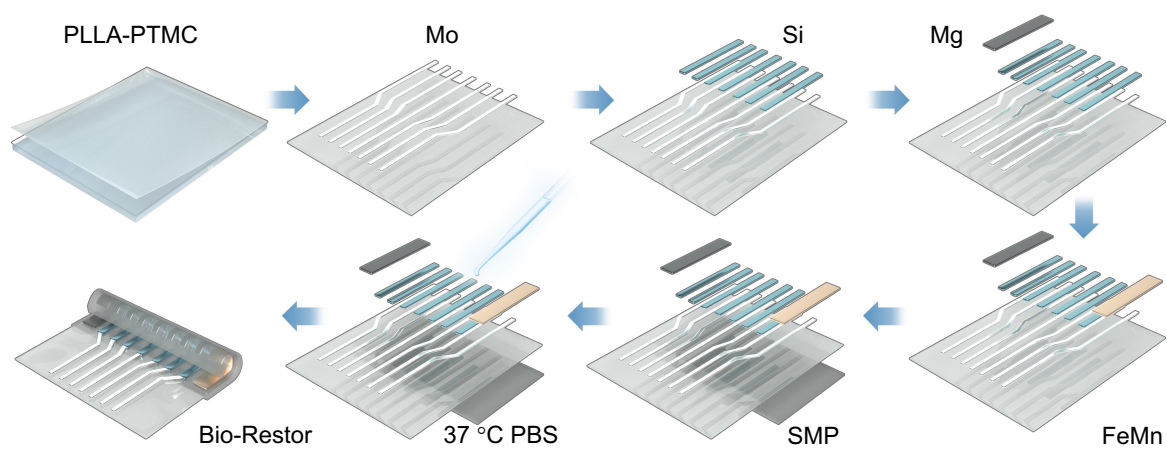


## Supplementary information

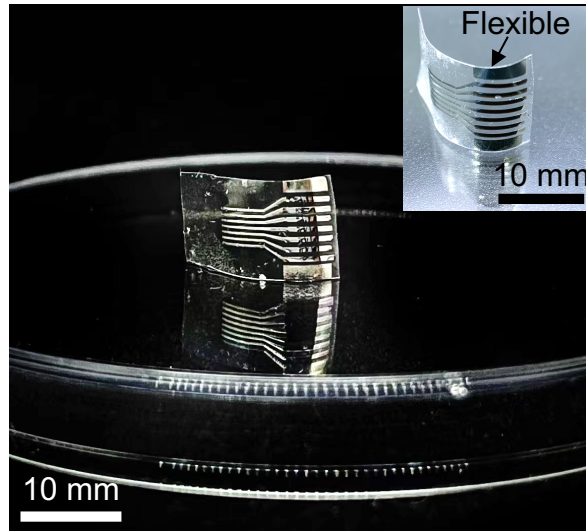
### **A biodegradable and restorative peripheral neural interface for the interrogation of neuropathic injuries**

Liu Wang, Tieyuan Zhang, Jiaxin Lei, Shirong Wang, Yanjun Guan, Kuntao Chen, Chaochao Li, Yahao Song, Weining Li, Shimeng Wang, Zhibo Jia, Shengfeng Chen, Jun Bai, Bingbing Yu, Can Yang, Pengcheng Sun, Qingyun Wang, Xing Sheng, Jiang Peng, Yubo Fan\*, Lizhen Wang\*, Milin Zhang\*, Yu Wang\*, Lan Yin\*

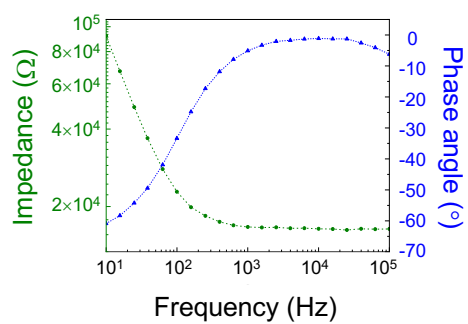
**This PDF file includes:**  
Supplementary Figures 1 to 26



