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Editorial

Experience and Development. Towards Smarter Biomaterials

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Man has worked long to control the surroundings and discovered various materials that can help living and life. Surgeons have used materials (biomaterials) to reconstructive, repair and regenerate tissues.

Biomaterials were first used to replace tissues, e.g. hip prosthesis and "inertness" was greatly valued to avoid inflammation, osteolysis and implant failure [1]. Much work with biomaterials appeared later for reconstructive surgery. Bioactive glass was experimented on in animals and was found to bind to bone without interfering fibrous tissue formation and the term "bonding" was used for the first time. Thus, new concept has started by Larry Hench of Florida in 1960s [2]. Later, biodegradable polymers attracted attention to develop sutures replacing natural materials, and even strong osteosynthesis devices successfully marketed in 1990s. In our research, we have worked on developing bioresorbable implants for bone regeneration [3,4] and osteosynthesis in orthopedics [5], hand [6,7], and cranio-maxillofacial [8] surgery. However, because of accompanying inflammation, osteolysis and fibrous tissue encapsulation that may lead to complications, several strategies were developed to prevent or modify such adverse tissue reactions. These include surface modification, e.g. with anti-biofouling polymer [9], or the use tissue reaction-modifying agents released from implants [10-12]. We have investigated various polymers and agents including anti-inflammatory drugs such as diclofenac sodium (DS) [10], dexamethasone (DX) [11], antiosteolytic such as the bisphosphonate (BS) [12], and antibiotics [13]. These implants are characterised by having early drug release peak and slower prolonged release at later stages. To advance this further, we developed "multicomponent" implant [14] that includes parts processed by using various techniques and have different release patterns. We have also developed an implant having several drugs, i.e. "multidrug" implant [15] that has DS, DX and BS as a model. Naturally, tissue reactions involve a multitude of events, soluble factors and reactions. Thus, there is often a need to use various active agents released from implant in orchestrated manner at various stages. We have employed possibilities offered by nanotechnology and used electrospinning to study various polymers and develop multifunctional biomimetic drug releasing nanofibres [16] that we have also combined them with macro-implants to achieve planned surface patterning and controlled cell attachment. We succeeded in achieving aligned organised attachment of chondrocytes [17]. Aligned fibres have effect on cell communication by paracrine and gap junctional means [18].

Further and more precise control of drug release from smart biomaterials remained an objective when such materials react to need in autonomous or remotely controlled way. Such bioresponsive materials [19] can act in response to chemical stimuli such as pH, NO, enzymes, glucose, etc. or physical such as magnetic field, electricity, ultrasound, temperature, light, etc., or combination of these triggers. Thus, these smart materials offer the possibility to be remotely controlled [20]. One can develop a system based on polymer responsive to pH and to glucose [21].

Implants may contain and release cells such as stem cells, erythrocytes, immune cells, bacteria or viruses may for targeted drug delivery [22]. Salmonella typhimurium (selectively targets tumours) was studied for treating prostate tumour in mice using weekly injections [23]. They can also be programmed to recognize they're in a tumour and release anti-cancer drugs which is too toxic as an injection [24]. As research and development continue, we are going to see more advanced devices in future with more precise control of their function, e.g. with on/off switchable system [25]. We will see more … better tools for the benefit of the craft and patient.

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