

**Fig. S1. Mn<sup>2+</sup> concentration dependency of image intensity of T<sub>1w</sub>-MRI of the kidney.**

T<sub>1w</sub>-MR image intensity (M(R<sub>1</sub>)) with a short echo-time could be written as follows:

$$M(R_1) = M_0 \cdot \sin\theta \cdot [1 - \exp(-T_R \cdot R_1)] / [1 - \cos\theta \cdot \exp(-T_R \cdot R_1)], \quad (1)$$

where M<sub>0</sub> is the equilibrium image intensity, and T<sub>R</sub> and θ are the repetition time and the flip angle of the excitation pulse, respectively. When Mn<sup>2+</sup> concentration is increased (C), the longitudinal relaxation rate of the kidney (R<sub>1</sub>) is increased as follows:

$$R_1(C) = R_1(0) + K \cdot C, \quad (2)$$

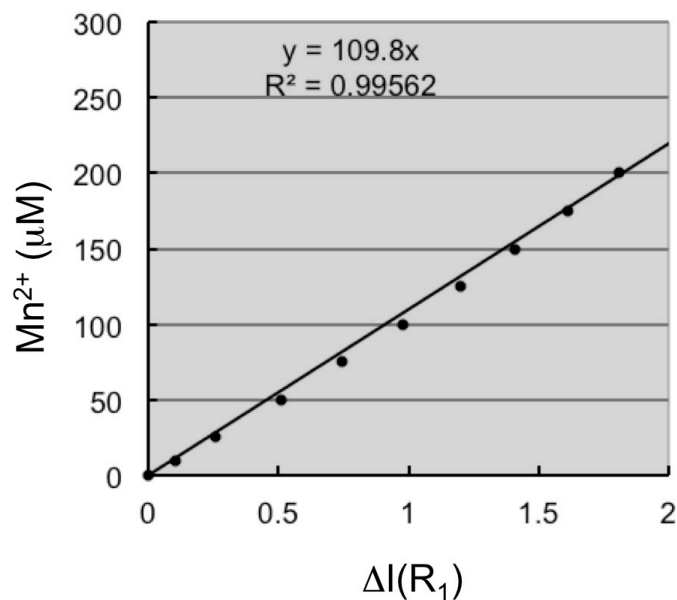
where R<sub>1</sub>(0) and K are, respectively, the intrinsic longitudinal relaxation rate of the kidney and the relaxivity value of Mn<sup>2+</sup> (6.3 mM<sup>-1</sup> s<sup>-1</sup>). Increase of image intensity (ΔI(R<sub>1</sub>)) could be written as follows:

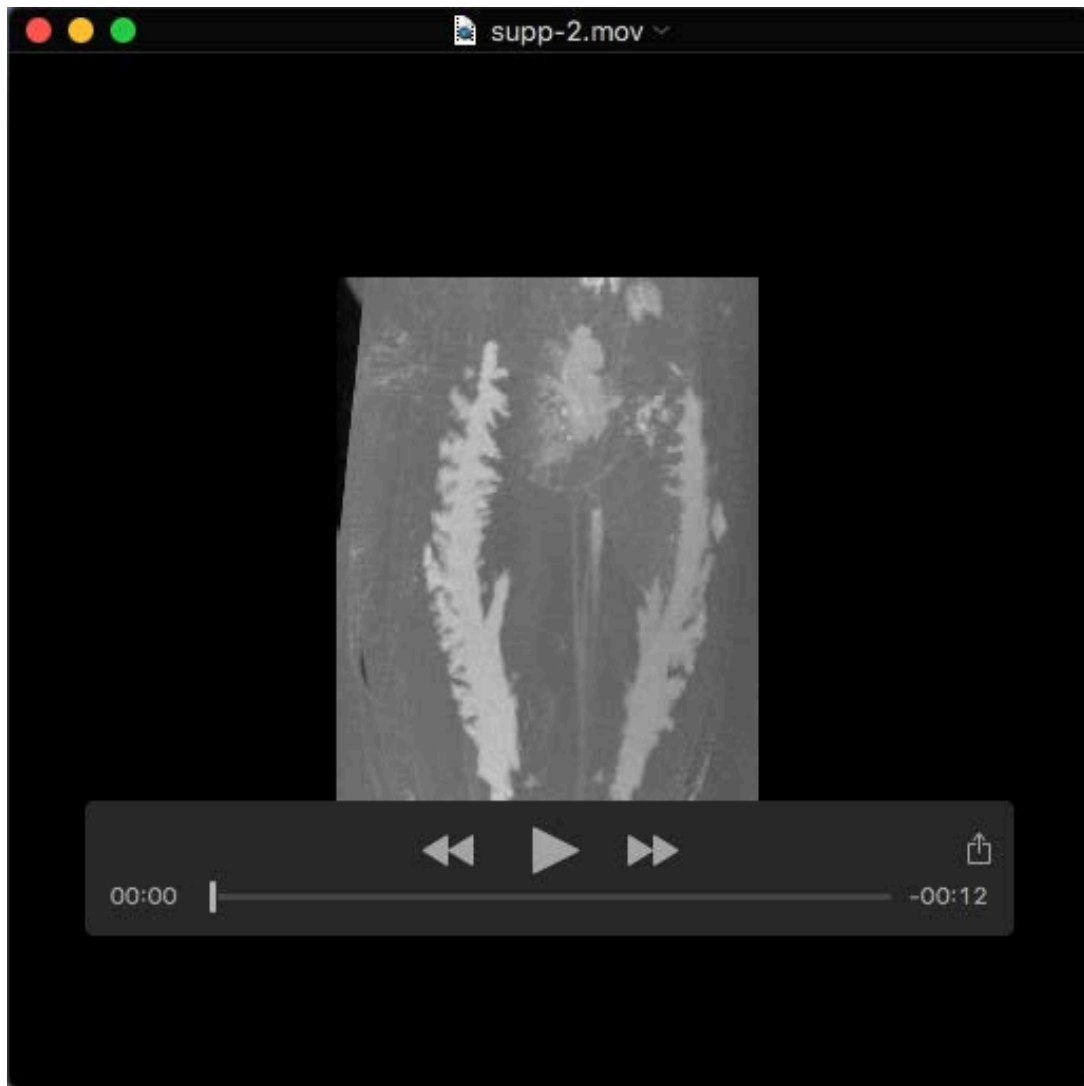
$$\Delta I(R_1) = M(R_1(C)) / M(R_1(0)) - 1 \approx a \cdot K \cdot C, \quad (3)$$

