KIF3A is essential for sperm tail formation and manchette function

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Background.
The correct formation of the sperm tail and manchette are essential for male fertility. Sperm tail development is a complex process organized by intraflagellar transport (IFT), mechanism that is utilized to transport molecules along the axonemal microtubule doublets. Two motor proteins are responsible for the transport; kinesin II, the anterograde motor, carries particles from the base towards the site of tail assembly. The retrograde motor, dynein, restores particles and motorproteins back to the pool of IFT components. Manchette is a microtubule and F-actin containing structure that appears transiently during spermiogenesis. It serves as a platform for intramanchette transport (IMT) where particles are carried first from the cytosol or Golgi to the manchette and then IMT delivers proteins to the sperm head or basal body region. We are interest in one of the kinesin II motor protein subunits, KIF3A, which has been shown to be present during sperm tail development, but its specific functions during spermiogenesis are poorly understood.
Results.
We have localized KIF3A in wild type mice in the manchette, basal body and flagella of elongating spermatids and in the principal piece of mature sperm tail. The depletion of KIF3A results in defects at late spermatogenesis. Spermatogonia, spermatocytes and round spermatids appear normal, but elongating spermatids have short and immotile flagella with disorganized axoneme and accessory structures. Manchette is elongated and perinuclear ring seems to squeeze the developing head causing its knob-like appearance. We were able to identify meiosis-specific nuclear structural protein 1 (MNS1) as an interacting partner for KIF3A. These proteins co-localize in the manchette and principal piece of the sperm tail. MNS1 appears to be delivered through manchette to the sperm tail, where it is required for the assembly of the flagella. In KIF3A KO mice manchette clearance was delayed and MNS1 staining remained in the manchette.
Conclusions.
Depletion of KIF3A causes defects during sperm tail development, manchette function and head shaping. Its interaction with MNS1 indicates that KIF3A may be involved in the transport of MNS1 to the developing tail. MNS1 concentrates in the manchette in the KIF3A KO mice suggesting a delay in the transport through the IMT. In addition, MNS1 and KIF3A co-localize in principal piece indicating the possible interaction site in mature sperm. We suggest that KIF3A has a role in manchette formation and function in addition to its well defined role in IFT. This study also highlights the essential role of KIF3A and IFT during spermiogenesis.