

TUBB3 Gene

Subjects: Genetics & Heredity

Contributor: Hongliu Chen

Tubulin beta 3 class III.

Keywords: genes

1. Normal Function

The *TUBB3* gene provides instructions for making one version of a protein called beta-tubulin (β -tubulin). This protein is part of the tubulin family of proteins that form and organize cell structures called microtubules. Microtubules are rigid, hollow fibers that make up the cell's structural framework (the cytoskeleton). They are composed of β -tubulin and a similar protein called alpha-tubulin (α -tubulin) that is produced from a different gene. Microtubules grow and shrink as tubulin proteins are added to and removed from the ends of fibers. This process allows cells to move and change shape.

β -tubulin produced from the *TUBB3* gene is found in nerve cells (neurons) in the brain. This β -tubulin protein plays a role in the growth of specialized nerve cell extensions called axons and dendrites (collectively called neurites). Studies show this protein is particularly important for the regrowth of neurites after injury. Neurites relay messages to and from the brain to control muscle movement and detect sensations.

In addition to their role in cell movement, microtubules also function as a track along which other proteins, called motor proteins, transport materials within cells. β -tubulin produced from the *TUBB3* gene appears to be important in the attachment of motor proteins to microtubules.

2. Health Conditions Related to Genetic Changes

2.1. Congenital Fibrosis of the Extraocular Muscles

More than 10 mutations in the *TUBB3* gene can cause congenital fibrosis of the extraocular muscles (CFEOM). These mutations most commonly cause a form of the condition called CFEOM3, and they are a rare cause of another form called CFEOM1. Individuals with any form of CFEOM are unable to move their eyes normally; they have difficulty looking upward or, less commonly, side-to-side, and most also have droopy eyelids (ptosis). In addition, people with CFEOM3 can have intellectual disability; behavioral, social, or language problems; or other neurological problems.

The *TUBB3* gene mutations that cause CFEOM change single protein building blocks (amino acids) in the β -tubulin protein. The altered proteins assemble into microtubules, although some do so more readily than others. Research shows that when more altered β -tubulin protein is incorporated into microtubules, the signs and symptoms of the condition are more severe.

Microtubules made with altered β -tubulin proteins do not grow and shrink as they should, which prevents neurite growth. Nerves in the head and face (cranial nerves) that control muscles that surround the eyes (extraocular muscles) are particularly affected, although other nerves can also be involved. Abnormal growth of cranial nerves impairs the function of extraocular muscles, leading to the characteristic features of CFEOM such as restricted eye movement and droopy eyelids. Researchers suspect that abnormal growth of neurites within the brain leads to brain abnormalities that underlie intellectual disability and other neurological problems in some people with CFEOM3.

Certain mutations in the *TUBB3* gene also appear to prevent motor proteins from attaching to microtubules. These mutations typically cause severe CFEOM3 that is associated with additional neurological problems, such as pain, weakness, or a decreased ability to feel sensations in the limbs (peripheral neuropathy) that begins in childhood or adulthood. It is unclear how these genetic changes contribute to specific signs and symptoms in severely affected individuals.

2.2. Other Disorders

Mutations in the *TUBB3* gene can also cause a condition called cortical dysplasia, complex, with other brain malformations 1 (CDCBM1). The brain abnormalities associated with this condition lead to intellectual disability, weak muscle tone (hypotonia), and progressive muscle stiffness (spasticity) in affected individuals. Brain malformations in CDCBM1 result from abnormal development of the surface of the brain (the cortex) and other regions such as a group of structures deep in the brain called the basal ganglia, which helps control movement; the tissue that connects the left and right halves of the brain (the corpus callosum); and the brainstem, which connects the upper parts of the brain with the spinal cord and regulates many basic body functions. Affected individuals do not typically have problems with the extraocular muscles as in CFEOM (described above). It is thought that mutations in the *TUBB3* gene disrupt the movement of neurons and axons to their correct locations, altering brain development and leading to brain malformations.

3. Other Names for This Gene

- class III beta-tubulin
- Tubulin, Beta 3 Class III Gene
- TUBULIN, BETA, CLASS III
- TUBULIN, BETA-3

References

1. Chew S, Balasubramanian R, Chan WM, Kang PB, Andrews C, Webb BD, MacKinnon SE, Oystreck DT, Rankin J, Crawford TO, Geraghty M, Pomeroy SL, Crowley WF Jr, Jabs EW, Hunter DG, Grant PE, Engle EC. A novel syndrome caused by the E410K amino acid substitution in the neuronal β -tubulin isotype 3. *Brain*. 2013 Feb;136(Pt2):522-35. doi: 10.1093/brain/aws345.
2. Grant PE, Im K, Ahtam B, Laurentys CT, Chan WM, Brainard M, Chew S, Drottar M, Robson CD, Drmic I, Engle EC. Altered White Matter Organization in the TUBB3E410K Syndrome. *Cereb Cortex*. 2019 Jul 22;29(8):3561-3576. doi:10.1093/cercor/bhy231.
3. Latremoliere A, Cheng L, DeLisle M, Wu C, Chew S, Hutchinson EB, Sheridan A, Alexandre C, Latremoliere F, Sheu SH, Golidy S, Omura T, Huebner EA, Fan Y, Whitman MC, Nguyen E, Hermawan C, Pierpaoli C, Tischfield MA, Woolf CJ, Engle EC. Neuronal-Specific TUBB3 Is Not Required for Normal Neuronal Function but Is Essential for Timely Axon Regeneration. *Cell Rep*. 2018 Aug 14;24(7):1865-1879.e9. doi: 10.1016/j.celrep.2018.07.029.
4. Romaniello R, Arrigoni F, Fry AE, Bassi MT, Rees MI, Borgatti R, Pilz DT, Cushion TD. Tubulin genes and malformations of cortical development. *Eur J Med Genet*. 2018 Dec;61(12):744-754. doi: 10.1016/j.ejmg.2018.07.012.
5. Tischfield MA, Baris HN, Wu C, Rudolph G, Van Maldergem L, He W, Chan WM, Andrews C, Demer JL, Robertson RL, Mackey DA, Ruddle JB, Bird TD, Gottlob I, Pieh C, Traboulsi EI, Pomeroy SL, Hunter DG, Soul JS, Newlin A, Sabol LJ, Doherty EJ, de Uzcátegui CE, de Uzcátegui N, Collins ML, Sener EC, Wabbels B, Hellebrand H, Meitinger T, de Berardinis T, Magli A, Schiavi C, Pastore-Trossello M, Koc F, Wong AM, Levin AV, Geraghty MT, Descartes M, Flaherty M, Jamieson RV, Møller HU, Meuthen I, Callen DF, Kerwin J, Lindsay S, Meindl A, Gupta ML Jr, Pellman D, Engle EC. Human TUBB3 mutations perturb microtubule dynamics, kinesin interactions, and axon guidance. *Cell*. 2010 Jan 8;140(1):74-87. doi:10.1016/j.cell.2009.12.011.
6. Whitman MC, Andrews C, Chan WM, Tischfield MA, Stasheff SF, Brancati F, Ortiz-Gonzalez X, Nuovo S, Garaci F, MacKinnon SE, Hunter DG, Grant PE, Engle EC. Two unique TUBB3 mutations cause both CFEOM3 and malformations of cortical development. *Am J Med Genet A*. 2016 Feb;170A(2):297-305. doi:10.1002/ajmg.a.37362.