Apical accumulation of MARCKS in neural plate cells during neurulation in the chick embryo

ABSTRACT

MARCKS is transiently accumulated at the apical region of neural plate and lens placode cells during processes of bending. This asymmetric subcellular distribution of MARCKS starts before the onset of neural plate bending. These results suggest possible upstream regulatory actions of MARCKS on some functions of the actin subapical meshwork.

INTRODUCTION

Background Major tissue movements during neurulation include neural plate bending as well as neural folds elevation and its convergence to fuse and close the neural tube. These movements of the neural plate result from the actions of extrinsic and intrinsic forces, and the latter are believed to be mainly driven by the actin cytoskeleton. Neural plate cells are polarized cells; actin and myosin are mainly restricted to regions of cell narrowing, especially to the apical border of the epithelium. In the apical region, cells are joined together by extensive actin-associated zonula adherens cell junctions, which are thought to be important in invagination processes. Knockout analyses in mice have shown that some actin binding or adherens junction proteins are important for neural tube formation. Examples of these proteins are: vinculin, shroom, and the two closely related actin cross-linking proteins MARCKS (Myristoylated Alanine-Rich C Kinase Substrate) and MacMARCKS (also called F52 and MRP). MARCKS is a ubiquitous protein substrate for different PKC family kinases and proline directed kinases such as MAPK and Cdks. Its PKC-phosphorylation domain or PSD (Phosphorylation Site Domain) is highly conserved and it is also the site for interaction with other molecules, such as calcium-calmodulin, negatively charged membrane phospholipids and F-actin. Binding to calcium-calmodulin and plasma membrane, as well as actin filament cross-linking activity, are antagonized by PSD phosphorylation. Conversely, calcium-calmodulin binding inhibits PSD phosphorylation and actin crosslinking. In addition to neural tube closure, MARCKS and MacMARCKS have been implicated in several other events related to actin cytoskeleton, such as cell motility, cell spreading, membrane ruffling, phagocytosis, exocytosis and neurite outgrowth. To examine possible anatomical relationships between MARCKS and actin during bending movements, we double labelled chick embryo cryosections at levels showing cranial and spinal neurulation. To compare with other invaginating epithelia we also analyzed the localization of these proteins in the lens placode finding that, in both cases, MARCKS is transiently accumulated in the apical border of the bending epithelia, in a position very close to the apical actin belt. In our knowledge, this is the first report showing a polarized distribution of MARCKS towards an apical cell border, as well as its association with the progression of an essential morphogenetic movement.

CONCLUSION

Conclusions Our results show that MARCKS protein is transiently accumulated to the apical border of neural plate and lens placode cells, in close apposition to the apical actin meshwork, during the processes of neural tube and lens vesicle formation. These observations provide additional structural counterparts to the knockout and transgenic mice analyses, although they also generate new problems, as respect to the role

of MARCKS in spinal neural plate bending. In addition, these new results concerning an apical concentration of MARCKS open new questions about the mechanisms able to generate and transiently maintain its asymmetric distribution.