**Supplementary Fig. 1 Schematic illustration of processing flow for the fabrication of Bio-Restor.**

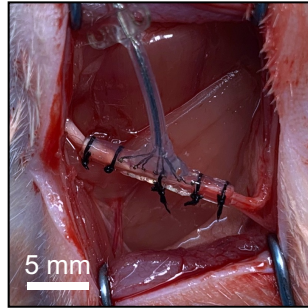


**Supplementary Fig. 2 Flexible Bio-Restor in the planar format.**

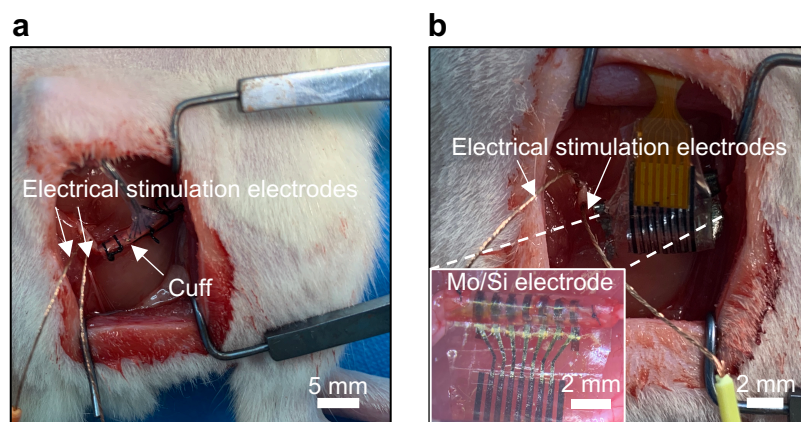


**Supplementary Fig. 3 Representative electrochemical impedance spectrum of Au recording electrode.**

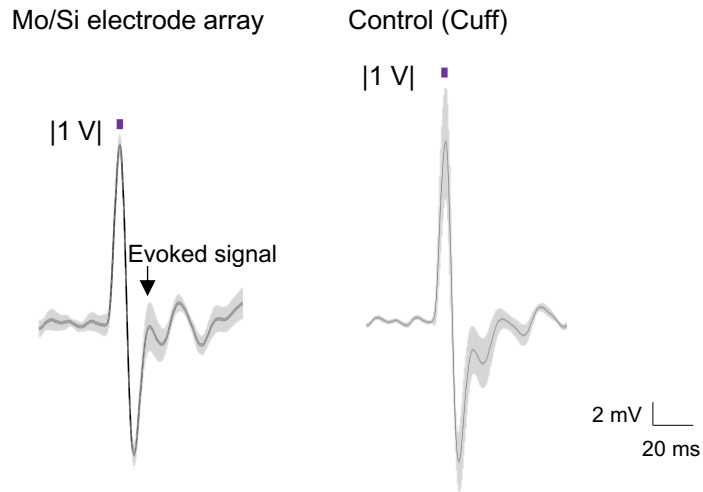




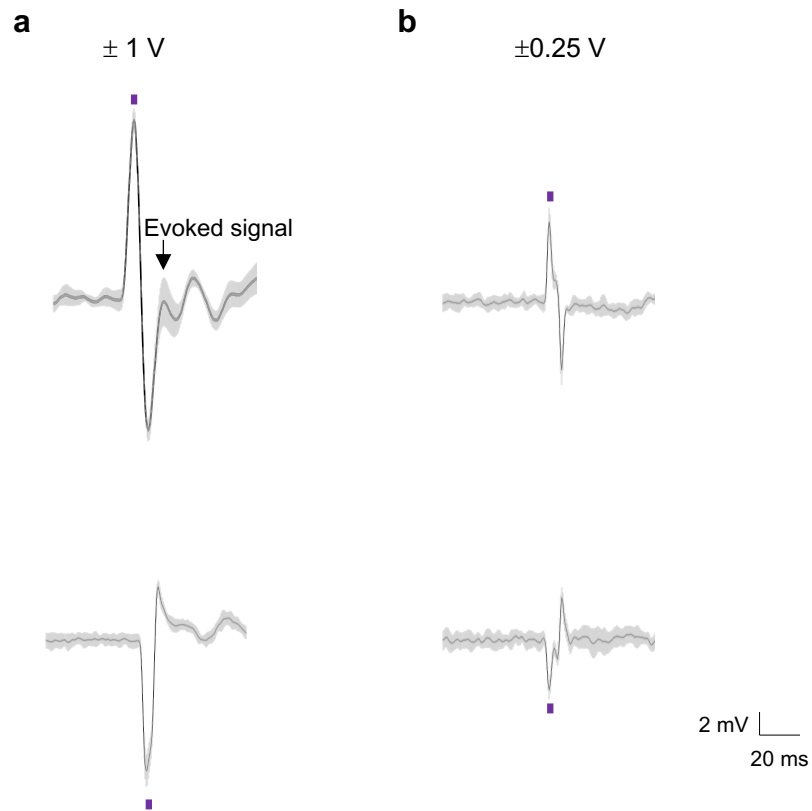
**Supplementary Fig. 4 A commercial cuff electrode implanted on the intact sciatic nerve.**



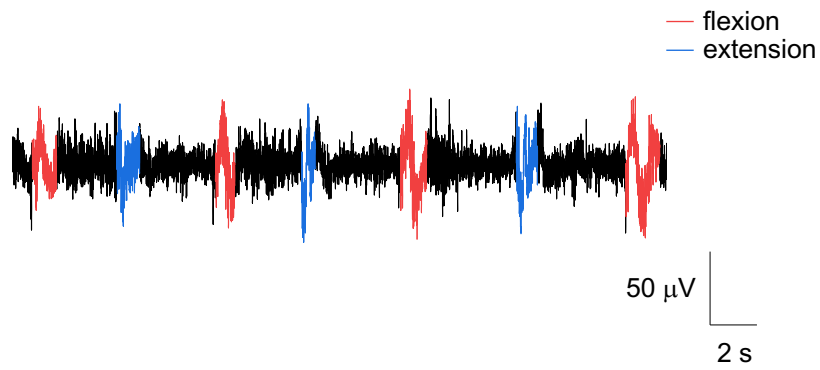
**Supplementary Fig. 5** Evoked neural signals recorded by **a**, cuff electrode and **b**, biodegradable Mo/Si electrode array.



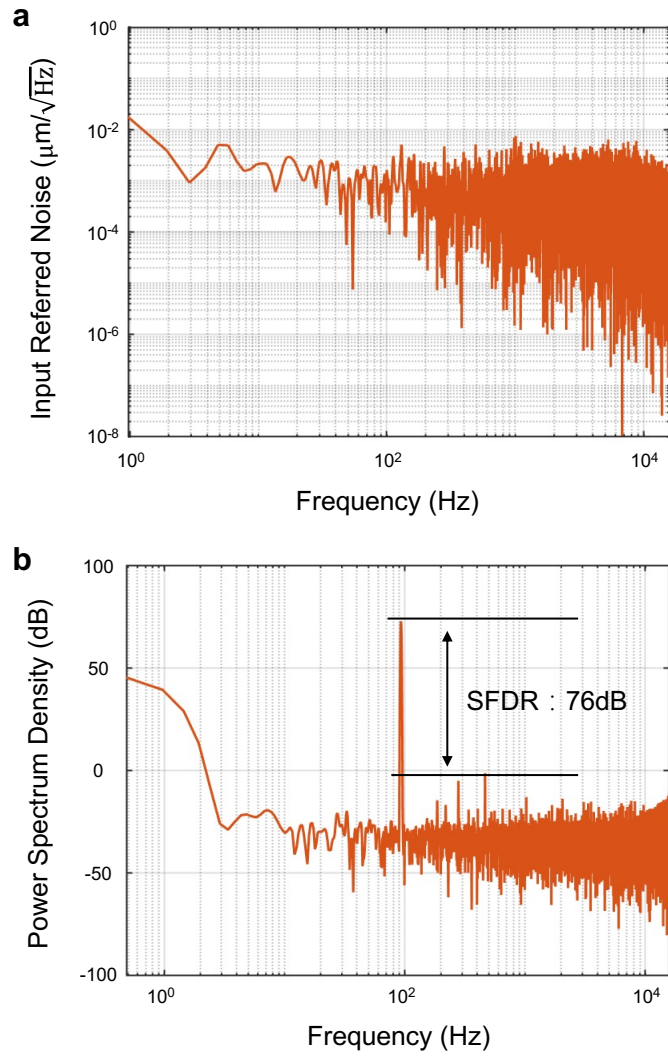
**Supplementary Fig. 6 Evoked neural signals recorded by the Mo/Si electrode array and a commercial cuff electrode as a control. Data are presented as mean  $\pm$  s.d.. Stimulation frequency: 1 Hz, pulse duration: 10 ms. Purple square represents stimulation artifacts.**



