

Supplementary figures

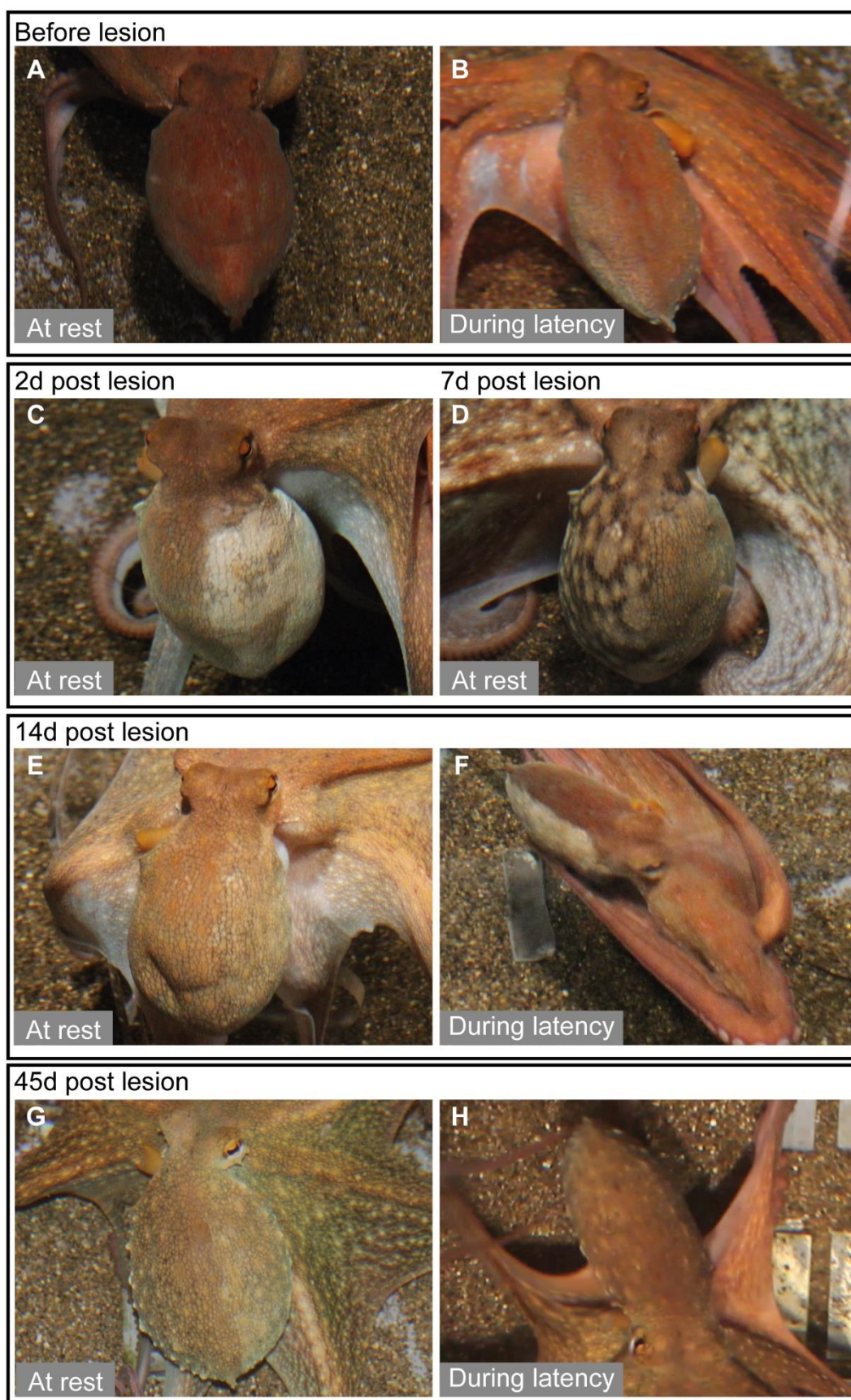


Figure S1. Skin functional recovery. Uninjured animals can tune body pattern bilaterally on the mantle (e.g. at rest in **A**) or unilaterally if necessary (e.g. during predatory performance in **B**). Two days post lesion (**C**) brown spots appear random on the denervated skin. A few days after, the whole affected skin area assumed a uniform colour (**D**) with some ability in matching contralateral side at rest (**E**). This ability is not retained during latency of attack (**F**) with the injured side becoming completely pale. Only 45 days to four months post lesion full control on skin patterning is resumed and observable both at rest and during prey attack (Unilateral effect, **G**; Uniform phase, **H**).

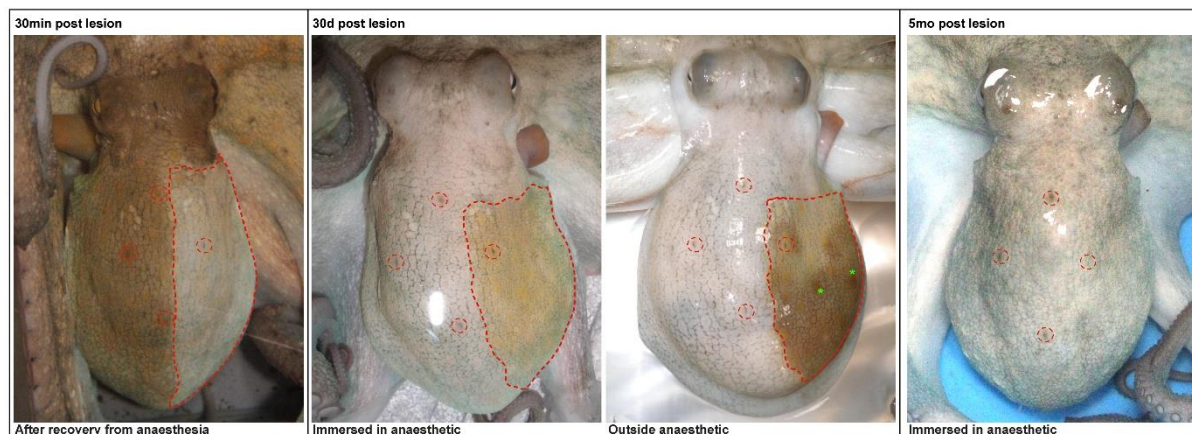


Figure S2. Effect of anaesthesia on octopus denervated skin. Soon after lesion (30 min post lesion) recovered animals show complete paling of the skin on the ipsilateral side of the lesion (denervated area is highlighted by red dotted line; red dotted circles are used to highlight the four main papillae hereby used as landmarks). 30 days (30d) post lesion the denervated skin of animals immersed in the anaesthetic gets yellowish in colour, in contrast to the rest of the body which respond to anaesthesia by paling. If only the mantle is taken out from anaesthetic solution, dark waves start propagating random on the skin (visible as dark brown spots, highlighted by green asterisks). The injured side also shows a reduction in the size of the denervated skin with time, highlighted by red dotted lines.

All these effects disappear in long denervated animals that fully recovered the lost function (e.g. five months – 5mo post lesion) with skin completely and homogeneously paling in anaesthetic solution.

