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An engineer's take on the bone-ligament interface: Utilizing novel technology to improve clinical outcomes

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Ligament repair is a common surgical practice with a significant lack of viable replacements. The current gold standard for repair is the use of tendon grafts from cadavers or from another place in the patient's body; however, these often cause more problems than they solve including immune responses or a lack of mobility in another place in the body. Synthetic replacements are of growing interest, though the ability to mimic the complex structure of the ligament and how it connects to the bone remains an obstacle. Our lab built a 3D bioprinter combined with an electrospinner to address this complicated issue. A 3D bioprinter is similar to the inkjet printers found in every office, except that the 'ink' is a material that is biocompatible and can be deposited layer-by-layer to form a 3-dimensional structure. Near-field electrospinning is a less well-known technique that uses an electrical field to pull fibers out of a solution and deposit them in a specified pattern. By combining these two techniques we aimed to create a scaffold that approaches the high compressive strength of bone and the high elasticity of ligament across a graded interface. We 3D bioprinted a hydrogel with bone incorporated as a support scaffold for cell growth, and near-field electrospun parallel polymer fibers that mimicked ligament's native architecture. These materials formed a composite scaffold with ligament-like tensile strength and increased compressive strength over traditional hydrogels to begin approximating the stiffer phase of the bone-ligament interface. When tested with a cell line, the materials were not toxic and began to show characteristic markers of bone and ligament cells. This work offers a new approach to a complex problem with the aim of improving clinical options and outcomes for patients suffering from torn or ruptured ligaments.