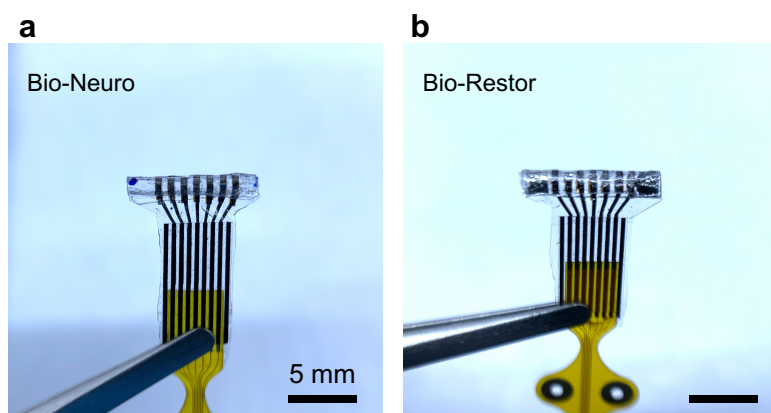
**Supplementary Fig. 7** Evoked neural signals recorded by the Mo/Si electrode array with **a**,  $\pm 1 \text{ V}$  and **b**,  $\pm 0.25 \text{ V}$ . Data are presented as mean  $\pm$  s.d.. Stimulation frequency: 1 Hz, pulse duration: 10 ms. Purple square represents stimulation artifacts.



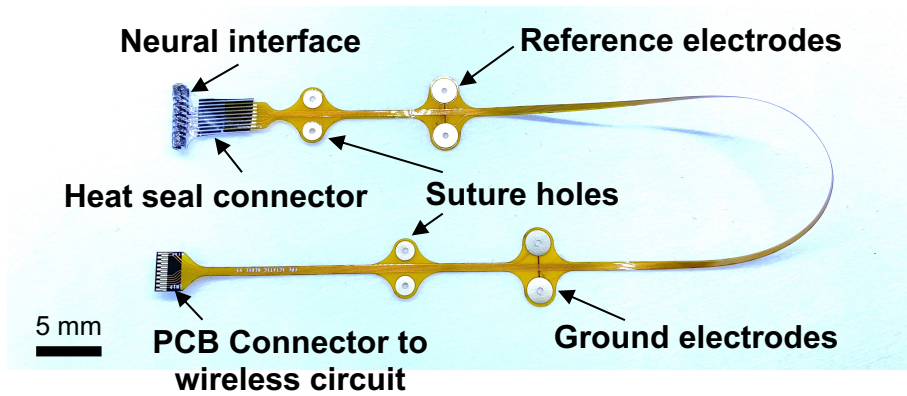
**Supplementary Fig. 8 Recorded signal traces using cuff electrodes on sciatic nerves during the flexion-extension movement of the hindlimb.**



**Supplementary Fig. 9 a**, The measured input-referred-noise of the AFE chip. **b**, The measured SFDR of the AFE chip, with a 93Hz, 14 mVpp input signal.