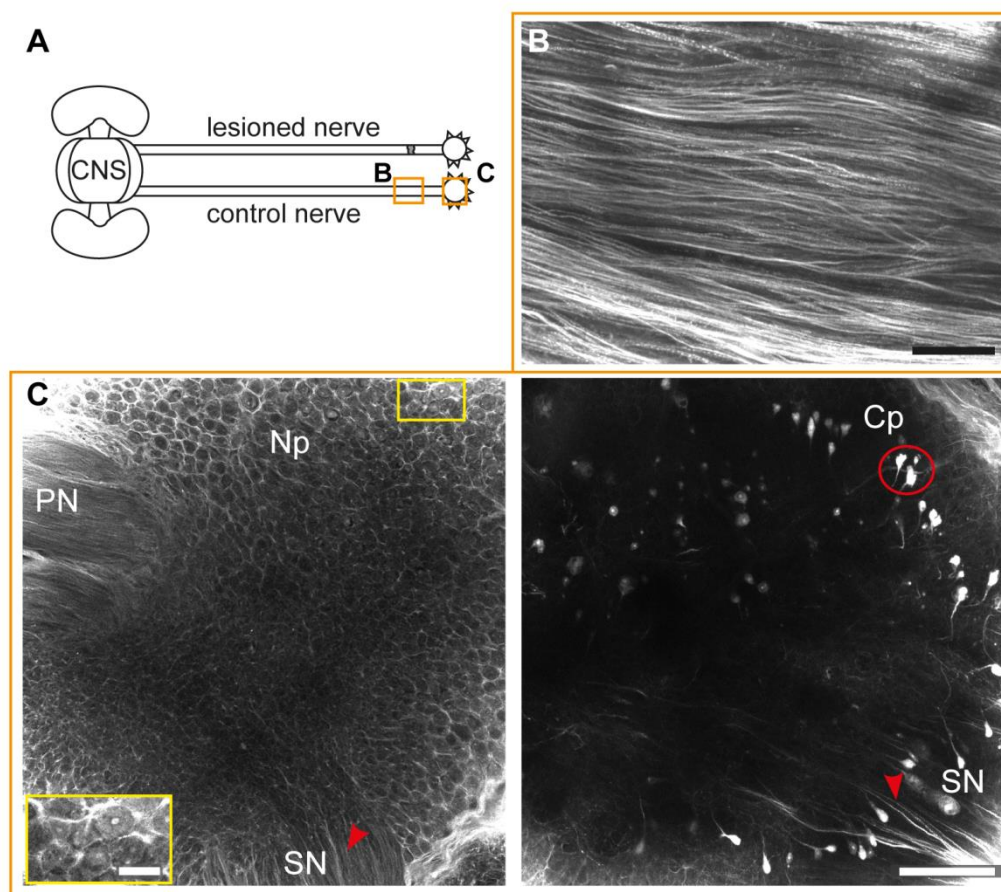


Figure S3. Backfilling of control pallial nerve. (A) Schematic drawing of the connections between the CNS and the periphery through the pallial nerves (PN). The orange rectangles highlight the area depicted in (B, C), corresponding to the control pallial nerve (B) and the control stellate ganglion (C). (B) Fibres from and to the brain are traced with Nb running inside the pallial nerve, mainly parallel to each other. (C, left) When reaching the stellate ganglion, some of these axons form an intricate neuropil (Np) around motoneurons (see enlargement in the yellow rectangle) and exit through the stellar nerves (SN) (red arrowheads) to innervate the chromatophores in

the skin. (C, right) Other fibres originate from the centripetal cells (Cp) inside the ganglion (marked by red circle).

Scale bars: (B) 150 μm , (C) 500 μm , yellow rectangle 100 μm . Abbreviations: CNS, central nervous system; Cp, centripetal cells; PN, pallial nerve; Np, neuropil; SN, stellar nerve.

