Communicating realistic expectations, embracing biological complexity, and fostering integrated approaches to advance clinical relevance of Tissue Engineering

Emanuele Domenico Giordano – *University of Bologna*

Tissue Engineering has made remarkable progress over the past decade, enabling the development of increasingly sophisticated biological constructs through advances in stem cell biology, biomaterials, bioprinting, and microenvironmental control. Despite these achievements, the translation of experimental successes into routine clinical therapies remains limited. This presentation argues that the primary obstacle is not technological immaturity but the intrinsic complexity of biological systems. Rather than viewing tissue engineering as a collection of individual technologies, it should be understood as an integrated, dynamic system in which cells, scaffolds, biochemical and mechanical cues, and the evolving microenvironment interact through continuous feedback. Consequently, engineered tissues are not simply built but emerge from carefully designed initial conditions. Current clinical successes, such as skin, cartilage, and bone substitutes, are largely confined to relatively simple tissues with limited systemic integration, whereas highly complex organs, including the heart and liver, continue to present significant translational challenges. Bridging the gap between laboratory models and clinical application requires greater emphasis on reproducibility, scalability, predictive experimental design, and interdisciplinary collaboration. Emerging computational approaches, including artificial intelligence and digital twins, offer promising tools to guide experimentation and improve predictive power. Ultimately, the future of Tissue Engineering depends on embracing biological complexity, communicating realistic expectations, and fostering integrated approaches that enhance clinical relevance.