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Editorial

Multi-Scale Characterization Advances: Interface Techniques for Bone and Biomaterials

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EDITORIAL

The necessity for biomedical devices to aid the functional healing of tissues has resulted in continued improvements in biomaterials production and characterization. Bone tissue is one such tissue for which biomaterials technologies are continuously being pursued. Bone, on the other hand, is a hierarchical material with a heterogeneous structure and chemistry throughout a wide range of length scales. Because of this complexity, the development and understanding of osseointegration, or the attachment of bone to implant materials, has remained a difficulty. Before learning how biomaterials interact with bone tissue, it's vital to understand the fundamentals of bone's structural and chemical organisation. Collagen, a ubiquitous protein found in many tissues, and bone mineral, specifically calcium phosphate in the form of Hydroxyapatite (HA), Carbonated-HA (cHA), or Amorphous Calcium Phosphate (ACP), are the two primary components of bone.

Bone is composed of approximately 65 percent mineral and 35 percent collagen by weight. The ideal materials properties demonstrated by bone, notably its intrinsic strength and toughness, are due to this composite structure. The mineralized collagen fibrils are made up of the collagen and hydroxyapatite core components. This hierarchical structure also gives bone more resilience, making the skeleton less prone to skeletal fractures in the event of minor impacts. Bone has various biological purposes in addition to mechanical integrity, such as storing bone marrow, which contains the adaptive immune response and regulates blood cell generation. In the 1950s, Brnemark was the first to create the word osseointegration to describe the functional relationship between bone and implant devices. Biomaterials have been studied for their ability to osseointegrate with bone since then. The ability of bone-forming cells, osteoblasts, to release mineral towards and on foreign objects, integrating them into the local bone to generate an attachment to the implant surface that supports mechanical loading, rather than surgical techniques, governs this connection.

Furthermore, titanium's appropriate mechanical qualities offer the essential strength for the skeleton to preserve its structural integrity. Of course, in addition to titanium implants, a variety of different natural and synthetic bone implant materials are frequently employed, including bone grafts: either autografts, or bone material from the host, or allografts from a donor. These grafts, as well as other natural biomaterials including proteins and polymer matrices, can be applied directly at wound sites or around titanium bone implants in the hopes of promoting bone growth and reducing device failure. Despite the fact that titanium has the potential to be a good bone integrating biomaterial, despite the potential of titanium as a bone-integrating biomaterial, problems occur due to the higher elastic modulus of titanium compared to bone. Because titanium is significantly stiffer than bone, it can overcompensate for surrounding bone tissue, causing host tissue resorption; a process known as stress-shielding, which is discussed extensively elsewhere.

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