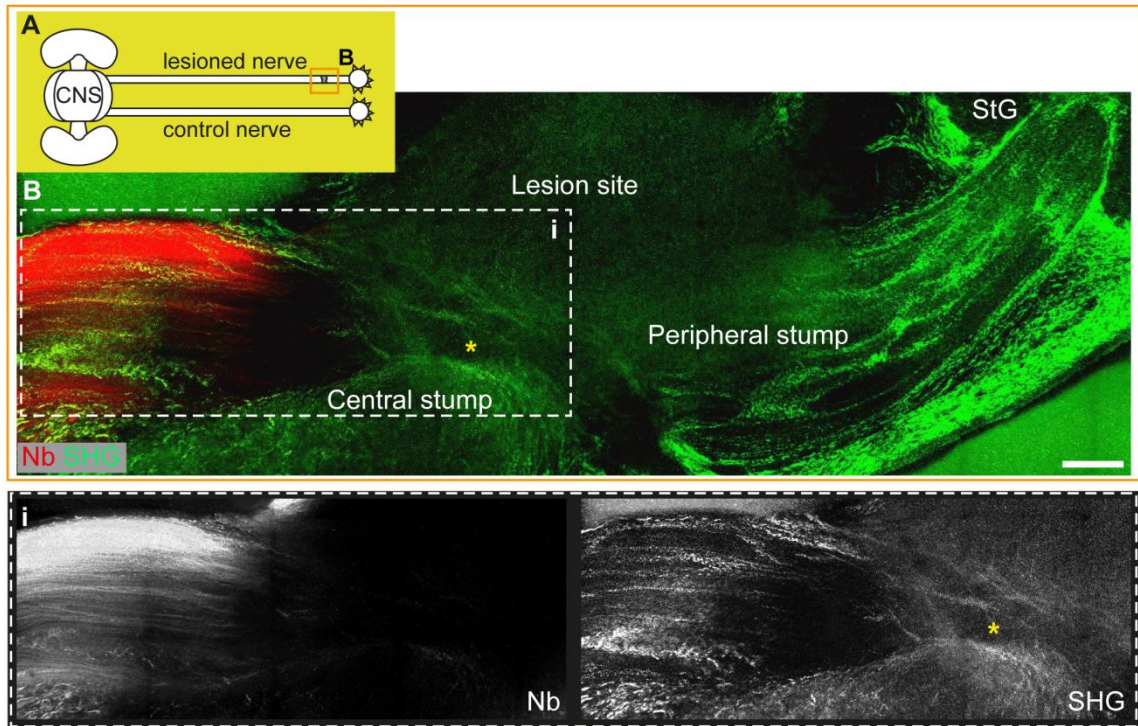
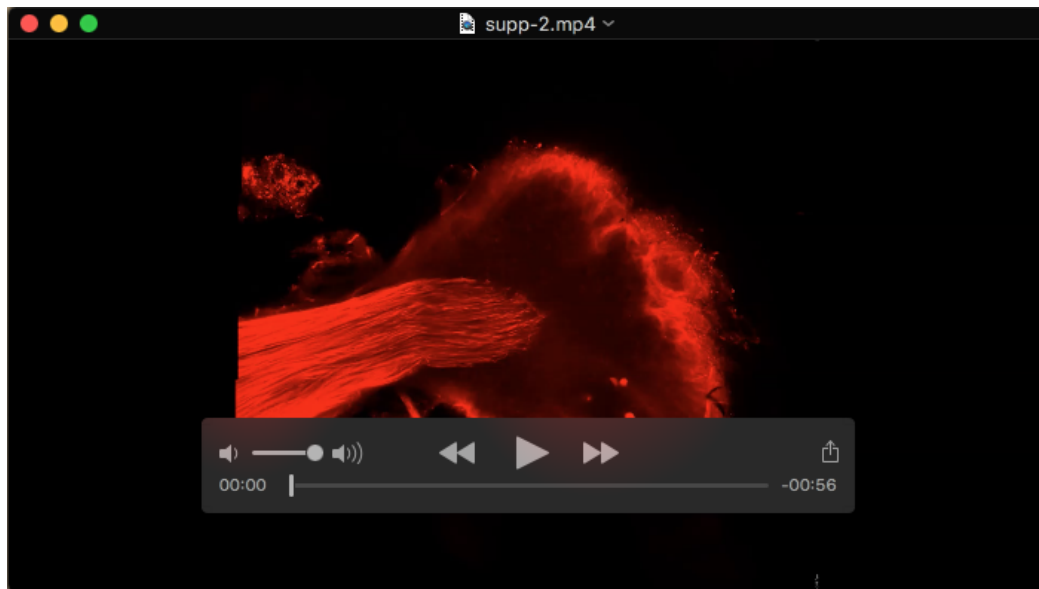
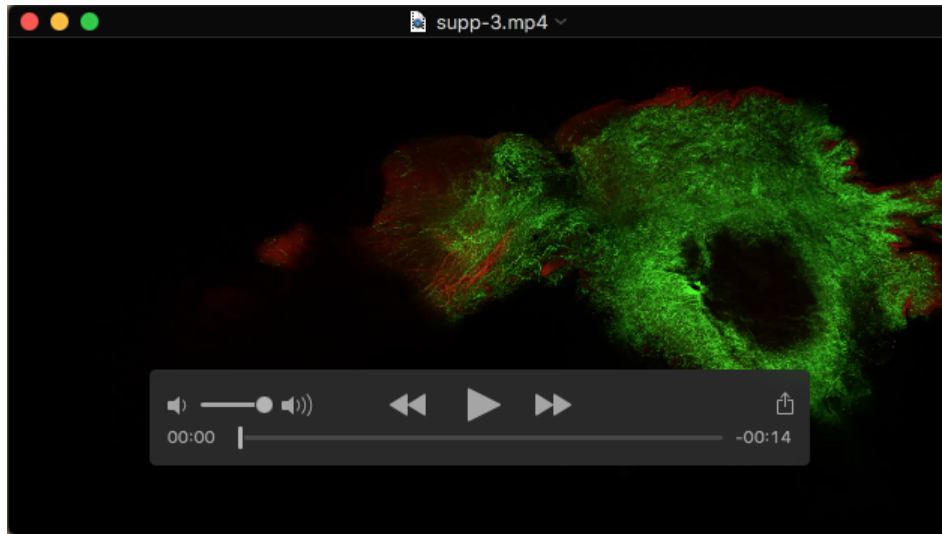


