EDITORIAL

Teaming Up; a Critical "Must Do" for Clinically Bone Tissue Engineering

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Despite the numerous specializations and subspecialties in medicine, many medical conditions require innovative treatment approaches. One such approach involves repairing and regenerating damaged tissues, which has elicited promising solutions in recent times. Regenerative medicine has opened up a wide range of possibilities for the field of medical sciences. Tissue engineering, which involves imitating the body's physiological processes step-by-step, represents a new solution to age-old problems. However, this process of point-by-point copying requires a broad multidisciplinary knowledgebase, with contributions from chemists, physicists, mathematicians, statisticians, biologists, surgeons, and engineers working together to address therapeutic problems. [1]

Tissue engineering is the converging hub for various sciences and technologies that aid in understanding, interpreting, imitating, and simulating the mechanisms and behaviors of bodily tissues. This collaborative effort exhibits a common nested connection between team members [Figure 1].

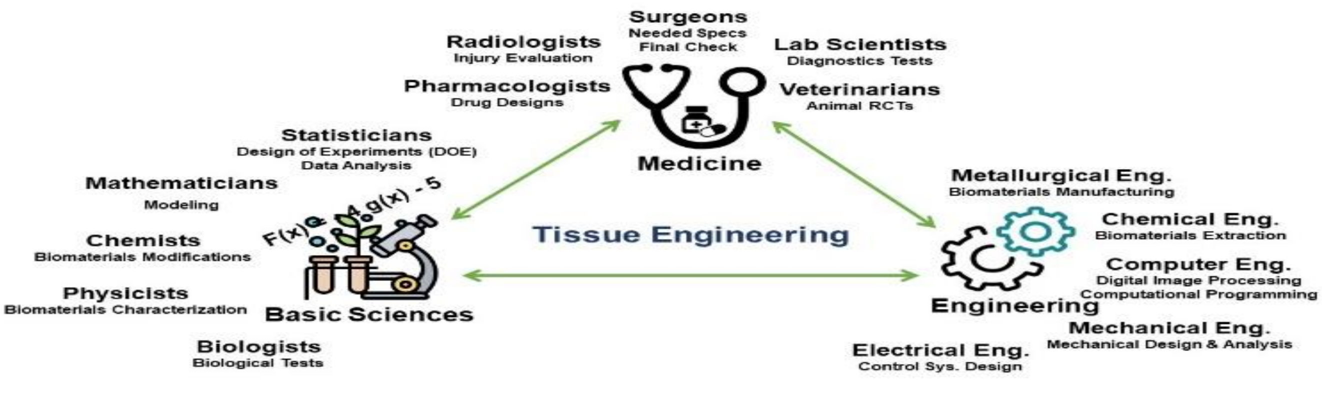

Figure 1. Schematic of a tissue engineering team

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Study Steps

In a case study, it may be necessary to involve all or some of the experts, depending on the scope of the problem. For example, orthopedists often encounter various bone-related issues in their patients. In addition to physical examinations, paraclinical modalities such as laboratory tests and imaging procedures may also be required to determine the extent of injury and identify possible treatment options. The orthopedic surgeon can define the key specifications for the optimal graft, particularly if auto- or allografts are insufficient to address the defect. In such cases, a precisely tailored construct may be the best option. Scaffold constructs with or without cells may be implanted in the bone void, and the physician will need to coordinate with a tissue engineering team to ensure that the implant meets all requirements. Effective multispectral coordination requires clear communication using a common language to design, fabricate, characterize, test, and finalize the optimal construct.

Based on the preliminary design by a mechanical engineer, may be through finite element analysis, the biomaterial scientists including chemists and polymer, metallurgy, and chemical engineers may come into a consensus and design and fabricate the initial structure. While commercial substrates may be sourced initially, they may require modifications or may need to be extracted or synthesized to meet specific requirements.[2] the complex fabrication processes are carried out in specialized tissue engineering laboratories, where device-assisted digital images may be processed to tailor the dimensions of the construct.

Design of Experiments (DOE)

Given the numerous variables involved in the design and fabrication process, it is essential to involve an expert statistician in designing experiments. Using predefined effective factors, mathematical modeling can provide a better understanding of the process. This model, which comprises a set of equations, establishes the relationships between the various process variables and facilitates the optimization procedure. However, tissue modeling may require several powerful computational programs that can handle a massive number of complex mathematical equations simultaneously. While finite element analysis (FEA) is typically used to solve partial differential equations, computational fluid dynamics (CFD) represents a more suitable approach for solving fluid-flow problems.

Engineers are primarily responsible for optimizing construct manufacturing parameters and surface modification methods. They use tools like FEA and CFD to determine the optimal parameters for these processes.

Analysis for Construct Characterization

After fabrication, the product must undergo in vitro/vivo qualifications to ensure its safety and efficacy. The physicochemical properties of the construct are evaluated through a series of standard characterization methods, including FTIR, TGA, DSC, DMA, and others. Biologists evaluate biocompatibility issues such as toxicity, degradation rate, antibacterial property, differentiation, and more. The fabricated niche will guide host cells through signaling pathways to regenerate the targeted tissue with similar functionalities.

The final product requires animal intervention studies. Veterinary scientists, along with methodologists, design in vivo experiments and randomized clinical trials (RCTs) involving animals to investigate the interactions between the living body and the construct. Human RCTs ultimately determine whether the engineered construct is suitable for clinical application. Expert teams comprising clinicians and methodologists conduct RCTs, during which orthopedic surgeons perform clinical evaluations of the product and provide feedback for intended corrections via a control back loop. As a final step, feasibility and cost-benefit analyses are performed, and feedback is obtained to help redesign and further refine the application of the engineered construct.

In conclusion, teaming up is essential for the success of any tissue regeneration process. All team members must be in a dynamic connection to guide the procedure toward an optimal product. Such contributions require multipotential leadership, with tissue engineers serving as team leaders who can translate the necessary specifications and feasibility possibilities through a common language that basic scientists and clinicians can understand.

References

1. Napolitano M, Matera S, Bossio M, et al. Autologous platelet gel for tissue regeneration in degenerative disorders of the knee. Blood Transfus.2012; 10(1):72. doi: 10.2450/2011.0026-11.
2. Ikada Y. Challenges in tissue engineering. J R Soc Interface. 2006;3(10):589-601. doi:10.1098/rsif.2006.0124.