Title: *KCNQ2*-Related Disorders *GeneReview* Table 4

Authors: Miceli F, Soldovieri MV, Joshi N, Weckhuysen S, Cooper E, Taglialatela M

Updated: March 2016

Note: The following information is provided by the authors listed above and has not been reviewed by *GeneReviews* staff.

Table 4. Overview of the Available Genetic, Clinical, and Functional Data from Families Affected with *KCNQ2*-Related Disorders

DNA Nucleotide Change	Amino Acid Change	Localization	Clinical Data	Functional Effects	Reference
c.(?_-177)_690+?del	p.=0?	N-terminal	BFNE	---	Soldovieri et al [2014]
c.1-?c.993+?del	p.?		BFNE	---	Heron et al [2007], Grinton et al [2015]
c.1A>G	p.Met1?		BFNE	---	Richards et al [2004], Grinton et al [2015], Milh et al [2015]
c.2T>C	p.Met1?		BFNE	---	Richards et al [2004], Grinton et al [2015]
c.63_66delGGTG	p.Val22AlafsTer18		BFNE	---	Goldberg-Stern et al [2009], Grinton et al [2015]
c.204_205insC	p.Lys69GlnfsTer50		BFNE	---	Richards et al [2004], Grinton et al [2015]
c.232delC	p.Gln78ArgfsTer54		BFNE	---	Claes et al [2004]
c.296+1G>A	p.Val99?	S1 helix	BFNE		Steinlein et al [2007]
c.297-2A>G	p.Val99?		BFNIS	---	Zara et al [2013]
c.314_316delCCT	p.Ser105del		BFNE	---	Claes et al [2004]
c.333_334delGT	p.Ser113HisfsTer6		BFNE	---	Soldovieri et al [2014]
c.340A>G	p.Thr114Ala		BFNE with later seizure recurrence	---	Grinton et al [2015]
c.341C>T	p.Thr114Ile		Likely EE	---	Saitsu et al [2012]
c.346_348delAAG	p.Lys116del	S1-S2 loop	ABPE	Reduction in current amplitude	Hahn & Neubauer [2009], Neubauer et al [2008]
c.356A>G	p.Glu119Gly		BFNE	Slight rightward shift in current voltage-dependence in the sub-threshold region; Slight decrease in current activation kinetics	Wuttke et al [2008]
c.365C>T	p.Ser122Leu		BFNE; FS in later life; seizures until 7	Rightward shift in current voltage-dependence in the sub-threshold region;	Hunter et al [2006]

DNA Nucleotide Change	Amino Acid Change	Localization	Clinical Data	Functional Effects	Reference
			years	decrease in current activation kinetics	
c.387+1G>T	p.Leu129?	S2 helix	BFNE	---	Singh et al [2003]
c.388-2_388delAGG	p.Glu130?		BFNE	---	Steinlein et al [2007]
c.431G>A	p.Arg144Gln		Infantile spasms	CHO cells: apparent gain-of-function due to reduction in membrane depolarization requirement for activation, no change in maximal current with strong depolarization, but increased current at rest.	Allen et al [2013], Miceli et al [2015]
c.460T>G	p.Tyr154Asp	S2-S3 loop	BFNIS	---	Zara et al [2013]
c.471G>A	p.Trp157Ter		Uncertain severity	---	Milh et al [2013]
c.474-940_c.1424+1582del	p.?		BFNE	---	Heron et al [2007] Grinton et al [2015]
c.475G>A	P.Gly159Arg		BFNE	---	Grinton et al [2015]
c.476G>A	p.Gly159Glu		BFNE	---	Zara et al [2013]
c.523G>C	p.Val175Leu	S3 helix	Infantile spasms	---	Samanta et al [2015], Milh et al [2013]
c.565-682_c.1295+?del	p.?	S3-S4 linker	BFNE	---	Grinton et al [2015]
c.565-?_c.1478+?(2)	p.?		BFNE	---	Heron et al [2007], Grinton et al [2015]
c.566G>T	p.Gly189Val		EE	---	Milh et al [2013]
c.583T>C	p.Ser195Pro		Infantile spasms	---	Weckhuysen et al [2013]
c.584_593delCTGCGCTCCGinsA	p.Ser195Ter		West syndrome with mild mental retardation	Lack of functional homomeric channels; markedly reduced current amplitude in heteromeric channels	Bassi et al [2005]
c.585_586insT	p.Ala196CysfsTer66		BFNE	---	Moulard et al [2001]
c.587C>T	p.Ala196Val		BFNE, Rolandic Seizures, Infantile spams	Rightward shift in current voltage-dependence; decrease in current activation kinetics; novel prepulse-dependence of current activation kinetics	Soldovieri et al [2007], Carvill et al [2013], Zara et al [2013]
c.[587C>T:590T>C]	p.[Ala196Val:Leu197Pro]		BFNE	Rightward shift in current voltage-dependence; decrease in current	Moulard et al [2001], Soldovieri et al [2007]

DNA Nucleotide Change	Amino Acid Change	Localization	Clinical Data	Functional Effects	Reference
				activation kinetics	
c.592_594delCGGinsA	p.Arg198LysfsTer63	S4 helix	BFNIS	---	Zara et al [2013]
c.601C>T	p.Arg201Cys		EE	CHO cells: expressed with wild-type KCNQ2 or with both wild-type KCNQ2 and KCNQ3 to mimic the heterozygous state, reduces the depolarization required for channel activation (gain of function).	Weckhuysen et al [2013], Miceli et al [2015]
c.602G>A	p.Arg201His		EE	---	Carvill et al [2013]
c.608T>C	p.Leu203Pro		EE	---	Milh et al [2015]
c.613A>G	p.Ile205Val		EE	Oocytes: expressed with wild-type KCNQ2 or with both wild-type KCNQ2 and KCNQ3 to mimic the heterozygous state, increases the depolarization required for channel activation.	Weckhuysen et al [2012], Pisano et al [2015], Orhan et al [2014], Dedek et al [2001]
c.619C>T	p.Arg207Trp		BFNE , Myokymia, EE	Marked rightward shift in current voltage-dependence; dramatic decrease in current activation kinetics	Dedek et al [2001], Blumkin et al [2012], Soldovieri et al [2014], Milh et al [2015]
c.620G>A	p.Arg207Gln		Myokymia, EE	Rightward shift in current voltage-dependence; decrease in current activation kinetics	Wuttke et al [2007], Milh et al [2015]
c.622A>G	p.Met208Val		BFNE. GS between 4 and 7 years	Small decrease in maximal current; increased rate of channel deactivation	Singh et al [2003]
C.628C>T	p.Arg210Cys		EE	---	Mercimek-Mahmutoglu et al [2015]
c.629G>A	p.Arg210His		EE	---	Weckhuysen et al [2013], Numis et al [2014]
c.635A>G	p.Asp212Gly		BFNE	Rightward shift in current voltage-dependence; increased rate of channel deactivation	Miceli et al [2009]
c.637C>T	p.Arg213Trp		BFNE, EE	Rightward shift in current voltage-dependence; increased rate of channel deactivation	Sadewa et al [2008], Miceli et al [2013], Milh et al [2015]

