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Biomimetic Patch for Vascular Repair and Patency Diagnosis

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INTRODUCTION & AIM

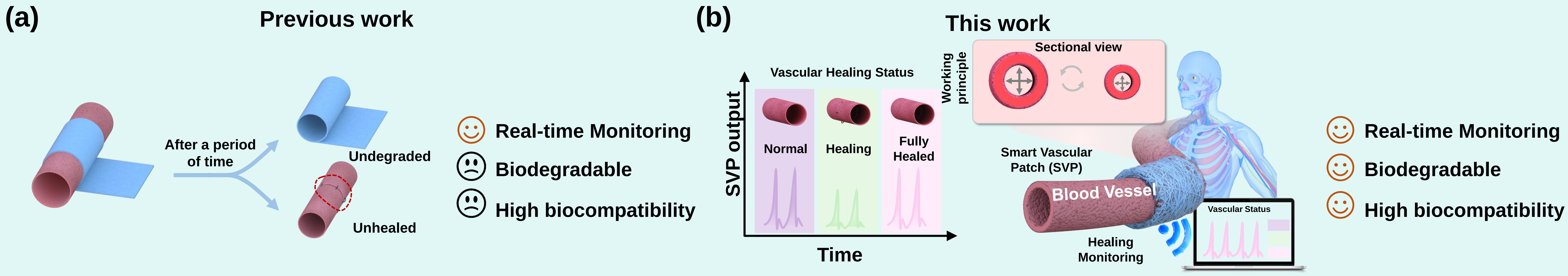

Fig. 1 (a) Previous Work Introduction, (b) This work Introduction.

As the crucial final step in cardiovascular surgery, vascular suturing often comes with risks such as vascular stenosis and occlusion, which pose threats to the patient's health. Currently, drug therapy and instrument-assisted diagnosis are used to prevent complications. However, the best solution for real-time monitoring and suppression of these situations has not yet been found.

METHODS

In view of the mechanical deformation caused by vascular dilation and contraction, this study prepared a biomimetic collagen substrate through electrospinning and the photopolymerization of gelatin methacrylate (GelMA). Tartaric acid (TA) and MXene modification respectively endowed it with the biological functions of promoting cell growth and anti-inflammatory as well as excellent sensing performance, aiming to promote vascular repair while monitoring vascular health signals.

