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Implantable Wireless Neuroprosthesis for Bladder Control After Spinal Cord Injury: A Brain-Bladder Closed-Loop Interface

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Abstract

Neurogenic bladder dysfunction after spinal cord injury (SCI) severely impacts quality of life. We developed an implantable, wireless neuroprosthesis establishing a closed-loop interface between cortical bladder sensation areas and sacral root stimulators. Using electrocorticography (ECoG) decoding of bladder fullness states and real-time pudendal nerve feedback, the system enabled on-demand, physiological voiding in 6 SCI patients during a 12-month trial. Participants achieved 85% voluntary voiding success, reduced urinary tract infections by 70%, and eliminated indwelling catheter dependence in 4 cases. This brain-bladder interface restores autonomic function through biomimetic neural engineering.

Keywords: neuroprosthesis, spinal cord injury, neurogenic bladder, brain-machine interface, closed-loop control, sacral nerve stimulation