DNA Nucleotide Change	Amino Acid Change	Localization	Clinical Data	Functional Effects	Reference
c.638G>A	p.Arg213Gln		EE	Marked rightward shift in current voltage-dependence (more intense that the p. R213W mutation); increased rate of channel deactivation	Weckhuysen et al [2012], Miceli et al [2013], Grinton et al [2015]
c.640C>T	p.Arg214Trp		BFNE	Slight rightward shift in current voltage-dependence; no effect on maximal current amplitude	Miraglia del Giudice et al [2000], Castaldo et al [2002]
c.643G>A	p.Gly215Arg	S4-S5 linker	Uncertain severity	---	Dalen Meurs-van der Schoor et al [2014]
c.649A>G	p.Thr217Ala		BFIS	Oocytes: expressed with KCNQ3 Thr246Ala (the homologous residue to this variant)—moderate increase in the depolarization required for channel activation, normal total cellular protein and normal surface expression.	Surti et al [2005], Zara et al [2013]
c.650C>A	p.Thr217Asn		Uncertain severity	Oocytes: expressed with KCNQ3 Thr246Ala (the homologous residue to KCNQ2 Thr246Ala variant)—moderate increase in the depolarization required for channel activation, normal total cellular protein and normal surface expression.	Surti et al [2005], Kato et al [2013]
c.684C>A	p.His228Gln		BFNE	---	Singh et al [2003]
c.700A>C	p.Thr234Pro	S5 helix	EE	---	Mercimek-Mahmutoglu et al [2015]
c.715G>C	p.Gly239Arg		EE	---	Milh et al [2013]
c.727C>T	p.Leu243Phe		BFNE	---	Singh et al [2003]
c.740C>A	p.Ser247Ter		BFNE	---	Hunter et al [2006]
c.740C>G	p.Ser247Trp		Identified in a boy with EE; mother with BNE (possible mosaicism; uncertain severity)	Markedly reduced maximal current amplitude (dominant-negative effect on Kv7.2 channels)	Dedek et al [2003]
c.749T>G	p.Val250Gly		Uncertain severity	---	Moulard et al [2001]

DNA Nucleotide Change	Amino Acid Change	Localization	Clinical Data	Functional Effects	Reference
c.757G>A	p.Ala253Thr		Uncertain severity	---	Milh et al [2015]
c.773A>G	p.Asn258Ser	Pore loop	BFNE. FS at 10 months	---	Yalcin et al [2007], Maljevic et al [2011]
c.793G>A	p.Ala265Thr		EE	---	Milh et al [2013], Weckhuysen et al [2013]
c.793G>C	p.Ala265Pro		EE	---	Weckhuysen et al [2012], Orhan et al [2014]
c.794C>T	p.Ala265Val		EE	---	Saitsu et al [2012], Kato et al [2013], Milh et al [2015]
c.802C>T	p.Leu268Phe		EE	---	Pisano et al [2015]
c.807G>A	p.Trp269Ter		BFNE. 1/7 late onset; 2/7 FS+GS in adulthood	---	Singh et al [2003]
c.812G>T	p.Gly271Val		BFIS	---	Zhou et al [2006], Wang et al [2015]
c.821C>T	p.Thr274Met		EE	---	Weckhuysen et al [2012], Milh et al [2013], Orhan et al [2014], Milh et al [2015]
c.827C>T	p.Thr276Ile		EE	---	Martin et al [2014]
c.835G>T	p.Gly279Cys		EE	---	Milh et al [2015]
c.836G>A	p.Gly279Ser		No human patient described	Marked dominant-negative current suppression. This variant has been studies studied in an over-expression transgenic mouse model, with severe phenotype. The homologous variant in KCNQ1 causes autosomal dominant LQTS.	Peters et al [2005]
c.841G>A	p.Gly281Arg		EE	---	Weckhuysen et al [2013]
c.841G>T	p.Gly281Trp		EE	---	Pisano et al [2015]
c.847_848insGT	p.Lys283SerfsTer36		BFNE. 5/19 GS between 21 and 45 years	---	Singh et al [1998]
c.851A>G	p.Tyr284Cys		BFNE	Markedly reduced current amplitude	Schroeder et al [1998], Singh et al [1998], Castaldo et al [2002]
c.854C>A	p.Pro285His		EE	---	Kato et al [2013]

DNA Nucleotide Change	Amino Acid Change	Localization	Clinical Data	Functional Effects	Reference
c.860C>A	p.Thr287Asn		EE	---	Milh et al [2013]
c.868G>A	p.Gly290Ser		EE	---	Kato et al [2013], Milh et al [2013]
c.869G>A	p.Gly290Asp		BFNE	Oocytes: Q2wt:Q2mut, ~70% reduced current; Q2wt:Q2mut:Q3, ~70% reduced current.	Weckhuysen et al [2012], Orhan et al [2014]
c.881C>G	p.Ala294Gly		BFNE	---	Steinlein et al [2007]
c.881C>T	p.Ala294Val		EE	This mutation alters the Im current and the localization of the KCNQ2/KCNQ3 tetramers with neurons.	Allen et al [2013], Kato et al [2013], Milh et al [2013], Allen et al [2014], Pisano et al [2015]
c.886A>C	p.Thr296Pro	S6 helix	EE	---	Milh et al [2013]
c.901G>A	p.Gly301Ser		EE	---	Milh et al [2015]
c.911T>C	p.Phe304Ser		EE	---	Milh et al [2013]
c.910_912delTTT/Cor c.913_915delTTC	p.Phe305del		BECTS	Lack of functional homomeric channels	Ishii et al [2009], Ishii et al [2012]
c.915C>A	p.Phe305Leu		EE	---	Weckhuysen et al [2013]
c.916G>A	p.Ala306Thr		BFNE. 11/69 FS; GS between 1 and 16 years	Oocytes: Q2wt:Q2mut:Q3, 20-30% reduced current	Schroeder et al [1998], Singh et al [1998], Soldovieri et al [2014]
c.917C>T	p.Ala306Val		EE	---	Carvill et al [2013], Milh et al [2015]
c.926C>T	p.Ala309Val		EE	---	Milh et al [2013]
c.928-1G>C	p.Gly310?		BFNE	---	Soldovieri et al [2014]
c.939_940insG	p.Ser314ValfsTer16		Uncertain severity	---	Steinlein et al [2007]
c.943G>C	p.Gly315Arg		EE	---	Weckhuysen et al [2013]
c.967C>T	p.Gln323Ter	Proximal C-terminal	BFNE. 2/6 BECTS at 2 and 4 years	Lack of functional homomeric channels; marked reduction in current amplitude in heteromeric channels	Singh et al [2003]
c.973A>C	p.His324Arg		EE	---	Numis et al [2014]; erratum corrected is c.973A>G; p.Arg325Gly.

