

Engineering functional Chordae Tendineae: a mandrel-less biofabrication approach for heart valve repair

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Currently, the use of expanded polytetrafluoroethylene (ePTFE) sutures is the standard approach in Chordae Tendineae (CT) repair/replacement. However, complications such as rupture, calcification, fibrosis, and slippage remain significant challenges. Hence, there is an urgent need for valve repair strategies that are simple, effective, and durable. CT are more not merely collagenous structures, but living tissue that supports and feeds the valvular apparatus.

In this study we introduce BioChord, the first tissue-engineered approach to substitute CT designed to mimic the native hierarchical structure and mechanics. We assessed BioChord's regenerative potential in vitro, focusing on how ultrastructural cues and mechanical conditioning influence cell growth and stress/strain signaling mechanisms.

Human CT (HCT) were harvested and characterized via scanning electron microscopy (SEM), histological analysis, and uniaxial tensile tests (UTT). BioChords were fabricated via mandrel-less electrodeposition method (PCT/US2018/022863), producing axially symmetric scaffolds from biodegradable/non-degradable polymers with tendon-like macro and microarchitecture. A comparative analysis between BioChords and HCT was performed.

SEM confirmed control over microfiber diameter and alignment: with comparable orientation index between HCT: 0.73 ± 0.07 and BioChords: 0.82 ± 0.11 . UTT showed similar initial modulus values BioChords: 88.15 ± 12.21 MPa; HCT: 91.05 ± 6.28 MPa. Cellular integration within BioChords was assessed in vitro in static and dynamic conditions. Cell infiltration and proliferation were assessed via histological analysis, confirming successful fibroblasts integration post-conditioning.

These results demonstrate BioChord offers biomimetic topological cues for enhanced cell infiltration, promoting host cell recruitment and de-novo tissue formation while providing mechanical support, making it a promising alternative for valve repair.