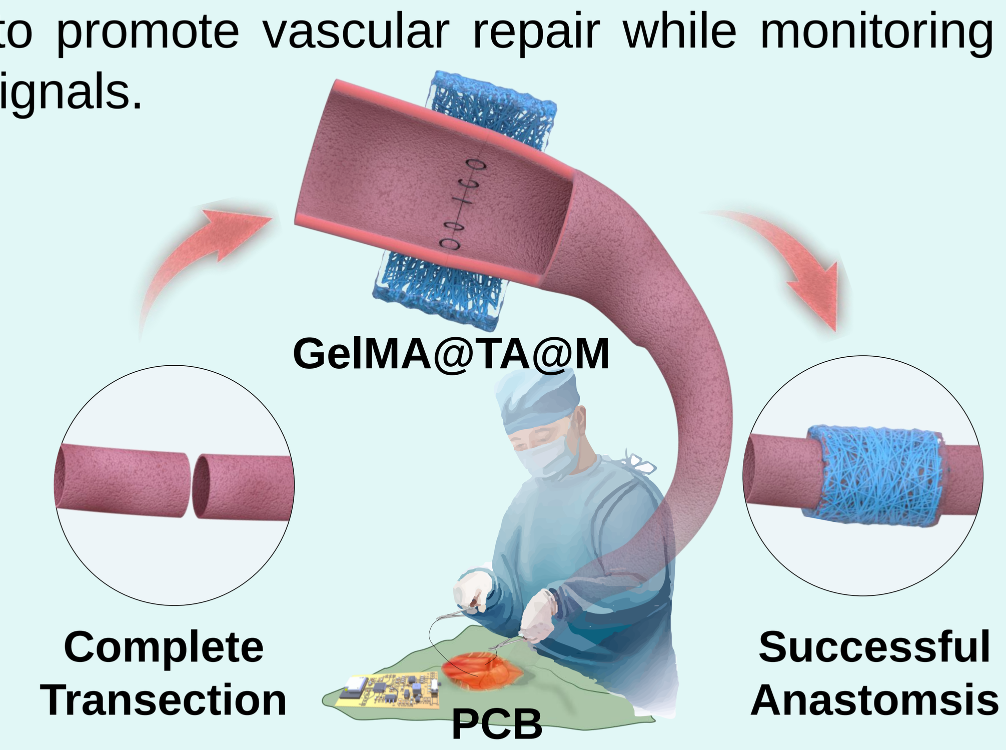

Fig. 2 Biomimetic Patch for Vascular Repair and Patency Diagnosis

RESULTS & DISCUSSION

Adhesion-Anti-Inflammation Dual-Functional GelMA Hydrogel Nanofibers

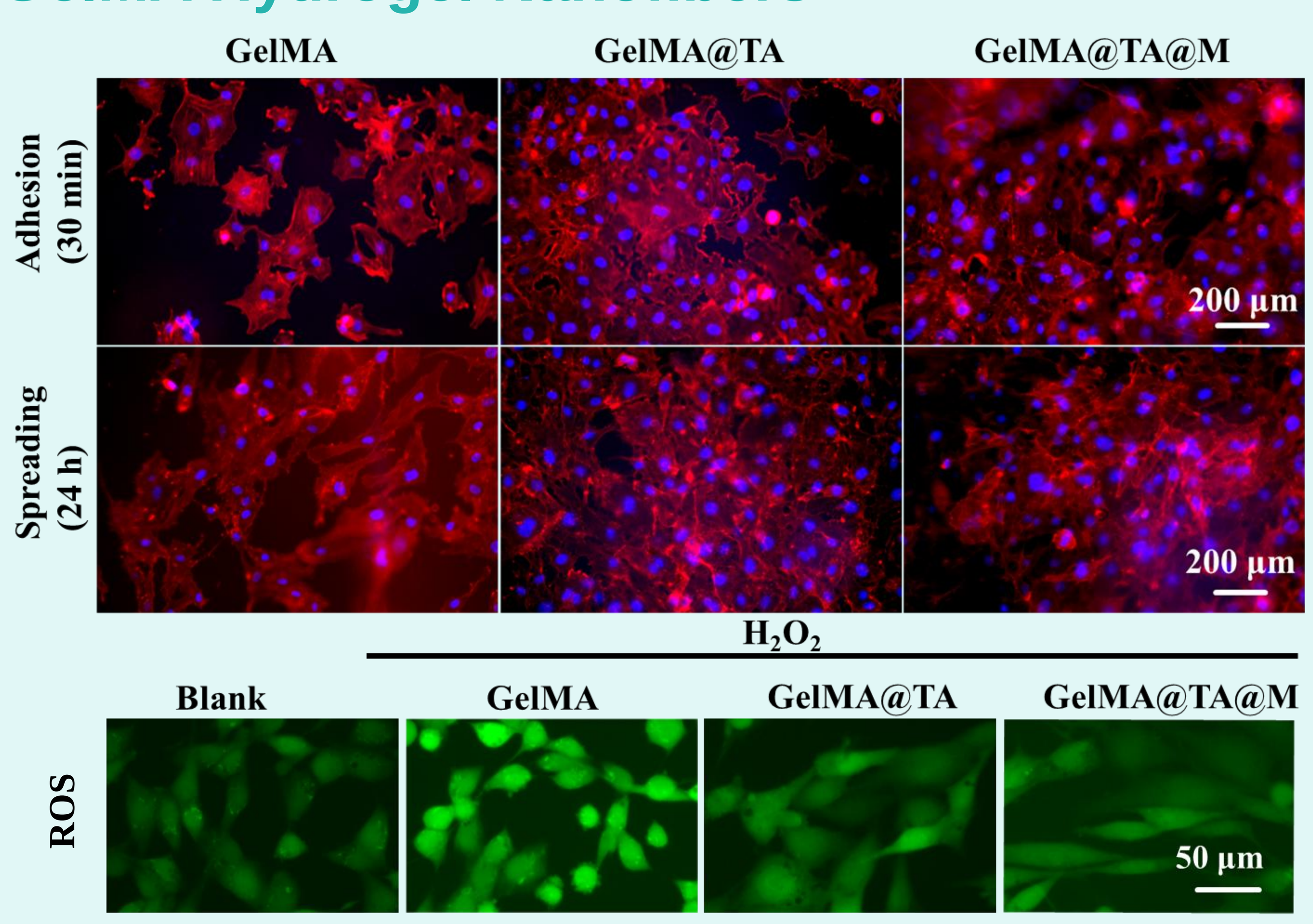

Fig. 3 GelMA hydrogel nanofibers promote cell adhesion, spreading, and antioxidation. TA and MXene dual-modified GelMA@TA@M hydrogel nanofibers enhance cell adhesion and spreading. The composite scaffold reduces intracellular ROS under oxidative stress, with favorable cytocompatibility and antioxidant performance.