where a is a constant.

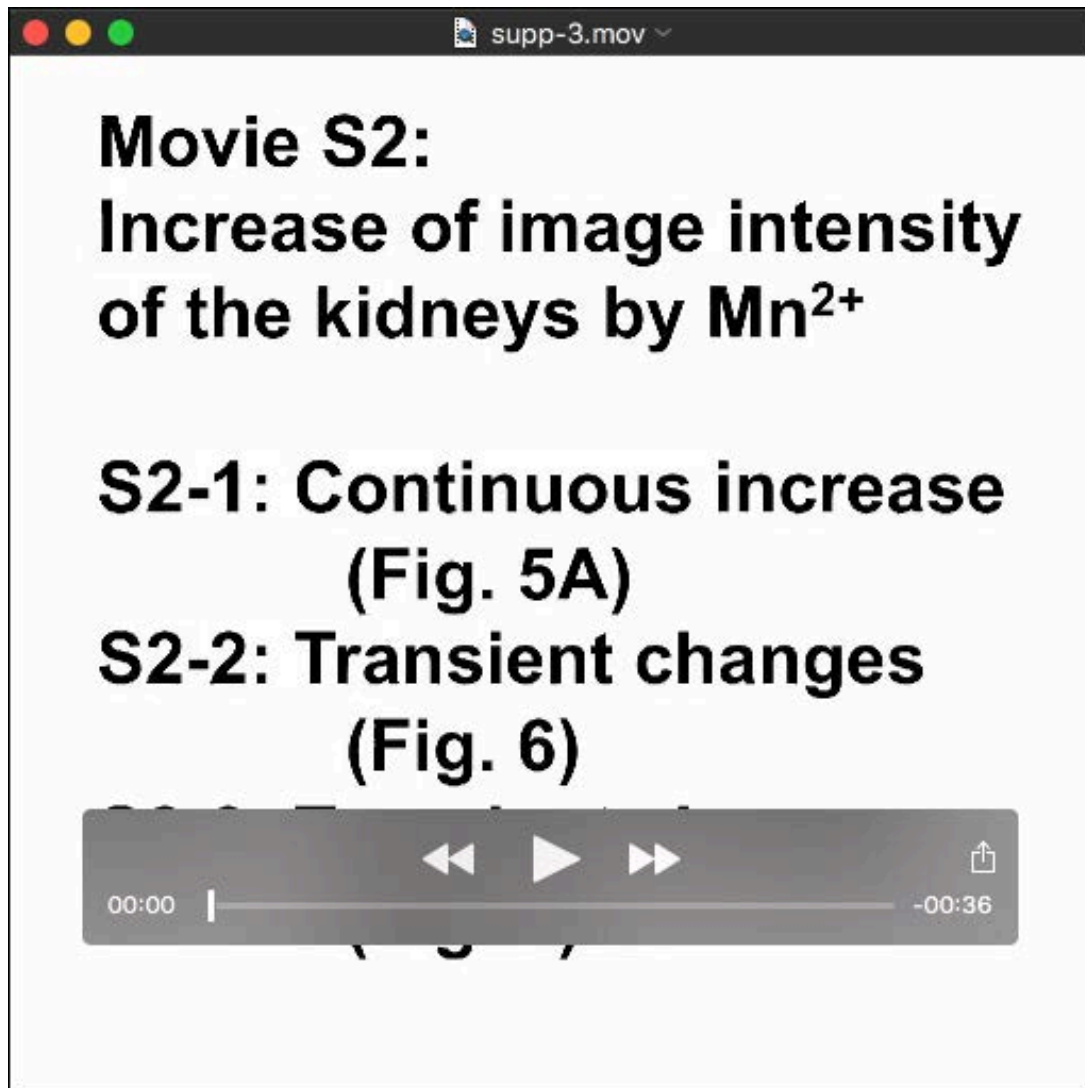
The dotted points were calculated under the condition: T<sub>R</sub>/θ/R<sub>1</sub>(0)/K = 50 ms/45°/0.55 s<sup>-1</sup>/6.3 mM<sup>-1</sup> s<sup>-1</sup>. The bold line is a result of a linear fitting to the dotted points with a function of C = k·ΔI(R<sub>1</sub>), where k is a constant (109.8 μM). Therefore, the Mn<sup>2+</sup> concentration in the kidney (C) could be estimated under the concentration of 250 μM.