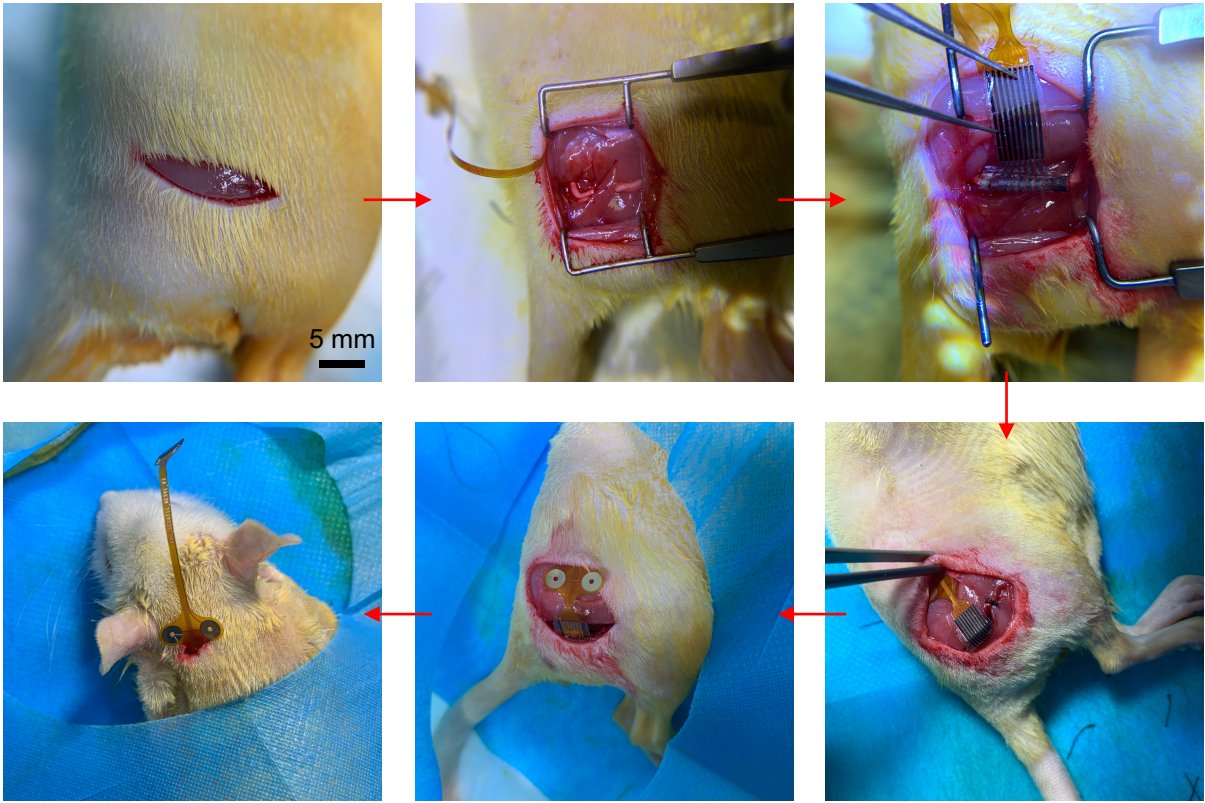


**Supplementary Fig. 10** Images of **a**, Bio-Neuro (without the galvanic cell) and **b**, Bio-Restor.

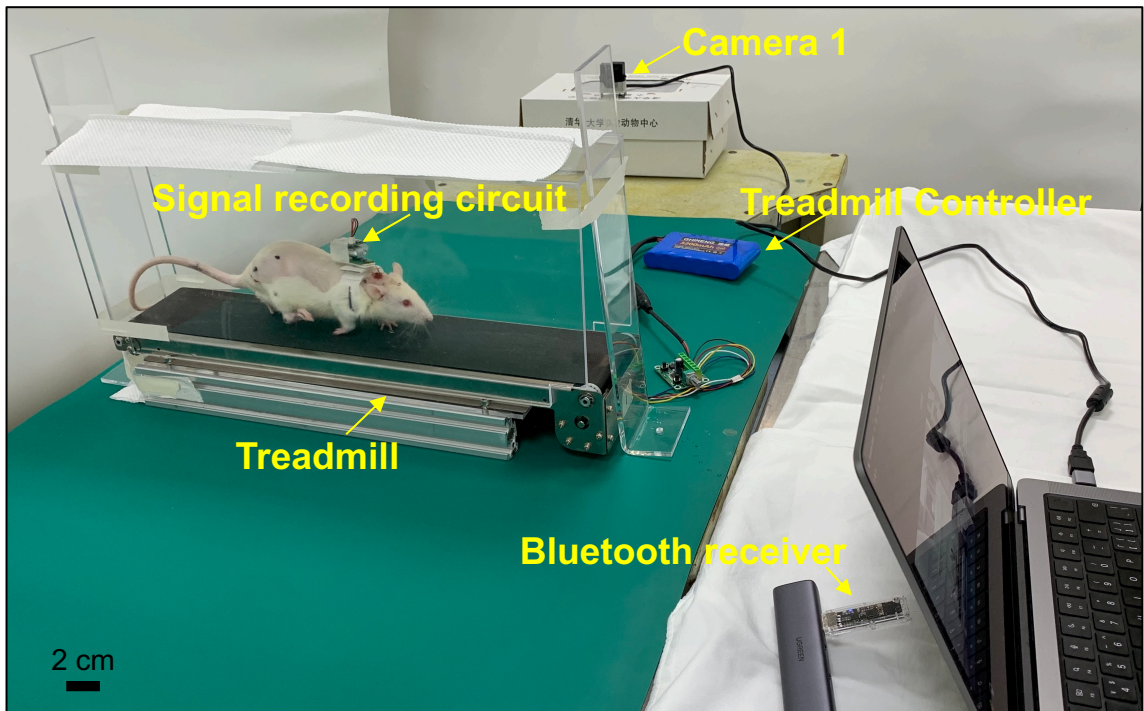


**Supplementary Fig. 11 Structure of the flexible FPC connecting the neural interface and wireless circuit.**





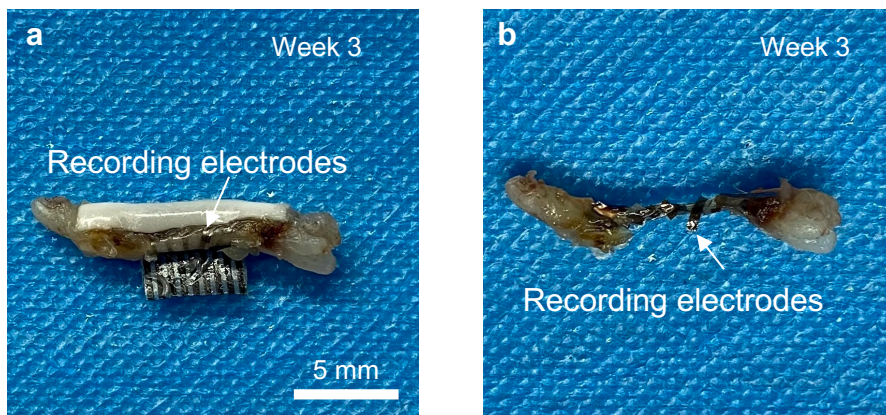
**Supplementary Fig. 12** Implantation process of neural interfaces on the sciatic nerve in SD rats.



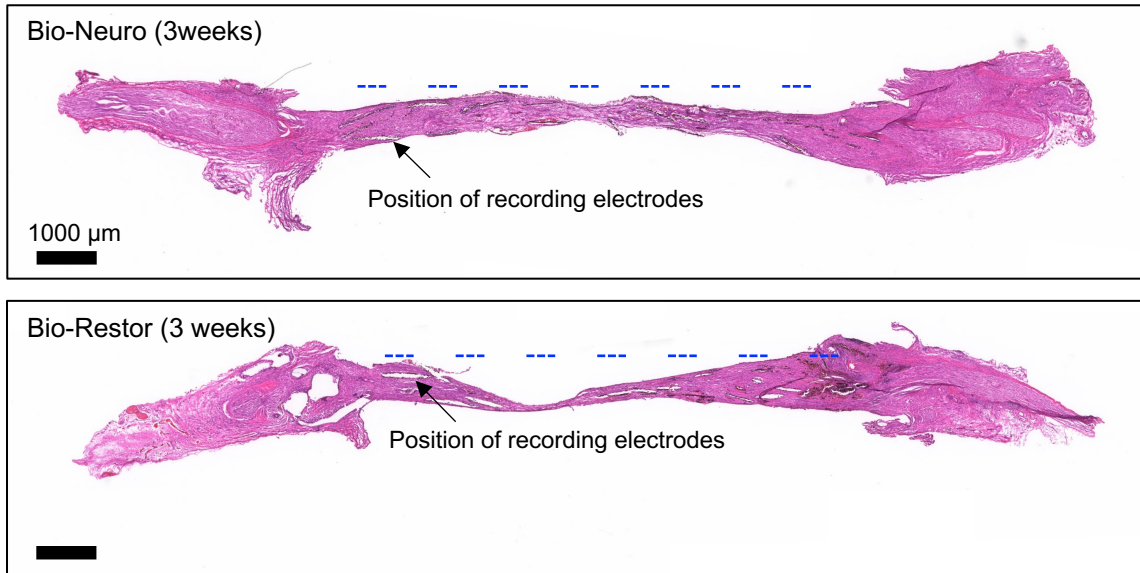
**Supplementary Fig. 13 Setup for sciatic nerve signal recording and simultaneous gait analysis from lateral directions.**