Hydrogel Nanofiber-Enabled Vascular Monitoring

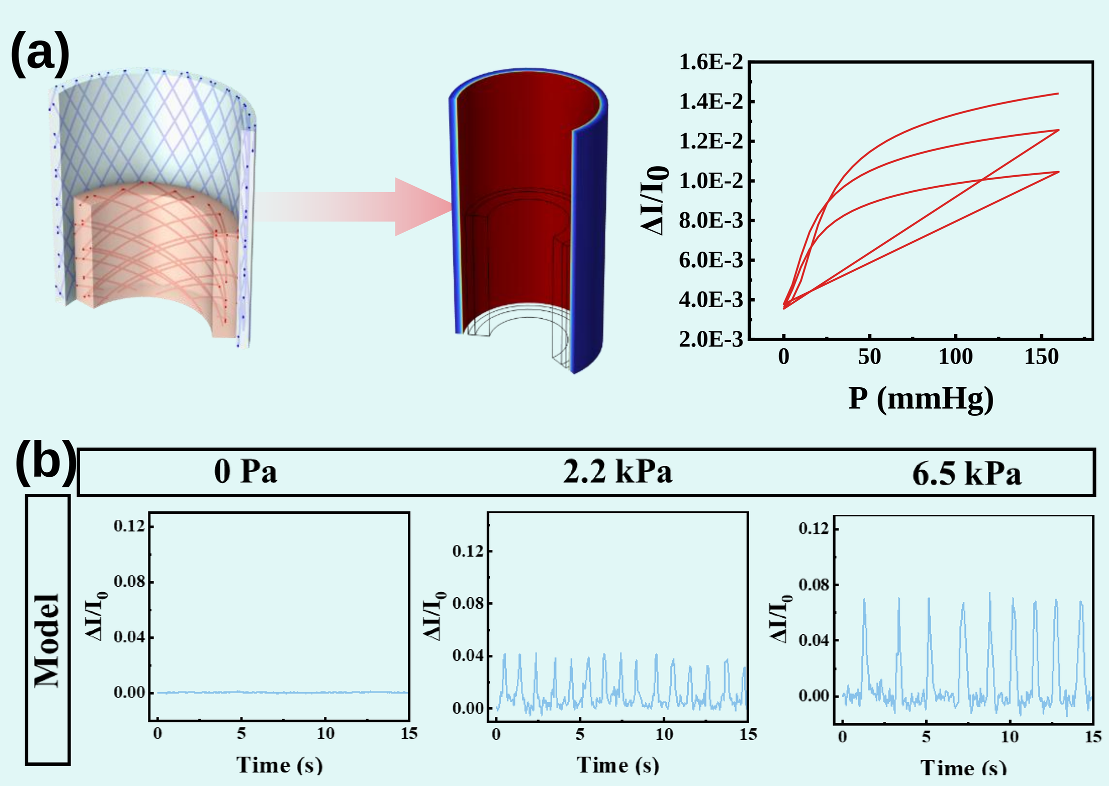

Fig. 4 (a) COMSOL simulation verification, (b) in vitro sensing simulation. The constructed vascular-sensor coupling model validates the applicability of hydrogel nanofiber sensors in vascular pressure detection. The sensor produces stable electrical responses across 0–150 mmHg and records periodic pulse signals at 2.2–6.5 kPa, with signal amplitude rising along with pressure. This work provides theoretical support for vascular health monitoring.