DNA Nucleotide Change	Amino Acid Change	Localization	Clinical Data	Functional Effects	Reference
c.973A>G	p.Arg325Gly		EE	No published data on this observed variant. Telezhkin studied the related but more conservative Arg325Ala in detail, expressed alone and compared to wild type KCNQ2 (CHO cells): 60% reduced current, reduced PIP2 binding, did not perform studies mimicking heterozygosity or of KCNQ3 co-expression.	Telezhkin et al [2013], Weckhuysen et al [2013], Numis et al [2014]
c.997C>T	p.Arg333Trp		EE	---	Schmitt et al [2005], Kato et al [2013], Milh et al [2013]
c.998G>A	p.Arg333Gln		BFNE	Reduction in current amplitude; Faster rate of current deactivation	Singh et al [2003]
c.1010C>G	p.Ala337Gly	C-terminal helix A	EE	---	Saitsu et al [2012]
c.1016T>G	p.Leu339Arg		BFNE	---	Moulard et al [2001]
c.1024-2A>G	p.Ser342?		EE	---	Milh et al [2015]
c.1030T>C	p.Trp344Arg		BFNE	CHO: Q2mut, no current expression; Q2wt:Q2mut:Q3, ~50% current reduction	Soldovieri et al [2014]
c.1051C>G	p. Leu351Val	C-terminal	BFNE	CHO: no effect on maximal current (in homomers or heteromers); slightly reduced Syx effects	Soldovieri et al [2014]
c.1051C>T	p.Leu351Phe		BFNE	CHO:Q2wt:Q2mut:Q3, ~ 20%reduced current expression; reduced Syx effects	Soldovieri et al [2014]
c.1053C>T	p.Leu351Leu		EE	---	Milh et al [2015]
c.1054T>C	p.Ser352Pro		BFNE	---	Grinton et al [2015]
c.1057C>G	p.Arg353Gly		BFNE	Reduced interaction with CaM	Richards et al [2004], Etxeberria et al [2008], Grinton et al [2015]
c.1058G>A	p.Arg353His		EE	---	Milh et al [2015]
c.1066C>G	p.Leu356Val		EE	---	Milh et al [2015]
c.1073C>T	p.Ser358Phe		BFNE	---	Grinton et al [2015]

DNA Nucleotide Change	Amino Acid Change	Localization	Clinical Data	Functional Effects	Reference
c.1076C>A	p.Thr359Lys		BFNE	Slight rightward shift in current voltage-dependence; reduction in current amplitude in heteromeric channels; decrease in current activation kinetics	Volkers et al [2009]
c.1085A>G	p.Tyr362Cys		BFNE	CHO: no effect on maximal current (in homomers or heteromers); slightly reduced Syx effects	Soldovieri et al [2014]
c.1118+1G>A	p.Ser373?		BNE	---	Claes et al [2004]
c.1118+3A>G	p.Ser373?		BFNE	---	Zara et al [2013]
c.1126delA	p.Thr376LeufsTer12		BFNE	---	Saadeldin et al [2013]
c.1119-?_(*382)del	p.?		BFNIS; 4/11 FS, GS until 10 yrs	---	Singh et al [1998]
c.1148+2T>G	p.Arg383?		BFNE	---	Lee et al [2000]
c.1192_1193delAA	p.Lys398GlufsTer1		BFNIS	---	Pereira et al [2004]
c.1195_1196delAG	p.Ser399Ter		BFNE	CHO: no current expression	Soldovieri et al [2014]
c.1203T>C	p.Ser401Ser		EE	---	Milh et al [2015]
c.1217+2T>G	p.Arg406?		BFNE	---	Lee et al [2000], Steinlein et al [2007]
c.1229?	p.Pro410fsTer12		BFNE	Slight rightward shift in current voltage-dependence; reduction in current amplitude in heteromeric channels; decrease in current activation kinetics	Volkers et al [2009]
c.1247+1G>A	p.Ser416?		BFNE	---	Grinton et al [2015]
c.1248-?_(*455_?)del	p.?		BFNE	---	Soldovieri et al [2014]
c.1259C>T	p.Pro420Met		EE	---	Milh et al [2015]
c.1264G>A	p.Val422Ile		EE	---	Milh et al [2015]
c.1302-1G>C	p.Ser434?		BFNE	---	Steinlein et al [2007]
c.1342C>T	p.Arg448Ter		BFNIS	30% reduction in maximal current amplitude in heteromeric channels	Moulard et al [2001], Singh et al [2003], Richards et al [2004], Yum et al [2010], Zara et al [2013]

DNA Nucleotide Change	Amino Acid Change	Localization	Clinical Data	Functional Effects	Reference
c.1382A>C	p.Gln461Pro		EE	---	Carvill et al [2013]
c.1418_1419delTC	p.Leu473ArgfsTer47		BFNE	---	Grinton et al [2015]
c.1479-768_c.1940+579del3018bp	p.?		BFNE	---	Heron et al [2007], Grinton et al [2015]
c.1481?	p.Gln494fs		BFNE	---	Lerche et al [2001]
c.1501G>C	p.Ala501Pro		EE	---	Milh et al [2015]
c.1525+1G>A	p.Glu509?		BFNE	---	Richards et al [2004]
c.1545G>C	p.Glu515Asp		BFNE	---	Lee et al [2009]
c.1569_1581delCCCTGCGAGTTT	p.Cys523TrpfsTer1		BFNIS; 1/6 FS at 2 years	---	Singh et al [1998]
c.1602G>A	p.Pro534Pro	C-terminal helix B	Non-pathogenic	---	Milh et al [2015]
c.1609A>T	p.Lys537Ter		BFNE	---	Soldovieri et al [2014]
c.1621A>G	p.Arg541Gly		Uncertain severity	Part of a consensus sequence for protein kinase C phosphorylation, no functional effect seen if the site was eliminated by mutagenesis (S539A)	Hoshi et al [2003], Milh et al [2015]
c.1631+1G>A	p.Cys544?		BFNE	---	Singh et al [1998], Grinton et al [2015]
c.1632-1G>T	p.Cys544?		BFNE	---	Steinlein et al [2007]
c.1636A>G	p.Met546Val		EE	---	Weckhuysen et al [2012], Orhan et al [2014]
c.1639C>T	p.Arg547Trp		BFNE	---	Zara et al [2013]
c.1641G>A	p.Arg547Arg		Non-pathogenic	---	Milh et al [2015]
c.1652T>C	p.Met551Thr		Non-pathogenic	---	Milh et al [2015]
c.1655A>C	p.Lys552Thr		EE	---	Weckhuysen et al [2013], Pisano et al [2015]
c.1657C>T	p.Arg553Trp		EE	R553 is part of a consensus sequence for protein kinase C phosphorylation, if the site was eliminated by mutagenesis (S551A), muscarinic modulation of KCNQ2 homomers in HEK cells was reduced 60%. no functional studies of the variant. See Arg 553Trp	Hoshi et al [2003], Kato et al [2013]