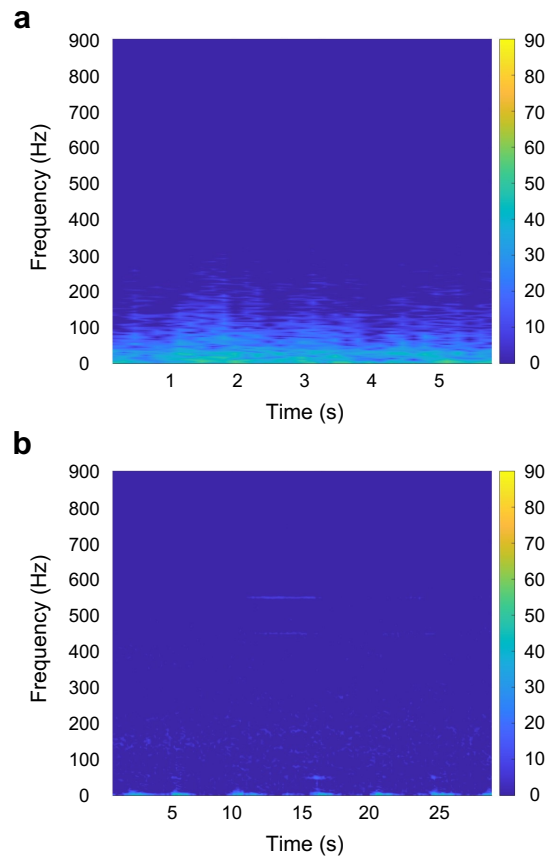
**Supplementary Fig. 14 Image of a rat after 3 weeks implantation.**



**Supplementary Fig. 15 a**, Intact Bio-Restor with regenerated nerve and **b**, the regenerated nerve has grown surrounding the recording electrodes at week 3.

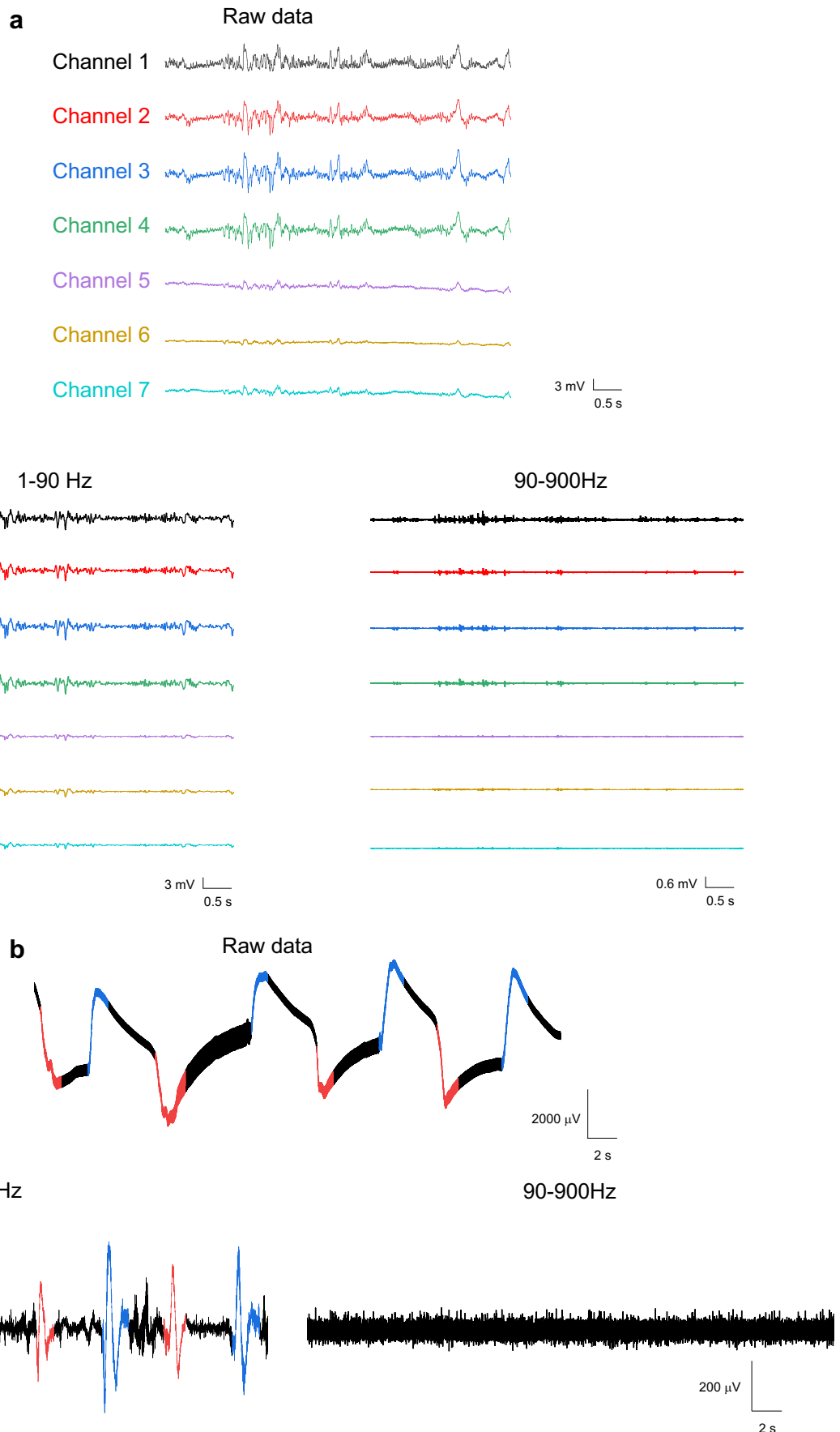


**Supplementary Fig. 16 H&E staining images of longitudinal section of nerve tissues in the Bio-Restor and Bio-Neuro group at 3 weeks postimplantation. Blue dashed lines indicate the predicted position of recording electrodes. n = 3 rats per condition.**