Wireless monitoring

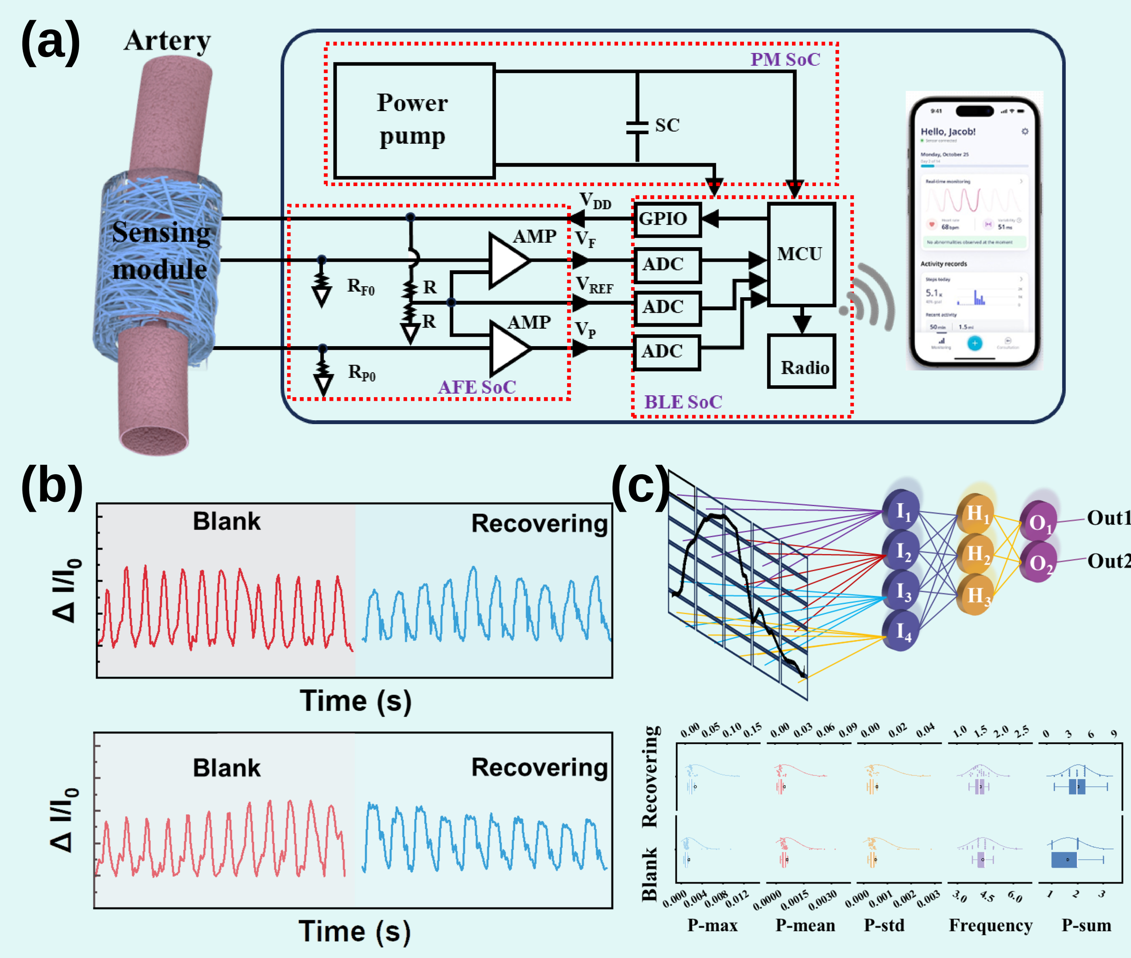

Fig. 5 (a) Vascular Wireless Monitoring Design System (b) Vascular signal monitoring at day 3 (top) and day 5 (bottom), (c) Machine learning-based feature extraction of the signals. We developed a hydrogel nanofiber-based vascular monitoring system integrating signal sensing, processing, and wireless transmission, with machine learning-assisted feature analysis for real-time, intelligent vascular health monitoring.

Promote vascular repair

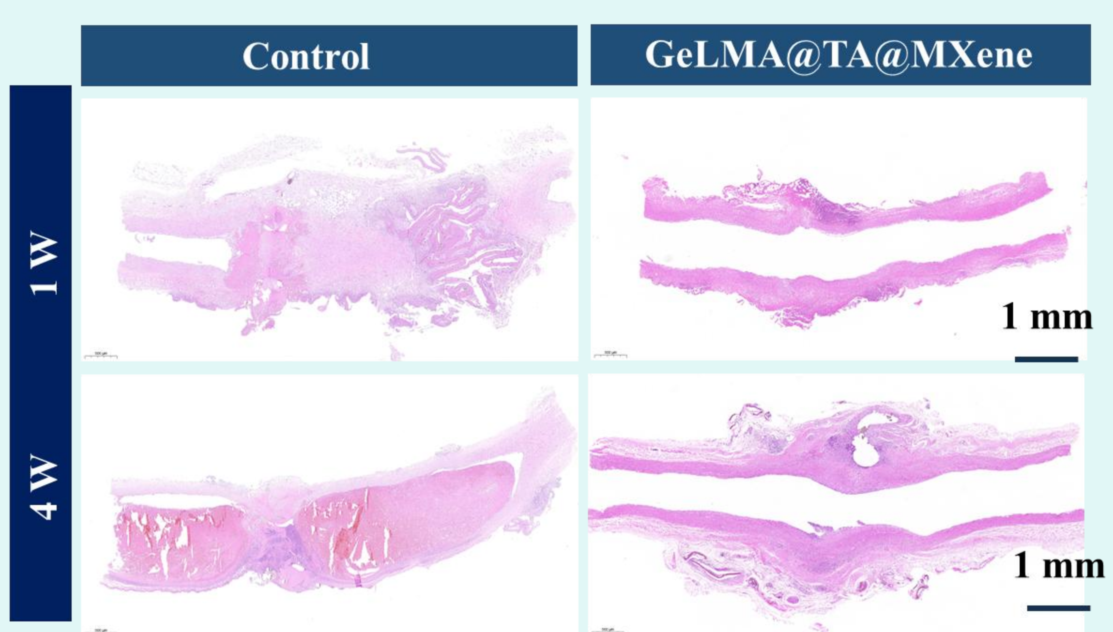

Fig. 6 Hydrogel Nanofibers Preserve Vascular Patency and Promote Tissue Repair. Histological analysis reveals unobstructed implants at 1 W enhanced tissue regeneration at 4 W, and superior tissue compatibility and repair performance.

CONCLUSIONS

In conclusion, this study successfully proves the potential of the biomimetic piezoresistive nanofiber system for integrated diagnosis and treatment through *in vitro* simulation and *in vivo* experiments, providing a promising example for vascular repair management.