Cytokinetic rings mind the gap

Cells can rapidly repair breaks in the contractile actomyosin ring to ensure the timely completion of cytokinesis.

At the end of mitosis, cells undergo cytokinesis by forming a contractile actomyosin ring to divide themselves in two (1). Most studies have focused on how this ring assembles at the right time and place, but how the ring behaves as it contracts remains largely unknown. Silva et al. reveal that the actomyosin ring can be rapidly repaired as it contracts, and their data favor the idea that the ring is composed of autonomous contractile units that make cytokinesis a highly robust process (2).

The process of cytokinetic ring constriction is difficult to study because most of the genetic perturbations that disrupt cytokinesis prevent the ring from assembling properly in the first place. Ana Carvalho and colleagues at the i3S/IBMC/University of Porto decided to study constriction by using laser microsurgery to create gaps in the cytokinetic ring as it contracts. Led by postdoc Ana Silva, the researchers were able to sever GFP-myosin II–labeled rings formed in early C. elegans embryos, without damaging the neighboring plasma membrane (2). “We saw that the rings snapped open, but only to a limited extent; they didn’t fall apart,” Carvalho explains. “Then the rings rapidly recovered, closed the gap, and kept constricting.”

The rings could even recover from multiple sequential cuts. In one experiment, Silva et al. severed the same ring 22 times, preventing it from resealing for 5 minutes. Yet the open ring continued to constrict, showing that a continuous ring is not necessary for constriction.

By comparing how far rings snapped open when severed at different stages of cytokinesis, Silva et al. found that, at the start of cytokinesis, severed rings snap open further and form a larger gap than rings severed at later stages of division. This indicates that the cortical tension that resists ring constriction decreases as rings grow smaller. Interestingly, “it always took the same amount of time—about 22 seconds—for cells to repair the gap, no matter how large or small it was,” Carvalho says. This suggested that cells repair rings by recruiting new material throughout the gap, rather than adding new components to the two severed ends of the ring. (If repair depended on the latter mechanism, larger gaps would take longer to repair). Accordingly, the researchers saw that GFP-myosin II was recruited to distinct foci spaced throughout the gap in the severed ring. These foci of myosin recruitment might correspond to sites of actin nucleation because inhibiting actin polymerization with low doses of latrunculin A impaired ring repair after laser microsurgery.

Remarkably, Silva et al. found that, after they were successfully repaired, actomyosin rings constricted faster than normal, allowing cells to complete cytokinesis at the same time as control cells whose rings were never damaged. This could be due, in part, to the fact that cells transiently recruited an excess of myosin II molecules to the repaired region of the ring. In addition, the authors propose that the presence of the gap could allow for the incorporation of new contractile modules that would contribute to the velocity of the ring. Thus, the work supports the idea that cytokinetic rings are modular structures composed of autonomous contractile units that allow cytokinesis to be completed on time, even if the ring is damaged in some way during constriction.

“Now we want to understand the molecular mechanisms underlying ring repair,” Carvalho says. “How is repair triggered? Why is there a hyperaccumulation of myosin at the repair site, and does this contribute to the increased velocity of ring constriction after repair?”

1. Green, R.A., et al. 2012. Annu. Rev. Cell Dev. Biol. 28:29–58.
2. Silva, A.M., et al. 2016. J. Cell Biol. http://dx.doi.org/10.1083/jcb.201605080