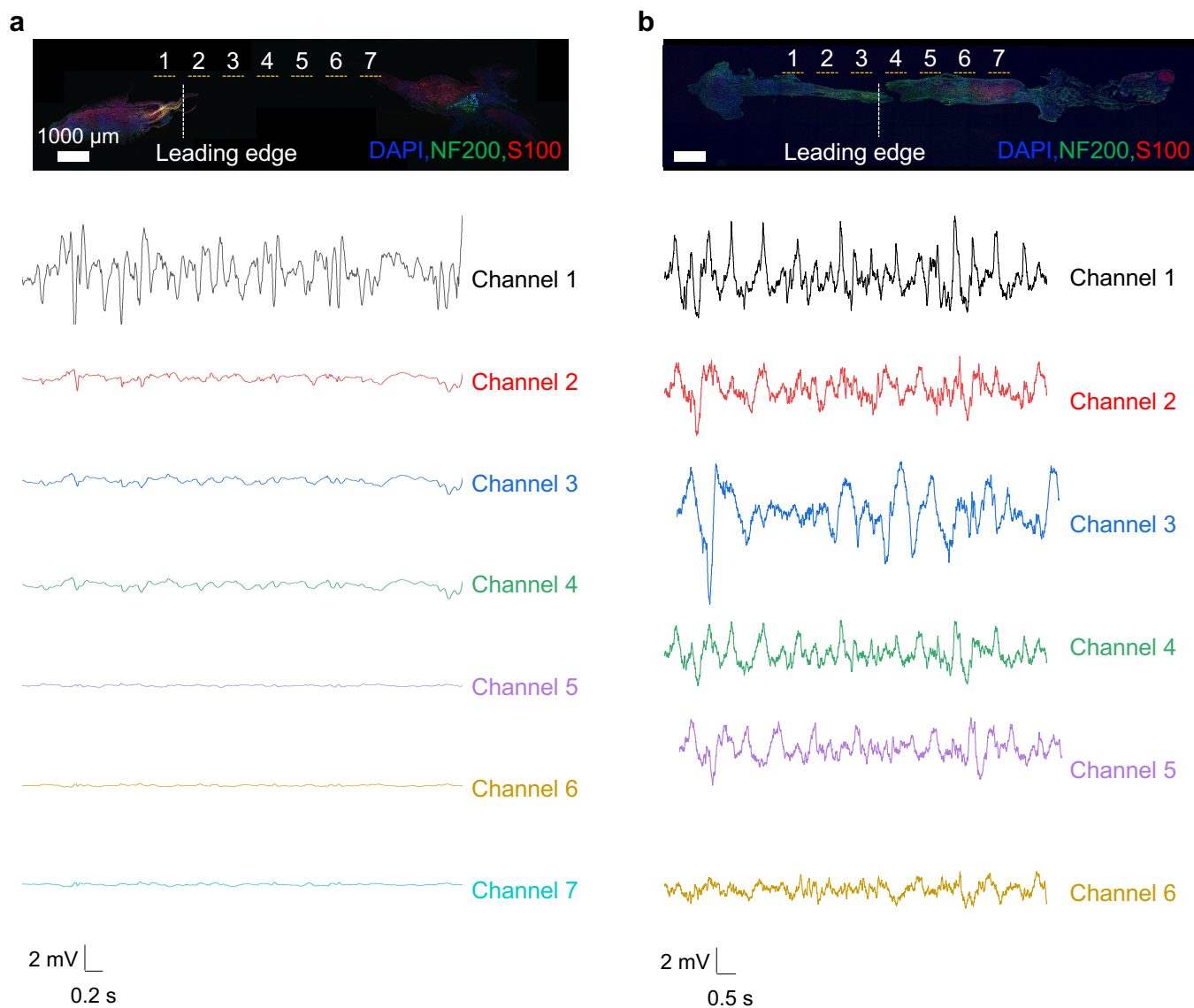


**Supplementary Fig. 17 Representative time-frequency spectrograms of the Bio-Neuro group. a**, walking on a treadmill at 3 weeks postimplantation and **b**, during the flexion-extension movement of the hindlimb.



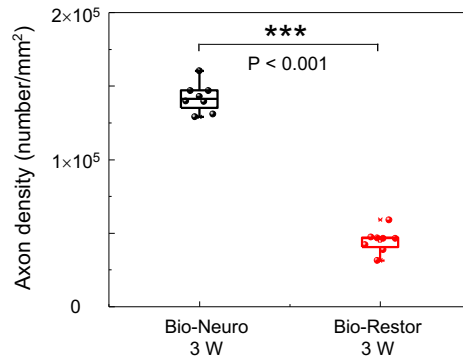


**Supplementary Fig. 18 Recorded raw signal traces and corresponding signals after low-frequency and high-frequency band filtering of the Bio-Neuro group. a**, walking on a treadmill at 3 weeks postimplantation and **b**, during the flexion-extension movement of the hindlimb. In **b**, there is some modulation of the baseline ( $\sim 0.2$  Hz) during manual flexion and extension movements, which can be effectively filtered out using a high-pass filter set at 1 Hz.

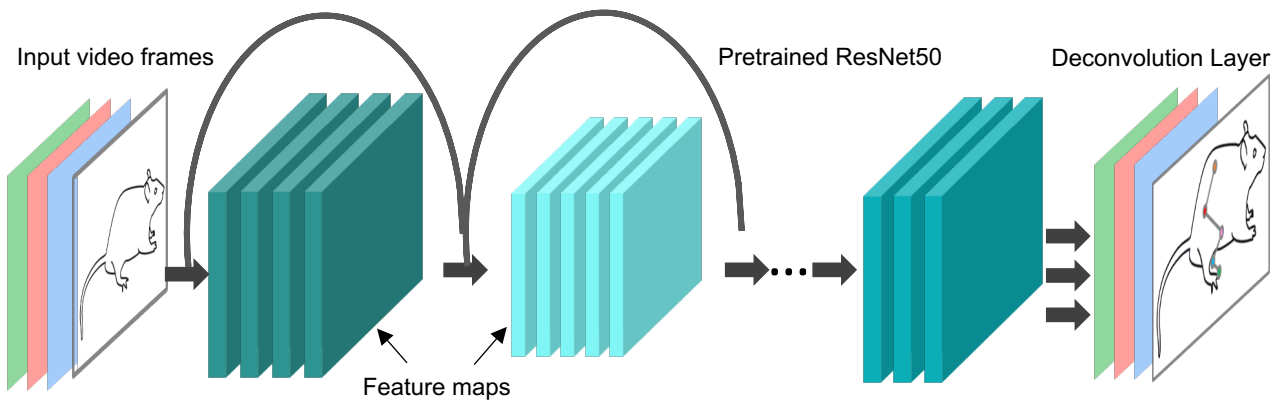


**Supplementary Fig. 19 Immunofluorescent images of the longitudinal section of the nerve segment and the corresponding recorded signal traces with implanted Bio-Neuro at 2 weeks postimplantation. a, case 1; b, case 2. Yellow dashed lines indicate the position of neural electrodes. Note: channel 7 in b is broken and therefore no signal was recorded.**