DNA Nucleotide Change	Amino Acid Change	Localization	Clinical Data	Functional Effects	Reference
c.1658G>A	p.Arg553Gln		BFNE	R553 is part of a consensus sequence for protein kinase C phosphorylation, if the site was eliminated by mutagenesis (S551A), muscarinic modulation of KCNQ2 homomers in HEK cells was reduced 60% R553 (CHO): Q2wt:Q2mut:Q3, 15% reduced current.	Moulard et al [2001], Hoshi et al [2003], Soldovieri et al [2014]
c.1658G>T	p.Arg553Leu		EE	---	Kato et al [2013]
c.1662G>C/T	p.Lys554Asn		Uncertain severity. 2/4 therapy-resistant seizures and intellectual disability	Slight rightward shift in current voltage-dependence; no effect on maximal current amplitude	Borgatti et al [2004]
c.1666A>G	p.Lys556Glu	C-terminal	EE	---	Weckhuysen et al [2013]
c.1678C>T	p.Arg560Trp		EE	Slight rightward shift in current voltage-dependence; no effect on maximal current amplitude	Hoshi et al [2003], Weckhuysen et al [2012], Orhan et al [2014], Pisano et al [2015]
c.1684_1685dupGCCCT	p.Tyr562CysfsTer4		BFNE	Lack of functional homomeric channels; reduction maximal current amplitude of heteromeric channels	Biervert et al [1998], Grinton et al [2015]
c.1682C>T	p.Pro561Leu		EE	---	Kato et al [2013]
c.1687G>A	p.Asp563Asn		EE	---	Weckhuysen et al [2013], Milh et al [2015]
c.1689C>G	p.Asp563Glu		EE	---	Kato et al [2013]
c.1689C>T	p.Asp563Asp		EE	---	Milh et al [2015]
c.1732A>G	p.Met578Val	C-terminal helix C	BFNE	---	Grinton et al [2015]
c.1734G>C	p.Met578Ile		EE	---	Numis et al [2014]
c.[1734G>A:1735C>A]	p.[Met578Ile:Leu579Met]		EE	---	Mercimek-Mahmutoglu et al [2015]
c.1741C>G	p.Arg581Gly		EE	---	Weckhuysen et al [2013]
c.1741C>T	p.Arg581Ter		BFNE	Slight rightward shift in current voltage-dependence; no effect on maximal current	Singh et al [2003], Grinton et al [2015]

DNA Nucleotide Change	Amino Acid Change	Localization	Clinical Data	Functional Effects	Reference
				amplitude	
c.1764-?_(*455_?)del	p.?		BFNE	---	Soldovieri et al [2014]
c.1764A>T	p.Arg588Ser		BFNE	Slight rightward shift in current voltage-dependence; no effect on maximal current amplitude	Richards et al [2004], Grinton et al [2015]
c.1764-2A>G	p.Arg588?		BFNE	---	Steinlein et al [2007]
c.1764-6C>A	p.Val589Ter		BFNE. In 1/11 seizures continued until 14 months of age; photosensitive myoclonic epilepsy at age 13 years	Slight rightward shift in current voltage-dependence; reduction in current amplitude in heteromeric channels	de Haan et al [2006], Volkers et al [2009]
c.1776C>G	p.Ile592Met	C-terminal	Uncertain severity	Oocytes: Q2mut, reduced current. No studies of co-expression mimicking heterozygous genotype found in patients	Neubauer et al [2008]
c.1783C>T	p.Arg595Trp		BFIS	---	Dyment et al [2015]
c.1856_1886del31bp	p.Met619ArgfsTer13		BFNE	---	Grinton et al [2015]
c.1887+5G>A	p.Gln629?	C-terminal helix D	BFNIS; FS	---	Zara et al [2013]
c.1910T>G	p.Leu637Arg		BFNE	Increased interaction with CaM	Richards et al [2004], Grinton et al [2015]
c.1930delT	p.Tyr644ThrfsTer285		BFNE. In all patients, seizures persisted until 12-18 months	---	Biervert & Steinlein [1999], Tang et al [2004]
c.1956delG	p.Thr653GlnfsTer276	C-terminal	BFNE	---	Singh et al [2003]
c.1956G>A	p.Pro652Pro		EE	---	Milh et al [2015]
c.2015delG	p.Ser672ThrfsTer257		BFNE. In all patients, seizures persisted until 12-18 months	---	Li et al [2003], Tang et al [2004]
c.2127delT	p.Val710SerfsTer219		BFNE	Lack of functional homomeric channels; reduction in current amplitude of heteromeric channels; decreased protein stability and	Coppola et al [2003], Soldovieri et al [2006], Zimprich et al [2006]

DNA Nucleotide Change	Amino Acid Change	Localization	Clinical Data	Functional Effects	Reference
				enhanced degradation	
c.2318_2319dupG	p.Cys774Leu fsTer90		BFNE	---	Milh et al [2013]
c.2597delG	p.Gly866AlafsTer63		BFNE	Reduction of current amplitude in homomeric and heteromeric channels	Lerche et al [1999], Su et al [2011]
c.2599_2603dupTGGGC	p.Arg871GlyfsTer61		BFNE	---	Soldovieri et al [2014]
c.2609_2610dupGGGCC	p.Arg871GlyfsTer60		BFNE. 3/12 seizures continued until age 2, 3, 7 years	Reduction in current amplitude; slight shift in activation voltage-dependence; slight acceleration of current deactivation	Singh et al [2003], Su et al [2011]
c.2613G>T	p.Arg871Ser		EE	---	Milh et al [2015]