Figure S4. Backfilling of the nerve five days post lesion. (A) Schematic drawing of the connections between the central brain (CNS) and the periphery through the pallial nerves. The orange rectangle highlights the areas depicted in (B), corresponding to the lesioned pallial nerve. (B) Shows a nerve five days post lesion in which neurobiotin (Nb, in red in the merged image) traces fibres only in the central stump. These fibres, although regenerating, do not cross the lesion site. SHG (in green in the merged image) highlights the connective tissue enwrapping the nerve and marks up both the central and the peripheral stump. This allows identification of a spike like structure of connective tissue around the central stump bridging it to the peripheral one. The latter doesn't contain any traced neural fibre. (Bi) Shows a zoom-in of the central stump in (B) with single channels for Nb and SHG. Scale bar: 250 μ m. Abbreviations: CNS, Central Nervous System; Nb, Neurobiotin; SHG, Second Harmonic Generation; StG, Stellate Ganglion.



Movie 1. Backfilling of a control pallial nerve. The control pallial nerve, backfilled with neurobiotin, is visible in red. Fibres are seen to run straight in the pallial nerve and reach the stellate ganglion. These fibres take part in forming the neuropil of the ganglion. Some of them do not form synapsis in the ganglion but directly run through the stellar nerves to innervate the chromatophores or come from the periphery to reach the CNS. Other fibres stop in the ganglion, forming synapsis with the motoneurons, which then innervate respiratory muscles. In the ganglion it is also possible to observe the presence of cells, named centripetal cells, sending their axons toward the pallial nerve.



Movie 2. Backfilling of the pallial nerve 45 days post lesion. A lesioned pallial nerve, 45 days post lesion, is backfilled with neurobiotin (in red) through its central stump. SHG is used to image connective tissue. See Figure 4 for details. In the second part of the video, a zoom-in of the lesioned site is of the same nerve is shown (Nb in red, SHG in green).