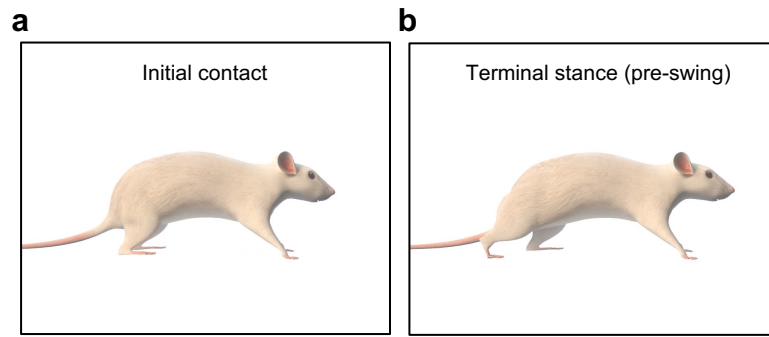




**Supplementary Fig. 20 Statistical analysis of the axon density. n = 8 samples in each group. Unpaired two-sided t-test was used for the statistical analysis (\*\*P < 0.001: P =  $3.6 \times 10^{-12}$ ). The box plot presents the median (center line), lower quartile (lower border), upper quartile (upper border), maximum (upper whisker) and minimum (lower whisker), which are  $\leq 1.5$  times the interquartile range.**

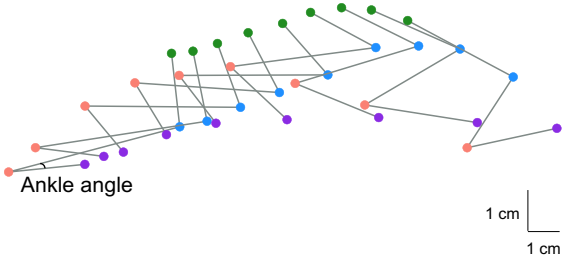


**Supplementary Fig. 21 A deep neural architecture (DeepLabcut) to predict the location of body parts based on corresponding images with markers on the hip, knee, ankle, and toe.**

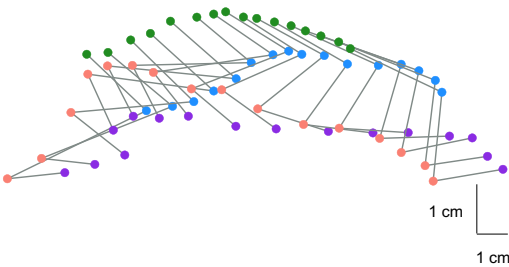


**Supplementary Fig. 22** Image of the **a**, initial and **b**, terminal of stance phase (pre-swing).

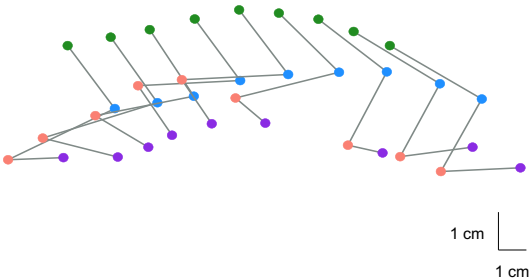
Bio-Neuro (2 W)



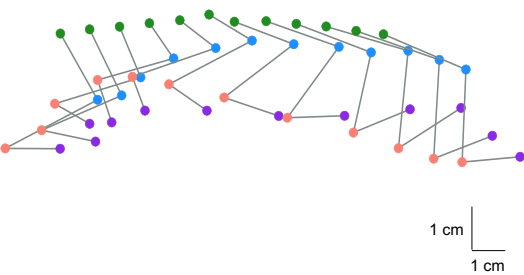
Bio-Restor (2 W)



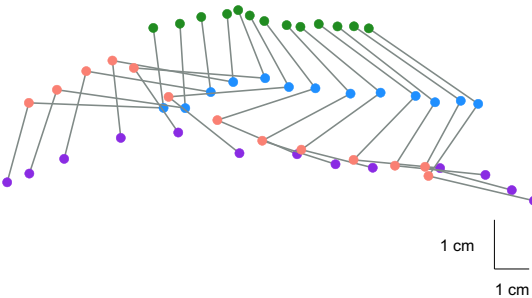
Bio-Neuro (3 W)



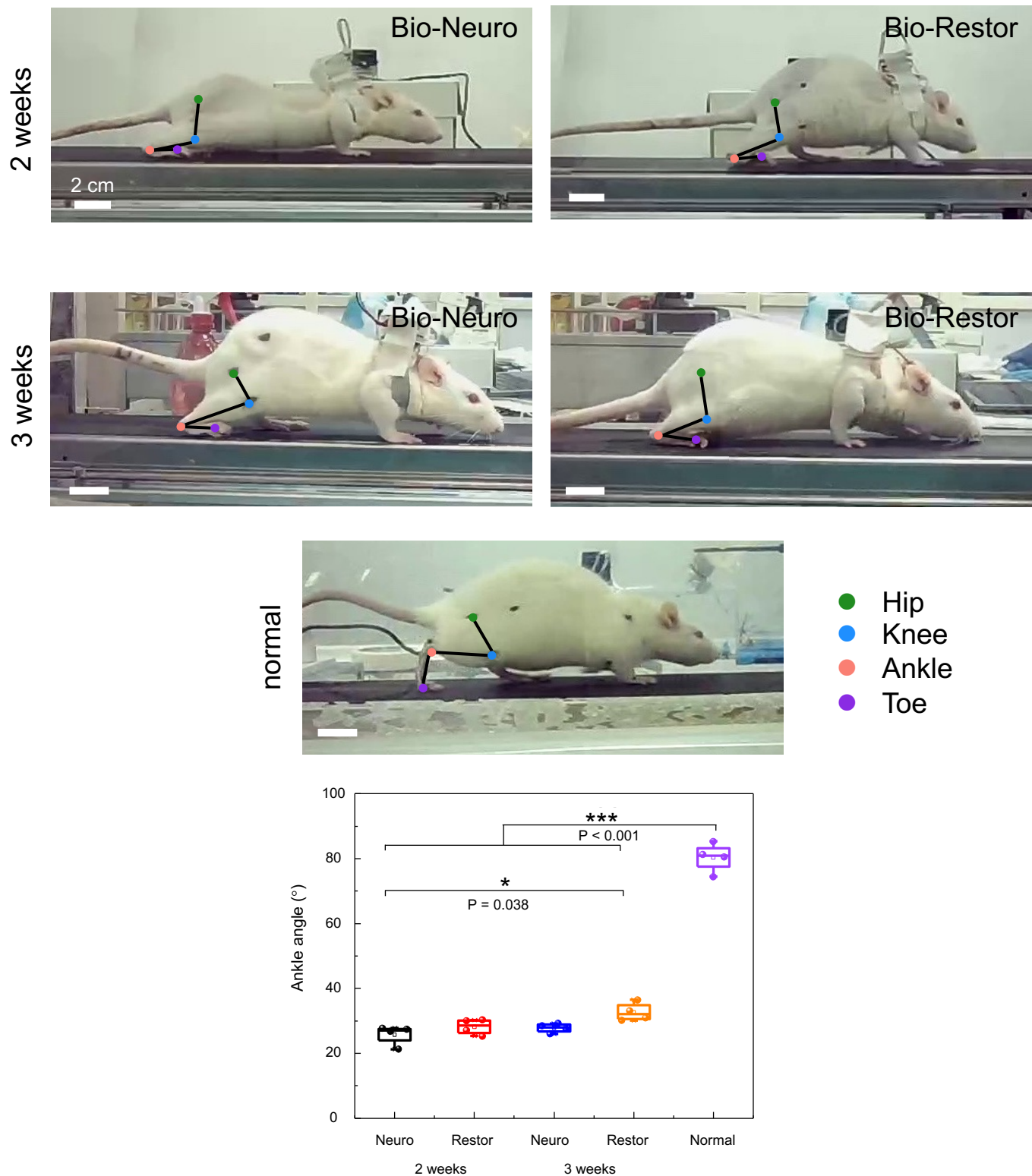
Bio-Restor (3 W)