FS: febrile seizures; GS: generalized seizures; BFNE: benign familial neonatal epilepsy; BNE: benign neonatal epilepsy; BFNIS: benign familial neonatal-infantile seizures; BFIS: benign familial infantile seizures; BECTS: benign epilepsy with centrotemporal spikes; ABPE: atypical benign partial epilepsy; EE: epileptic encephalopathy

Reference sequences. For *KCNQ2*, for clarity and homogeneity among different isoform sequences used in the literature, the ATG translation start codon is given nucleotide position 1 (NM_172107.2)

References

Allen AS, Berkovic SF, Cossette P, Delanty N, Dlugos D, Eichler EE, Epstein MP, Glauser T, Goldstein DB, Han Y, Heinzen EL, Hitomi Y, Howell KB, Johnson MR, Kuzniecky R, Lowenstein DH, Lu YF, Madou MR, Marson AG, Mefford HC, Esmaeeli Nieh S, O'Brien TJ, Ottman R, Petrovski S, Poduri A, Ruzzo EK, Scheffer IE, Sherr EH, Yuskaitis CJ, Abou-Khalil B, Alldredge BK, Bautista JF, Berkovic SF, Boro A, Cascino GD, Consalvo D, Crumrine P, Devinsky O, Dlugos D, Epstein MP, Fiol M, Fountain NB, French J, Friedman D, Geller EB, Glauser T, Glynn S, Haut SR, Hayward J, Helmers SL, Joshi S, Kanner A, Kirsch HE, Knowlton RC, Kossoff EH, Kuperman R, Kuzniecky R, Lowenstein DH, McGuire SM, Motika PV, Novotny EJ, Ottman R, Paolicchi JM, Parent JM, Park K, Poduri A, Scheffer IE, Shellhaas RA, Sherr EH, Shih JJ, Singh R, Sirven J, Smith MC, Sullivan J, Lin Thio L, Venkat A, Vining EP, Von Allmen GK, Weisenberg JL, Widdess-Walsh P, Winawer MR. (2013) De novo mutations in epileptic encephalopathies. Nature 501:217–21

Allen NM, Mannion M, Conroy J, Lynch SA, Shahwan A, Lynch B, King MD (2014) The variable phenotypes of KCNQ-related epilepsy. Epilepsia 55:e99-105.

Bassi MT, Balottin U, Panzeri C, Piccinelli P, Castaldo P, Barrese V, Soldovieri MV, Miceli F, Colombo M, Bresolin N, Borgatti R, Taglialatela M (2005) Functional analysis of novel KCNQ2 and KCNQ3 gene variants found in a large pedigree with benign familial neonatal convulsions (BFNC). Neurogenetics 6:185-93.

Biervert C, Schroeder BC, Kubisch C, Berkovic SF, Propping P, Jentsch TJ, Steinlein OK (1998) A potassium channel mutation in neonatal human epilepsy. Science 279:403-6.

Biervert C, Steinlein OK (1999) Structural and mutational analysis of KCNQ2, the major gene locus for benign familial neonatal convulsions. Hum Genet 104:234-40.

Blumkin L, Suls A, Deconinck T, De Jonghe P, Linder I, Kivity S, Dabby R, Leshinsky-Silver E, Lev D, Lerman-Sagie T (2012) Neonatal seizures associated with a severe neonatal myoclonus like dyskinesia due to a familial KCNQ2 gene mutation. Eur J Paediatr Neurol 16:356-60

Borgatti R, Zucca C, Cavallini A, Ferrario M, Panzeri C, Castaldo P, Soldovieri MV, Baschirotto C, Bresolin N, Dalla Bernardina B, Taglialatela M, Bassi MT (2004) A novel mutation in KCNQ2 associated with BFNC, drug resistant epilepsy, and mental retardation. Neurology 63:57-65.

Carvill GL, Heavin SB, Yendle SC, McMahon JM, O'Roak BJ, Cook J, Khan A, Dorschner MO, Weaver M, Calvert S, Malone S, Wallace G, Stanley T, Bye AM, Bleasel A, Howell KB, Kivity S, Mackay MT, Rodriguez-Casero V, Webster R, Korczyn A, Afawi Z, Zelnick N, Lerman-Sagie T, Lev D, Møller RS, Gill D, Andrade DM, Freeman JL, Sadleir LG, Shendure J, Berkovic SF, Scheffer IE, Mefford HC (2013) Targeted resequencing in epileptic encephalopathies identifies de novo mutations in CHD2 and SYNGAP1. Nat Genet 45:825-30

Castaldo P, del Giudice EM, Coppola G, Pascotto A, Annunziato L, Taglialatela M (2002) Benign familial neonatal convulsions caused by altered gating of KCNQ2/KCNQ3 potassium channels. J Neurosci 22:RC199.

Claes LR, Ceulemans B, Audenaert D, Deprez L, Jansen A, Hasaerts D, Weckx S, Claeys KG, Del-Favero J, Van Broeckhoven C, De Jonghe P (2004) De novo KCNQ2 mutations in patients with benign neonatal seizures. Neurology 63:2155-8.

Coppola G, Castaldo P, Miraglia del Giudice E, Bellini G, Galasso F, Soldovieri MV, Anzalone L, Sferro C, Annunziato L, Pascotto A, Taglialatela M (2003) A novel KCNQ2 K+ channel mutation in benign neonatal convulsions and centrotemporal spikes. Neurology 61:131-4.

Dalen Meurs-van der Schoor C, van Weissenbruch M, van Kempen M, Bugiani M, Aronica E, Ronner H, Vermeulen RJ (2014) Severe Neonatal Epileptic Encephalopathy and KCNQ2 Mutation: Neuropathological Substrate? Front Pediatr 2:136.

de Haan GJ, Pinto D, Carton D, Bader A, Witte J, Peters E, van Erp G, Vandereyken W, Boezeman E, Wapenaar MC, Boon P, Halley D, Koeleman BP Lindhout D (2006) A novel splicing mutation in KCNQ2 in a multigenerational family with BFNC followed for 25 years. Epilepsia 47:851-9.

Dedek K, Fusco L, Teloy N, Steinlein OK (2003) Neonatal convulsions and epileptic encephalopathy in an Italian family with a missense mutation in the fifth transmembrane region of KCNQ2. Epilepsy Res 54:21-7.

Dedek K, Kunath B, Kananura C, Reuner U, Jentsch TJ, Steinlein OK (2001) Myokymia and neonatal epilepsy caused by a mutation in the voltage sensor of the KCNQ2 K+ channel. Proc Natl Acad Sci U S A 98:12272-7.

