause the mechanical parameter test is difficult, want to obtain the data needed in the technology is a bit difficult, therefore, in order to ensure the accuracy and reliability of mechanical parameters test, you need to strictly abide by the test method during the mechanical parameters test process and requirements, at the same time to improve the test accuracy and reduce error exploration and research [1, 2].

At present, biomechanics has some applications in orthopedic clinical practice, such as the use of biomechanics to solve lumbar disc degenerative disease (Degenerative dise disease, DDD), which is one of the most common diseases in spinal surgery, is the main cause of low back pain and disability in adults. Surveys show that most people have experienced symptoms of low back pain in their lives, so it is important to solve this problem. Due to DDD changes, it produces low back pain (Low back pain, LBP). Clinically, according to the different conditions, conservative, simple nucleus pulposus extraction, spinal fusion and internal fixation were used to treat DDD. Interbody fusion is the last resort in traditional spinal surgery. The advantages of internal fixation include remodeling physiological lordosis, providing internal stability, and theoretically easier fusion, which is known as the "gold standard". In order to meet these technologies, it is necessary to use biomechanics to analyze human bones and muscles, and have a deeper understanding that can better solve the disease of low back pain. But, despite the fusion of a circular cage, the interbody fusion rate has reached more than 95 percent, and the clinical "excellent" results are only about 30 percent. However, associated complications have been reported in 33%, and pseudarthrosis caused by implant failure accounts for 7% to 10% of patients. In addition, strong fixation and fusion can also lead to the occurrence of intervertebral arthritis and adjacent segment degeneration (Adjacentsegment degeneration, ASD), with the incidence of up to 52.5%. Therefore, a less invasive strategy that provides a safe and effective balance is needed. The selection of more efficient and safe materials and changes to related treatments is warranted [3].

2. Biomechanics in the Orthopaedic Clinic

2.1. Bone Mechanical Properties

The principle of this technique biomechanics plays a crucial role in prosthetic design, integrating the disciplines of mechanics, anatomy and physiology to understand the biomechanical principles of limb movements. For example: conventional biomechanical testing technology in the field of orthopedic basic biomechanics research is very important, mainly using the principle of engineering and testing technology of the mechanical properties and functions of bone and muscle system inspection and evaluation, at the same time like a lot of orthopedic equipment before application to clinical trials through biomechanical testing and evaluation. Using biomechanical knowledge, prosthetic designers are able to create prostheses with superior functionality and motility. In order to achieve this properties, biomechanics of muscle mechanics and joint mechanics use deeper and related knowledge to create a prosthesis with superior functionality and motility. Joint mechanics is an important consideration in prosthetic design. The joint of the prosthesis needs to withstand forces similar to the natural joint, while also allowing natural and smooth movement. Biomechanics use computer models and experimental tests to calculate and measure the forces sustained by prosthetic joints and optimize joint design based on these data. Muscle mechanics is also crucial for prosthetic design. Only by using muscle mechanics can we better analyze the problems of muscles, because muscles are closely combined with bone. In the analysis and design of artificial limbs, the influence on muscles needs to be involved, so it is necessary to have a deeper understanding of muscle mechanics. Prostheses need to be able to compensate for lost muscle function to power movement. Biomechanics study the mechanical properties of muscles, such as strength, contraction speed, and energy expenditure, in order to design prostheses that can use muscle strength effectively [4].

2.2. Mechanical Modeling of Bone

Bone is a highly complex biomaterial, whose mechanical properties vary with location, age, sex and other factors. Biomechanical studies aim to quantify these properties such as elastic modulus, compressive strength, toughness, to assess the healthy state of the bone. For example, bone densitometry is one of the important means to diagnose osteoporosis, and the understanding of stress distribution at specific sites is essential for preventing fractures and to design effective rehabilitation programs. Only with a more complete understanding of this aspect can suitable methods or models be better analyzed according to the mechanical characteristics of bone.

2.3. Applications

2.3.1 Fracture repair

In the process of fracture repair, biomechanical knowledge is extremely important for choosing the appropriate fixation device, judging the healing process, and predicting the risk of complications. Through computational methods such as finite element analysis, the researchers can simulate the force at the fracture site and thus optimize the surgical plan. Moreover, using customized biomechanical models to guide the selection and use of fixation equipment can help to improve the treatment effect [5].

2.3.2 Joint replacement

The development and clinical application of artificial joints is a major achievement of biomechanics in the field of orthopedics. In Both hip and knee replacement surgery, a precise calculation of the pressure distribution in the load-bearing area of the joint is needed to ensure a good match of the implant to the host bone. Biomechanical studies can also help to evaluate the wear resistance of different materials and prolong the service life of artificial joints [5].

3. Biomechanical Materials

Because bones are widely distributed within the human body, the material selection of prosthetic limbs is very important. First, we must choose the materials that are comfortable to the human body and will not cause harm to the human body, such as choosing lighter materials to prevent increasing the physiological burden of the human body. Secondly, consider the strength and durability of the material, and finally, also consider the economy, consider whether the material is easy to obtain, whether people can bear the cost. In short, we should consider many factors to choose the most appropriate material [6].