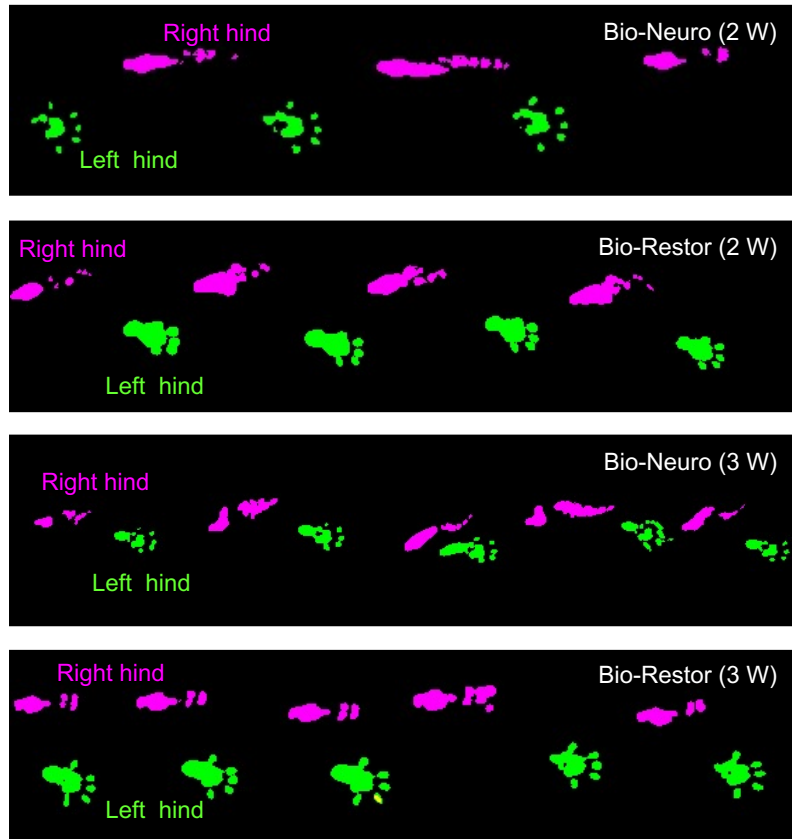
Normal



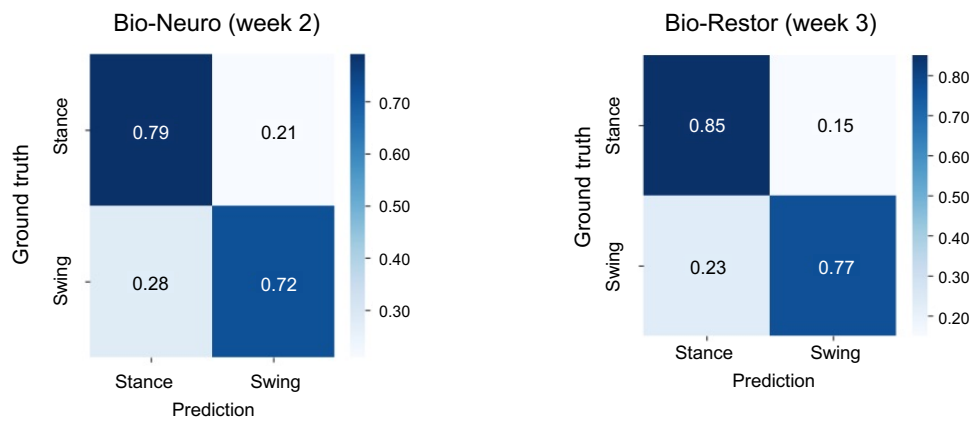
**Supplementary Fig. 23 Stick diagram decompositions of hindlimb movements in Bio-Restor group, Bio-Neuro (2 and 3 weeks) after implantation and normal group.**



**Supplementary Fig. 24 Representative images and statistics of ankle angle for Bio-Neuro, Bio-Restor and normal groups on terminal stance at 2 and 3 weeks after implantation. n = 4 samples in each group. One-way ANOVA followed by Turkey test was used for the statistical analysis (\* $P < 0.05$ , \*\*\* $P < 0.001$ : Neuro (2W)-Normal:  $P = 1.9 \times 10^{-12}$ , Restor (2W)-Normal:  $P = 2.5 \times 10^{-12}$ , Neuro (3W)-Normal:  $P = 2.4 \times 10^{-12}$ , Restor (3W)-Normal:  $P = 6.2 \times 10^{-12}$  pairwise comparisons not shown on graphs are  $p > 0.05$  (not significant)). The box plot presents the median (center line), lower quartile (lower border), upper quartile (upper border), maximum (upper whisker) and minimum (lower whisker), which are  $\leq 1.5$  times the interquartile range.**



**Supplementary Fig. 25 Representative hindlimb footprints for both injured (right hind) and contralateral sides (left hind) at 2 and 3 weeks after implantation.**



**Supplementary Fig. 26 Confusion matrix of prediction and ground truth of swing and stance phase of the Bio-Neuro group at week 2 and Bio-Restor at week 3 postimplantation.**