Arm transplantation in sea stars

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1 Motivation

Sea stars have usually five arms with the same structure and function in appearance, forming pentaradial symmetry. Previous studies demonstrated a slight tendency of their behavioral direction based on repetitive experiment [1, 2]. Developmental and paleontological works in echinoderms have revealed ontogenetic and phylogenetic aspects of the symmetrical body parts [3–8]. However, it has never been investigated whether these seemingly symmetrical structures are equivalent and exchangeable in terms of function. The aims of this study are *i*) to develop a transplantation technique in sea stars and *ii*) to transplant an arm into another arm-position, which enables us to examine functional cooperation across the body suture.

2 Material and Methods

This study used *Patiria pectinifera* (Muller & Troschel, 1842), which is a common species of sea stars in Japanese waters (Figure 1). In total, 96 arms in 44 individuals were auto-transplanted with several methods on suture and apparatus. For successfully implanted arms, the yarns were removed at a week after the suture. Cooperation of movement between the implants and proximal bodies was assessed per week. This study focused on *i*) locomotion by tube feet, *ii*) defensive reaction of closing ambulacral furrows, and *iii*) food conveyance by tube feet.

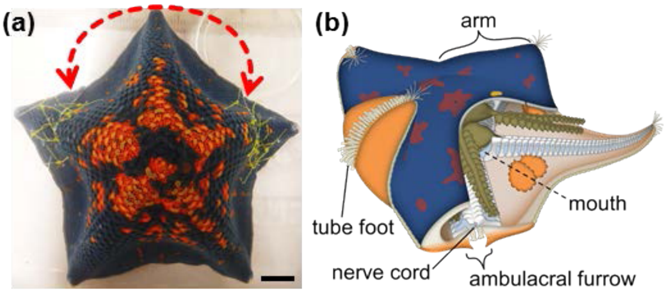

Figure 1: *Patiria pectinifera*. (a) Arm exchange transplantation with nylon yarns; viewed from the aboral side. Scale bar represents 1 cm. (b) Schematic body parts.

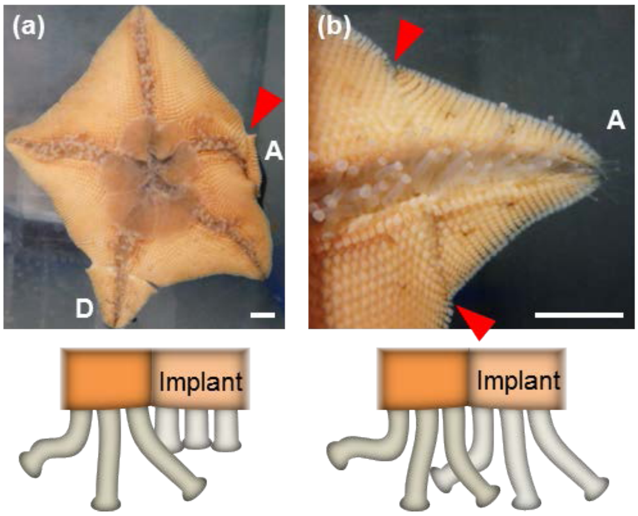

Figure 2: Functional recovery of an implanted arm of a sea star. (a) An individual at two weeks after exchange transplantation of Arms A and D. (b) Arm A at six weeks. Arrowheads indicate the suture of Arm A. Scale bars represent 5 mm. Lower figures schematize locomotion of tube feet in the implant.

3 Results

Seven arm tips were completely implanted with a suture method by nylon yarns under water, amputated at one third the length of the arm from the tip (Figure 1a). Four of them were implanted in the original arm-positions (control), while the other three were into different ones. The movement seemed to recover in the same process and period regardless of whether the arms were implanted into the original or different arm-positions.

At two weeks after the suture, tube feet in the implants neither stretched in the direction of locomotion nor adhered to a wall, making the implants hang down from the proximal bodies (Figure 2a). A portion of the tube feet randomly stuck to the wall but were hard to detach, thus the implants sometimes stayed in place while strongly pulled by the locomoting bodies.

At six weeks after the suture, the tube feet in the implants worked regularly in cooperation with the proximal locomotion (Figure 2b). When oral surfaces near to the suture were physically stimulated, ambulacral furrows normally closed in the touched side, however, did not close in the other side over the line. In contrast to other intact arms, the implants poorly showed a reaction to foods.

At 12 weeks after the suture, the reaction of closing ambulacral furrows transmitted smoothly across the suture line in both of the proximal and distal directions. Moreover, the implants caught foods and conveyed them from the tips to the proximal mouth as usual.

4 Conclusion

This study demonstrated that the arms which are autotransplanted into the original or different arm-positions gradually move in cooperation with the proximal manner. This finding indicates that nervous system reconnects across the suture, providing functional recovery of the implants even though these arms originate in other arm-positions. Therefore, the arms of a sea star can be identified as equivalent and exchangeable structures in the aspect of neural function.

5 References

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