3.1. Metal

3.1.1 Molybdenum

A rare and precious metal with unique physical and chemical characteristics such as high melting point, large strength, wear resistance and corrosion resistance, and has good biocompatibility and stability. In the field of orthopedics, it can be used as a filling material in all parts of the human body: at the same time, it can also be made into tantalum coating, as the biological basis for the surface modification of artificial prosthesis and other biomaterials. But the cost of this material is too big to bear such a high cost. If improvements are needed, combine molybdenum with other metals, and choose cheaper metal materials for chemical reactions with the greatest possible guarantee of maintaining the original properties. Create or directly use composite materials. For example, the selection of medical composite materials, composite / inorganic material between metal and polymer materials, polylactic acid / hydroxyapatite (PDLLA / HA) composite materials, not only has good biocompatibility and a certain mechanical strength, but also overcome the weakness of similar materials under ordinary X-ray development. In the past two years, 19 cases of "taking lactic acid / hydroxyapatite absorpbable cancellous bone fractures" in PLA 203 Hospital had ideal clinical efficacy: all cases were fixed to healing without displacement, no wound infection, and the limb function recovered well.

3.1.2 Magnesium

The density and elastic modulus of absorbable magnesium alloy are close to that of human bones, which can effectively alleviate and even avoid the "stress shielding effect". At the same time, magnesium has good biocompatibility and degradability, which can avoid the problem of secondary surgical removal. In addition, magnesium produced by magnesium degradation from biodegradable magnesium ions and slightly alkaline environment can promote bone tissue healing. But magnesium is slightly less durable and may be significantly stronger with the number of use. At the same time, magnesium metal is more prone to corrosion and oxidation, which may affect the appearance. If it is to be improved, you can add paint to help no metal reduce contact with water or air and slow down the oxidation and corrosion of magnesium. For example, some prosthetic limbs are very beautiful, and some patterns will be drawn on the outside, which can prevent the metal from direct contact with the air or water, increasing the beauty while also slowing down the corrosion and oxidation of the metal.

3.2. Degradable Polymer

Natural polymers, such as collagen, fibrin, etc., this material has good biocompatibility. In addition to meeting the general requirements of biological materials, such as non-toxic, non-teratogenicity, etc., it should also be conducive to seed cell adhesion, proliferation, degradation products are non-toxic to cells, do not cause inflammatory reaction, and even conducive to cell growth and differentiation. It also has good biodegradability. The matrix material can be degraded after completing the scaffold action, and the degradation rate should be adapted to the growth rate of tissue cells, and the degradation time should be artificially regulated according to the tissue growth characteristics. This material also has good plasticity and can be pre-made into a certain shape. And has a certain mechanical strength to provide support for the new tissue, and maintain a certain time until the new tissue has its own biomechanical properties. However, there are many disadvantages, such as the limitation of mass production, the difference of different batch products, the difficulty of controlling the material itself (such as mechanical strength, degradation speed, etc.). Artificial polymers, such as polylactic acid and polyglycolic acid, can avoid the above difficulties. The microstructure and general morphology of the materials can be designed and regulated in advance, and finally degraded completely, and the long-term problem of foreign body reaction can be avoided [7].

We have now selected some materials in the orthopedic clinical aspect. For example, Bone screw, generally used for bone fixation, consists of four parts: head, rod, thread, and tail. Also, from a mechanical point of view, you can change the torsional force into axial pressure, or fix the steel plate and bone. The screw of this material has a strong holding force for the bones, but sometimes it is difficult to control the direction. Because of its many advantageous features, it is a very common orthopedic internal fixator. In addition, cerclage materials are also widely used in orthopedic clinical practice. Most of these materials are used in cerclage and semi-cerclage, and they are also combined with other fixation materials to supplement the support and bending support during fracture. This material can increase the stability of long oblique fractures, spiral fractures, and comminuted fractures. The material is short in length and can be well fixed in the diameter of the bone marrow cavity[8].

4. Conclusion

In orthopedic surgery, the replacement prosthesis is used to replace the degenerate joints, greatly improving the problems that could not be solved clinically in the past, and the success rate of surgery has reached quite satisfactory results. In addition, the application of new orthopedic materials and new internal and external fixation devices is inseparable from the biomechanical theory. Biomechanical analysis. Biomechanical analysis provides quantitative standards for clinical application and research, and the biomechanical testing technology provides very valuable information for clinical treatment. If the biomechanics is applied to the selection of orthopedic clinical materials will have a huge impact for the control of living bone reconstruction performance of stress, mechanical determination, mathematical modeling, quantitative analysis of three-dimensional finite element model and orthopedic new materials, new internal and external fixed equipment research and application and new innovation open a new idea. More effective guidance of orthopedic clinical practice is helpful for orthopedic surgeons to better understand and treat the injuries and conditions of the muscle-skeletal system, and to make the diagnosis and treatment more scientific. At the same time, it also lays a solid theoretical foundation for the frontier integration of traditional Chinese medicine and world medicine, and to promote and open a new development platform for the treatment of various injuries and bone diseases and biomechanics. For the characteristics of TCM bone therapy for the treatment of orthopedics injury and bone disease mechanical environment scale of mathematical modeling, mechanical determination and quantitative analysis to provide the basis, combined with clinical innovation makes the science of TCM new development, for the modernization of traditional Chinese medicine, global development lay a good foundation, better service for medical clinical and research. There is also much room for this idea, because the application of biomechanics in the skeletal system is a dynamic area of research, which not only drives advances in orthopedic medicine, but also provides strong support for bone health management and disease prevention. With the continuous emergence of new technologies, the future of biomechanical research in the skeletal system will continue to deepen, bringing more benefits to human beings. At the same time, with the enhancement of computing power and the application of new imaging technologies, biomechanical research is moving towards higher precision and deeper level. In the future, combining artificial intelligence and big data analysis, biomechanics is expected to play a greater role in personalized medicine and precision therapy [9,10].

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