Torques and forces in the mitotic spindle

Iva Tolic[1]

[1] *RBI, Zagreb, Croatia*

The mitotic spindle is a fascinating and complex micro-machine made of microtubules and the accompanying proteins. Spindle microtubules attach to chromosomes via protein complexes called kinetochores. We have recently shown that a bundle of antiparallel microtubules, termed “bridging fiber”, connects sister kinetochore fibers [1, 2]. Bridging microtubules are linked together by the protein regulator of cytokinesis 1 (PRC1). To explore the role of bridging fibers, we developed an optogenetic approach to remove PRC1 from the spindle in a fast and reversible manner. PRC1 removal during metaphase reduced bridging fibers, changed spindle shape, decreased interkinetochore distance, and resulted in misaligned chromosomes. Thus, our optogenetic experiments show that PRC1, by crosslinking bridging microtubules and kinetochore fibers, regulates spindle mechanics and forces acting on kinetochores in metaphase, promoting chromosome alignment. In addition to linear forces, rotational forces (torques) may also exist in the spindle. We have shown that the spindle is chiral, based on our finding that microtubule bundles follow a left-handed helical path [3]. Our theoretical model predicts that bending and twisting moments generate curved shapes of the bundles. We conclude that torques, in addition to linear forces, exist in the spindle and determine its chiral architecture.

[1] J. Kajtez, A. Solomatina, M. Novak et al., Nat Commun 7, 10298 (2016).

[2] K. Vukusic, R. Buda et al., Dev Cell 43, 11-23 (2017).

[3] M. Novak, B. Polak, J. Simunic, Z. Boban, B. Kuzmic et al., Nat Commun 9, 3571 (2018).