Dyment DA, Tétreault M, Beaulieu CL, Hartley T, Ferreira P, Chardon JW, Marcadier J, Sawyer SL, Mosca SJ, Innes AM, Parboosingh JS, Bulman DE, Schwartzentruber J, Majewski J, Tarnopolsky M, Boycott KM; FORGE Canada Consortium; Care4Rare Canada (2015) Whole-exome sequencing broadens the phenotypic spectrum of rare pediatric epilepsy: a retrospective study. Clin Genet 88:34-40.

Etxeberria A, Aivar P, Rodriguez-Alfaro JA, Alaimo A, Villacé P, Gómez-Posada JC, Areso P, Villarroel A. Calmodulin regulates the trafficking of KCNQ2 potassium channels. FASEB J. 2008;22:1135-43.

Goldberg-Stern H, Kaufmann R, Kivity S, Afawi Z, Heron SE (2009) Novel mutation in KCNQ2 causing benign familial neonatal seizures. Pediatr Neurol 41:367-70.

Grinton BE, Heron SE, Pelekanos JT, Zuberi SM, Kivity S, Afawi Z, Williams TC, Casalaz DM, Yendle S, Linder I, Lev D, Lerman-Sagie T, Malone S, Bassan H, Goldberg-Stern H, Stanley T, Hayman M, Calvert S, Korczyn AD, Shevell M, Scheffer IE, Mulley JC, Berkovic SF (2015) Familial neonatal seizures in 36 families: Clinical and genetic features correlate with outcome. Epilepsia 56:1071-80.

Hahn A, Neubauer BA (2009) Sodium and potassium channel dysfunctions in rare and common idiopathic epilepsy syndromes. Brain Dev 31:515-20.

Heron SE, Cox K, Grinton BE, Zuberi SM, Kivity S, Afawi Z, Straussberg R, Berkovic SF, Scheffer IE, Mulley JC. Deletions or duplications in KCNQ2 can cause benign familial neonatal seizures. J Med Genet. 2007;44:791-6.

Hoshi N, Zhang JS, Omaki M, Takeuchi T, Yokoyama S, Wanaverbecq N, Langeberg LK, Yoneda Y, Scott JD, Brown DA, Higashida H. AKAP150 signaling complex promotes suppression of the M-current by muscarinic agonists. Nat Neurosci. 2003;6:564-71.

Hunter J, Maljevic S, Shankar A, Siegel A, Weissman B, Holt P, Olson L, Lerche H, Escayg A (2006) Subthreshold changes of voltage-dependent activation of the K(V)7.2 channel in neonatal epilepsy. Neurobiol Dis 24:194-201.

Ishii A, Fukuma G, Uehara A, Miyajima T, Makita Y, Hamachi A, Yasukochi M, Inoue T, Yasumoto S, Okada M, Kaneko S, Mitsudome A, Hirose S (2009) A de novo KCNQ2 mutation detected in non-familial benign neonatal convulsions. Brain Dev 31:27-33.

Ishii A, Miyajima T, Kurahashi H, Wang JW, Yasumoto S, Kaneko S, Hirose S (2012) KCNQ2 abnormality in BECTS: Benign childhood epilepsy with centrotemporal spikes following benign neonatal seizures resulting from a mutation of KCNQ2. Epilepsy Res 102:122-5.

Kato M, Yamagata T, Kubota M, Arai H, Yamashita S, Nakagawa T, Fujii T, Sugai K, Imai K, Uster T, Chitayat D, Weiss S, Kashii H, Kusano R, Matsumoto A, Nakamura K, Oyazato Y, Maeno M, Nishiyama K, Kodera H, Nakashima M, Tsurusaki Y, Miyake N, Saito K, Hayasaka K, Matsumoto N, Saitsu H (2013) Clinical spectrum of early onset epileptic encephalopathies caused by KCNQ2 mutation. Epilepsia 54:1282-7.

Lee IC, Chen JY, Chen YJ, Yu JS, Su PH (2009) Benign familial neonatal convulsions: novel mutation in a newborn. Pediatr Neurol 40:387-91.

Lee WL, Biervert C, Hallmann K, Tay A, Dean JC, Steinlein OK (2000) A KCNQ2 splice site mutation causing benign neonatal convulsions in a Scottish family. Neuropediatrics 31:9-12.

Lerche H, Biervert C, Alekov AK, Schleithoff L, Lindner M, Klinger W, Bretschneider F, Mitrovic N, Jurkat-Rott K, Bode H, Lehmann-Horn F, Steinlein OK (1999) A reduced K+ current due to a novel mutation in KCNQ2 causes neonatal convulsions. Ann Neurol 46:305-12.

Lerche H, Jurkat-Rott K, Lehmann-Horn F (2001) Ion channels and epilepsy. Am J Med Genet 106:146-59.

Li HY, Tang BS, Zhang AM, Cao QH, Meng GL, Jiang H, Shen L (2003) A novel mutation of KCNQ2 gene in a Chinese family with benign familial neonatal convulsions. Zhonghua Yi Xue Yi Chuan Xue Za Zhi. 20:482-5.

Maljevic S, Naros G, Yalçin Ö, Blazevic D, Loeffler H, Cağlayan H, Steinlein OK, Lerche H (2011) Temperature and pharmacological rescue of a folding-defective, dominant-negative KV 7.2 mutation associated with neonatal seizures. Hum Mutat 32:E2283-93

Martin HC, Kim GE, Pagnamenta AT, Murakami Y, Carvill GL, Meyer E, Copley RR, Rimmer A, Barcia G, Fleming MR, Kronengold J, Brown MR, Hudspith KA, Broxholme J, Kanapin A, Cazier JB, Kinoshita T, Nabbout R; WGS500 Consortium, Bentley D, McVean G, Heavin S, Zaiwalla Z, McShane T, Mefford HC, Shears D, Stewart H, Kurian MA, Scheffer IE, Blair E, Donnelly P, Kaczmarek LK, Taylor JC (2014) Clinical whole-genome sequencing in severe early-onset epilepsy reveals new genes and improves molecular diagnosis. Hum Mol Genet 23:3200-11.

Mercimek-Mahmutoglu S, Patel J, Cordeiro D, Hewson S, Callen D, Donner EJ, Hahn CD, Kannu P, Kobayashi J, Minassian BA, Moharir M, Siriwardena K, Weiss SK, Weksberg R, Snead OC 3rd (2015) Diagnostic yield of genetic testing in epileptic encephalopathy in childhood. Epilepsia 56:707-16.

