X-ray diffraction studies of a molluscan smooth muscle in the catch state

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Introduction

Molluscan smooth muscles show a specialized contractile behavior called catch in which tension is maintained for a very long time with very little expenditure of energy. It was attempted to detect structural changes which might provide clues to understand the molecular mechanism of catch by small-angle X-ray diffraction studies of the anterior byssus retractor muscle of *Mytilus edulis* (ABRM) using conventional X-ray apparatus [1], but any structural features which characterize the catch state has not been detected. In this work, some structural changes during catch contraction were obseved by improving accuracy in measuring intensity and position of reflections using strong X-rays from the synchrotron ring.

Experimental Results and Discussions

Small-angle X-ray diffractin patterns were recorded on imaging plates using a point focusing camera with a camera-length of 200 cm. The specimen was stimulated with a strong acetylcholine solution (10^{-3} M) to produce high tensions. The pattern in the active state was recorded at a plateau of tension. The catch tension was relaxed with serotonin (2.5×10^{-5} M) to record the pattern in the resting state. The pattern in the catch state was recorded 8 min after washing of acetylcholine [2].

The intensities of the reflections from the thick filaments which appear on and near the meridian were integrated radially. After subtraction of the background intensities, the profiles of the integrated intensities were compared between the resting , active and catch states. The periods corresponding to the axial positions of the intensity peaks are elongated in the active state, and more elongated in the catch state (Table1). The intensities of the 145 and 73 A meridional reflections decreases and increases in the active state respectively [3], and partially return in the catch state to the intensities in the resting state.

The intensities of the layer line reflections from the thin filaments were radially integrated within the range where the 59 A reflection is not much broadened by disorder of filament orientation. The changes in the axial periods and intensities of the 51 and 59Å reflections in the active state partially recover in the catch state to the periods and intensities in the resting state (Table 2).

Comparing intensity profiles of the equatorial reflection integrated within the width of the reflection, the intensity of the peak due to lateral packing of the thin filaments decreases, and the background intensity increases in the active state. However, the peak and the background are almost equal in intensity in the active and catch states.

The above results indicate the following structural features in the catch state. The thick filaments are elongated more strongly in the catch state than in the active state. Although the thin filaments maintain the packing of rosette around the thick filaments [4], a number of the myosin heads return to the surface of the thick filaments, and the thin filaments partly return to the structure in the resting state. It is probable that the thin filaments play a role to tie the thick filaments by strong association between the myosin head and actin, and that the catch tension is held mainly by the thick filaments.

References

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Table 1 Change in the axial period and intensity of the thick filament reflections compared to them in the resting state.

	(Axial Period)		(Intensity)	
	145Å	73Å	145Å	73Å
Active	0.21%	0.22%	-21%	12%
Catch	0.26	0.26	-11	4.4

Table 2 Change in the axial period and intensity of the thin filament reflections compared to them in the resting state.

	(Axial Period)		(Intensity)	
	59Å	51Å	59Å	51Å
Active	0.71%	1.05%	-8.9%	39%
Catch	0.51%	0.74%	-6.8	22

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