## Supplementary Fig. S1





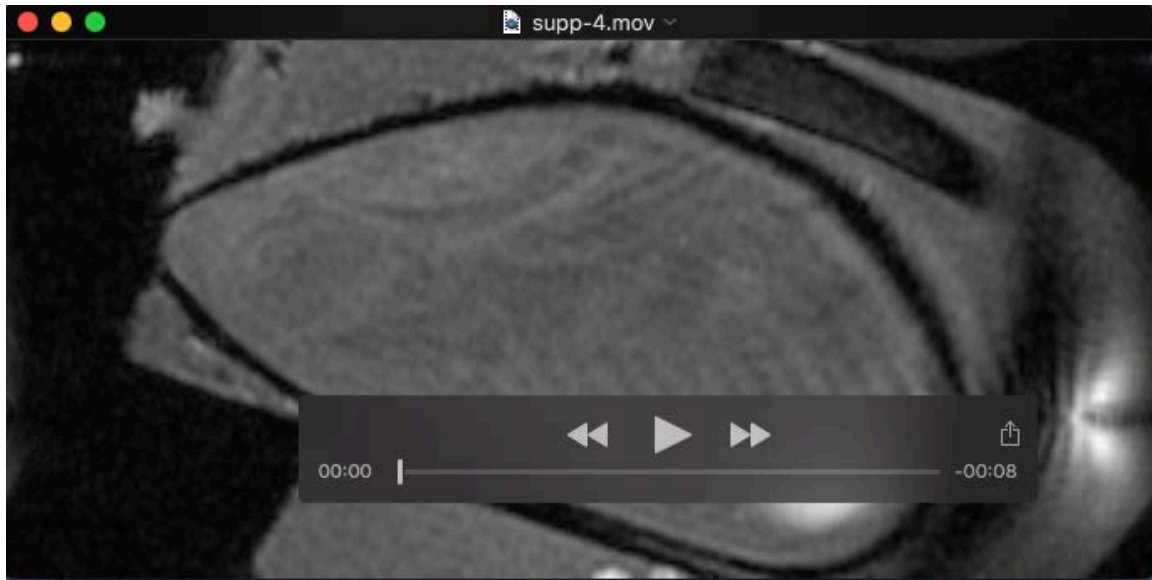
**Movie 1. 3D structure of kidneys of the *Mytilus galloprovincialis*.** Maximum intensity projection images and 3D reconstructed images of 3D  $T_{1w}$ -MRI are rotated in the longitudinal axis of the mussel. The top side shows the anterior direction of the mussel.



**Movie 2-1. Increase of image intensity of the kidneys by 10  $\mu\text{M}$   $\text{Mn}^{2+}$ .** Transverse images from 3D  $T_{1w}$ -MRI of *Mytilus galloprovincialis* before and after the  $\text{Mn}^{2+}$  exposure. Four and 32 images obtained before and after the 10  $\mu\text{M}$   $\text{Mn}^{2+}$  exposure every 3 min 24 s.

**Movie 2-2. Transient changes in the image intensity in kidneys due to  $\text{Mn}^{2+}$  exposure.** Transverse images from 3D  $T_{1w}$ -MRI of *Mytilus galloprovincialis* before and after the  $\text{Mn}^{2+}$  exposure. After taking 4 images, the mussels were exposed to 10  $\mu\text{M}$   $\text{Mn}^{2+}$  and 32 images were obtained every 3 min 24 s. Then, the mussels were exposed to 20  $\mu\text{M}$   $\text{Mn}^{2+}$  32 images were obtained every 3 min 24 s.

**Movie 2-3. Transient changes in the image intensity of the kidneys due to 10  $\mu\text{M}$   $\text{Mn}^{2+}$ .** Transverse images from 3D  $T_{1w}$ -MRI of *Mytilus galloprovincialis* before and after the  $\text{Mn}^{2+}$  exposure. Four and 32 images obtained before and after the 10  $\mu\text{M}$   $\text{Mn}^{2+}$  exposure every 3 min 24 s.



**Movie 3. Increase in the image intensity of the left kidney by 10  $\mu\text{M}$   $\text{Mn}^{2+}$ .** Sagittal images from 3D  $T_{1w}$ -MRI of the *Mytilus galloprovincialis* before and after the  $\text{Mn}^{2+}$  exposure. Four and 32 images obtained before and after the 10  $\mu\text{M}$   $\text{Mn}^{2+}$  exposure every 3 min 24 s. The left side shows the anterior direction of the mussel.