Miceli F, Soldovieri MV, Ambrosino P, Barrese V, Migliore M, Cilio MR, Taglialatela M (2013) Genotype-phenotype correlations in neonatal epilepsies caused by mutations in the voltage sensor of Kv7.2 potassium channel subunits. Proc Natl Acad Sci USA. 110:4386-91

Miceli F, Soldovieri MV, Ambrosino P, De Maria M, Migliore M, Migliore R, Taglialatela M (2015) Early-onset epileptic encephalopathy caused by gain-of-function mutations in the voltage sensor of Kv7.2 and Kv7.3 potassium channel subunits. J Neurosci 35:3782-93.

Miceli F, Soldovieri MV, Lugli L, Bellini G, Ambrosino P, Migliore M, del Giudice EM, Ferrari F, Pascotto A, Taglialatela M (2009) Neutralization of a unique, negatively-charged residue in the voltage sensor of K V 7.2 subunits in a sporadic case of benign familial neonatal seizures. Neurobiol Dis 34:501-10.

Milh M, Boutry-Kryza N, Sutera-Sardo J, Mignot C, Auvin S, Lacoste C, Villeneuve N, Roubertie A, Heron B, Carneiro M, Kaminska A, Altuzarra C, Blanchard G, Ville D, Barthez MA, Heron D, Gras D, Afenjar A, Dorison N, Doummar D, Billette de Villemeur T, An I, Jacquette A, Charles P, Perrier J, Isidor B, Vercueil L, Chabrol B, Badens C, Lesca G, Villard L (2013) Similar early characteristics but variable neurological outcome of patients with a de novo mutation of KCNQ2. Orphanet J Rare Dis 8:80.

Milh M, Lacoste C, Cacciagli P, Abidi A, Sutera-Sardo J, Tzelepis I, Colin E, Badens C, Afenjar A, Dieux Coeslier A, Dailland T, Lesca G, Philip N, Villard L (2015) Variable clinical expression in patients with mosaicism for KCNQ2 mutations. Am J Med Genet A. 167A:2314-8.

Miraglia del Giudice E, Coppola G, Scuccimarra G, Cirillo G, Bellini G, Pascotto A (2000) Benign familial neonatal convulsions (BFNC) resulting from mutation of the KCNQ2 voltage sensor. Eur J Hum Genet 8:994-7.

Moulard B, Picard F, le Hellard S, Agulhon C, Weiland S, Favre I, Bertrand S, Malafosse A, Bertrand D (2001) Ion channel variation causes epilepsies. Brain Res Brain Res Rev 36:275-84.

Neubauer BA, Waldegger S, Heinzinger J, Hahn A, Kurlemann G, Fiedler B, Eberhard F, Muhle H, Stephani U, Garkisch S, Eeg-Olofsson O, Muller U, Sander T (2008) KCNQ2 and KCNQ3 mutations contribute to different idiopathic epilepsy syndromes. Neurology 71:177-83.

Numis AL, Angriman M, Sullivan JE, Lewis AJ, Striano P, Nabbout R, Cilio MR (2014) KCNQ2 encephalopathy: delineation of the electroclinical phenotype and treatment response. Neurology 82:368-70.

Orhan G, Bock M, Schepers D, Ilina EI, Reichel SN, Löffler H, Jezutkovic N, Weckhuysen S, Mandelstam S, Suls A, Danker T, Guenther E, Scheffer IE, De Jonghe P, Lerche H, Maljevic S (2014) Dominant-negative effects of KCNQ2 mutations are associated with epileptic encephalopathy. Ann Neurol 75:382-94.

Pereira S, Roll P, Krizova J, Genton P, Brazdil M, Kuba R, Cau P, Rektor I, Szepetowski P (2004) Complete loss of the cytoplasmic carboxyl terminus of the KCNQ2 potassium channel: a novel mutation in a large Czech pedigree with benign neonatal convulsions or other epileptic phenotypes. Epilepsia 45:384-90.

Peters HC, Hu H, Pongs O, Storm JF, Isbrandt D. Conditional transgenic suppression of M channels in mouse brain reveals functions in neuronal excitability, resonance and behavior. Nat Neurosci. 2005;8:51-60.

Pisano T, Numis AL, Heavin SB, Weckhuysen S, Angriman M, Suls A, Podesta B, Thibert RL, Shapiro KA, Guerrini R, Scheffer IE, Marini C, Cilio MR (2015) Early and effective treatment of KCNQ2 encephalopathy. Epilepsia 56:685-91

Richards MC, Heron SE, Spendlove HE, Scheffer IE, Grinton B, Berkovic SF, Mulley JC, Davy A (2004) Novel mutations in the KCNQ2 gene link epilepsy to a dysfunction of the KCNQ2-calmodulin interaction. J Med Genet 41:e35.

Saadeldin IY, Milhem RM, Al-Gazali L, Ali BR. Novel KCNQ2 mutation in a large Emirati family with benign familial neonatal seizures. Pediatr Neurol 2013;48:63-6.

Sadewa AH, Sasongko TH, Lee MJ, Daikoku K, Yamamoto A, Yamasaki T, Tanaka S, Matsuo M, Nishio H (2008) Germ-line mutation of KCNQ2, p.R213W, in a Japanese family with benign familial neonatal convulsion. Pediatr Int 50:167-71.

Saitsu H, Kato M, Koide A, Goto T, Fujita T, Nishiyama K, Tsurusaki Y, Doi H, Miyake N, Hayasaka K, Matsumoto N (2012) Whole exome sequencing identifies KCNQ2 mutations in Ohtahara syndrome. Ann Neurol 72:298-300

Samanta D, Ramakrishnaiah R, Willis E, Frye RE (2015) Myoclonic epilepsy evolved into West syndrome: a patient with a novel de novo KCNQ2 mutation. Acta Neurol Belg 115:475-8

Schmitt B, Wohlrab G, Sander T, Steinlein OK, Hajnal BL (2005) Neonatal seizures with tonic clonic sequences and poor developmental outcome. Epilepsy Res 65:161-8.

Schroeder BC, Kubisch C, Stein V, Jentsch TJ (1998) Moderate loss of function of cyclic-AMP-modulated KCNQ2/KCNQ3 K+ channels causes epilepsy. Nature 396:687-90.

Singh NA, Charlier C, Stauffer D, DuPont BR, Leach RJ, Melis R, Ronen GM, Bjerre I, Quattlebaum T, Murphy JV, McHarg ML, Gagnon D, Rosales TO, Peiffer A, Anderson VE, Leppert M (1998) A novel potassium channel gene, KCNQ2, is mutated in an inherited epilepsy of newborns. Nat Genet 18:25-9.

Singh NA, Westenskow P, Charlier C, Pappas C, Leslie J, Dillon J, Anderson VE, Sanguinetti MC, Leppert MF (2003) KCNQ2 and KCNQ3 potassium channel genes in benign familial neonatal convulsions: expansion of the functional and mutation spectrum. Brain 126:2726-37.

