EDITORIAL

Recent Advances in Processing of Biological Tissues

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The advancement of surgical technology has greatly improved the capability of clinical treatments in recent decades. Advanced surgical technologies, such as minimally invasive, implantation interventional, and robot-assisted surgeries, have been emerging, and bring enormous benefits to patients. While these technologies have been widely employed in clinical applications, the fundamentals of the clinical surgeries can also be interpreted in an engineering term as the processing and manipulation of biological tissues and has been merging with biomechanics, materials science and manufacturing science, although surgical technology may stand and often treated as an individual discipline.

The objective of this special issue is to bring the state-of-the-art development in the processing of biological tissues and foster integration of biomechanics, materials science and manufacturing science to promote the advancement of surgical technology.

This special issue focuses on cutting theory, methods, tools, navigation, and facilities for processing biological tissues. Three reviews and ten research papers, which represent the latest research outcomes in this active area, have been selected in this special issue after rigorous review.

The reviews describes in detail the progress of soft biological tissue manipulating technologies, surface structure design of medical devices, and fabrication and application of multiscale needles. The review on "Recent advances in soft biological tissue manipulating technologies" written by Liu et al. provides a systematic overview of the different soft tissue manipulation techniques

currently used, including mechanical, laser, waterjet and ultrasonic cutting, as well as the advanced anastomosis and reconstruction processes, with highlighting their governing removal mechanisms and the surface/subsurface damages. The review on "Bioinspired functional surface for medical devices" written by Zhang et al. presents the current progress of natural functional surfaces for medical devices, including ultra-slipperiness and strong wet attachment. Their underlying mechanisms are ascribed to the coupling effect of surface materials and featured micro-nano structures. Various medical device surfaces have been validated to perform better contact property. The review on "A review of Nano/Micro/Milli Needles Fabrications for Biomedical Engineering" written by Liu et al. provides an overview of multiscale needle fabrication techniques and their biomedical applications. The needles are classified as nanoneedles, microneedles or millineedles based on the needle diameter. Nanoneedles bridge the inside and outside of cells, achieving intracellular electrical recording, biochemical sensing, and drug delivery. Microneedles penetrate the stratum corneum layer to detect biomarkers/bioelectricity in interstitial fluid and deliver drugs through the skin into the human circulatory system. Millineedles, including puncture, syringe, acupuncture and suture needles, are presented. The future perspectives for nextgeneration multiscale needles are also discussed.

The processing of biological tissue can be divided into hard biological tissue processing and soft biological tissue processing. Bone tissue is a typical hard biological material that is difficult to machine. In this special tissue, Luo et al. propose the analytical models for four typical bone cutting conditions to optimize cutting parameters to suppress vibration and avoid undesired fracture in precise cutting processes in surgeries. In particular, the impact of

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the depth of cut and the cutting direction relative of bone osteon orientation on chip formation and fracture toughness are investigated. A method for prediction of implant torque is proposed by Li et al. The mechanical model for the insertion torque is established based on bone quality, implant geometry and surgical methods which are considered by defined bone-quality coefficients, chip load and insertion speeds, respectively.

Exploring new low-injury, high-efficiency processing methods, online monitoring methods, and surgical navigation methods are important research directions for bone tissue processing. In this special issue, Robles-Linares et al. investigate the effects of laser type on the necrotic damage and surface integrity in fresh bovine cortical bone after ex-situ laser machining. Ying et al. propose a machine learning-based method to monitor the cutting state and force in the milling process to reduce the surgical risk using sound signals. A dental implant robot system guided by optical navigation is developed by Yan et al., with an x-shaped tool and an irregular pentagonal tracer are designed for spatial registration and needle tip positioning strategy respectively. Based on 6-UCU (universal cylindrical universal) configuration, Dong et al. propose a bone-attached parallel manipulator (PM) that is characterized by small volume, compact structure, high precision and six-dimensional force feedback.

Mechanical-based models such as the finite element method are widely used to compute the deformations of soft tissue. In this special issue, Jiang et al. propose a viscoelastic constitutive equation suitable for muscle tissue and a method to define the fracture characteristics of muscle tissue material in the simulation process. Lv et al. establish an accurate 3D dynamic puncture model with finite element method. For better real-time deformation feedback, Lei et al. apply a Kriging-based method to model the soft tissue deformation to strike a balance between the accuracy and efficiency of deformation feedback. Wang et al. propose ultrasonic assisted cutting required less force compared to conventional cutting. With the reduction of surface roughness and force, it is possible to state that ultrasonic cutting reduces wear of the blade, which made an increase of blade life.

It is hoped that the publication of this issue can attract more effort for interdisciplinary research to advance surgical technologies and promote the development in medical devices to improve the clinical treatment and rehabilitation practice for the benefit of humankind. Manufacturing engineering makes life better.

Author contributions
All authors read and approved the final manuscript.

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Competing interests
The authors declare no competing fnancial interests.

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