Soldovieri MV, Boutry-Kryza N, Milh M, Doummar D, Heron B, Bourel E, Ambrosino P, Miceli F, De Maria M, Dorison N, Auvin S, Echenne B, Oertel J, Riquet A, Lambert L, Gerard M, Roubergue A, Calender A, Mignot C, Taglialatela M, Lesca G (2014) Novel KCNQ2 and KCNQ3 mutations in a large cohort of families with benign neonatal epilepsy: first evidence for an altered channel regulation by syntaxin-1A. Hum Mutat 35:356-67.

Soldovieri MV, Castaldo P, Iodice L, Miceli F, Barrese V, Bellini G, Miraglia del Giudice E, Pascotto A, Bonatti S, Annunziato L, Taglialatela M (2006) Decreased subunit stability as a novel mechanism for potassium current impairment by a KCNQ2 C terminus mutation causing benign familial neonatal convulsions. J Biol Chem 281:418-28.

Soldovieri MV, Cilio MR, Miceli F, Bellini G, Miraglia del Giudice E, Castaldo P, Hernandez CC, Shapiro MS, Pascotto A, Annunziato L, Taglialatela M (2007) Atypical gating of M-type potassium channels conferred by mutations in uncharged residues in the S4 region of KCNQ2 causing benign familial neonatal convulsions. J Neurosci 27:4919-28.

Steinlein OK, Conrad C, Weidner B (2007) Benign familial neonatal convulsions: always benign? Epilepsy Res 73:245-9.

Su J, Cao X, Wang K (2011) A novel degradation signal derived from distal C-terminal frameshift mutations of KCNQ2 protein which cause neonatal epilepsy. J Biol Chem 286:42949-58

Surti TS, Huang L, Jan YN, Jan LY, Cooper EC (2005) Identification by mass spectrometry and functional characterization of two phosphorylation sites of KCNQ2/KCNQ3 channels. Proc Natl Acad Sci U S A. 102:17828-33.

Tang B, Li H, Xia K, Jiang H, Pan Q, Shen L, Long Z, Zhao G, Cai F (2004) A novel mutation in KCNQ2 gene causes benign familial neonatal convulsions in a Chinese family. J Neurol Sci 221:31-4.

Telezhkin V, Thomas AM, Harmer SC, Tinker A, Brown DA (2013) A basic residue in the proximal C-terminus is necessary for efficient activation of the M-channel subunit Kv7.2 by $PI(4,5)P_2$. Pflugers Arch 465:945-53.

Volkers L, Rook MB, Das JH, Verbeek NE, Groenewegen WA, van Kempen MJ, Lindhout D, Koeleman BP (2009) Functional analysis of novel KCNQ2 mutations found in patients with Benign Familial Neonatal Convulsions. Neurosci Lett 462:24-9.

Wang J, Li Y, Hui Z, Cao M, Shi R, Zhang W, Geng L, Zhou X (2015) Functional analysis of potassium channels in Kv7.2 G271V mutant causing early onset familial epilepsy. Brain Res 1616:112-22.

Weckhuysen S, Mandelstam S, Suls A, Audenaert D, Deconinck T, Claes LR, Deprez L, Smets K, Hristova D, Yordanova I, Jordanova A, Ceulemans B, Jansen A, Hasaerts D, Roelens F, Lagae L, Yendle S, Stanley T, Heron SE, Mulley JC, Berkovic SF, Scheffer IE, de Jonghe P (2012) KCNQ2 encephalopathy: emerging phenotype of a neonatal epileptic encephalopathy. Ann Neurol 71:15-25

Weckhuysen S, Ivanovic V, Hendrickx R, Van Coster R, Hjalgrim H, Møller RS, Grønborg S, Schoonjans AS, Ceulemans B, Heavin SB, Eltze C, Horvath R, Casara G, Pisano T, Giordano L, Rostasy K, Haberlandt E, Albrecht B, Bevot A, Benkel I, Syrbe S, Sheidley B, Guerrini R, Poduri A, Lemke JR, Mandelstam S, Scheffer I, Angriman M, Striano P, Marini C, Suls A, De Jonghe P; KCNQ2 Study Group (2013) Extending the KCNQ2 encephalopathy spectrum: clinical and neuroimaging findings in 17 patients. Neurology 81:1697-703

Wuttke TV, Jurkat-Rott K, Paulus W, Garncarek M, Lehmann-Horn F, Lerche H (2007) Peripheral nerve hyperexcitability due to dominant-negative KCNQ2 mutations. Neurology 69:2045-53.

Wuttke TV, Penzien J, Fauler M, Seebohm G, Lehmann-Horn F, Lerche H, Jurkat-Rott K (2008) Neutralization of a negative charge in the S1-S2 region of the KV7.2 (KCNQ2) channel affects voltage-dependent activation in neonatal epilepsy. J Physiol 586:545-55.

Yalcin O, Caglayan SH, Saltik S, Cokar O, Agan K, Dervent A, Steinlein OK (2007) A novel missense mutation (N258S) in the KCNQ2 gene in a Turkish family afflicted with benign familial neonatal convulsions (BFNC). Turk J Pediatr 49:385-9.

Yum MS, Ko TS, Yoo HW (2010) The first Korean case of KCNQ2 mutation in a family with benign familial neonatal convulsions. J Korean Med Sci.25:324-6.

Zara F, Specchio N, Striano P, Robbiano A, Gennaro E, Paravidino R, Vanni N, Beccaria F, Capovilla G, Bianchi A, Caffi L, Cardilli V, Darra F, Bernardina BD, Fusco L, Gaggero R, Giordano L, Guerrini R, Incorpora G, Mastrangelo M, Spaccini L, Laverda AM, Vecchi M, Vanadia F, Veggiotti P, Viri M, Occhi G, Budetta M, Taglialatela M, Coviello DA, Vigevano F, Minetti C (2013) Genetic testing in benign familial epilepsies of the first year of life: Clinical and diagnostic significance. Epilepsia 54:425-36.

Zhou X, Ma A, Liu X, Huang C, Zhang Y, Shi R, Mao S, Geng T, Li S (2006) Infantile seizures and other epileptic phenotypes in a Chinese family with a missense mutation of KCNQ2. Eur J Pediatr 165:691-5.

Zimprich F, Ronen GM, Stogmann W, Baumgartner C, Stogmann E, Rett B, Pappas C, Leppert M, Singh N, Anderson VE (2006) Andreas Rett and benign familial neonatal convulsions revisited. Neurology 67:864-6.