Molecular causes of Congenital Anomalies of the Kidney and Urinary Tract (CAKUT)

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Supplemental Table 1: 50 genes that represent monogenic causes/candidate genes of “isolated” CAKUT in humans

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Gene** | **Protein** | **Level of evidence1** | **OMIM2** | **Ref.** |
| **Autosomal recessive (n = 16)** | | | | |
| *ACE* | Angiotensin I–converting enzyme | G(+), R(+), A (+) | [267430](https://www.omim.org/entry/267430) | [1] |
| *AGT* | Angiotensinogen | G(+), R(+), A (+) | [267430](https://www.omim.org/entry/267430) | [1] |
| *AGTR1* | Angiotensin II receptor, type 1 | G(+), R(0), A (+) | [267430](https://www.omim.org/entry/267430) | [1] |
| *CHRM3* | Muscarinic acetylcholine receptor M3 | G(+), R(+), A (+) | [100100](https://www.omim.org/entry/100100) | [2] |
| *FGF20* | Fibroblast growth factor 20 | G(+), R(0), A (+) | [615721](https://www.omim.org/entry/615721) | [3] |
| *FRAS1* | ECM protein FRAS1 | G(+), R(+), A (+) | [219000](https://www.omim.org/entry/219000) | [4, 5] |
| *FREM1* | FRAS1-related ECM protein 1 | G(0), R(0), A (+) | [248450](https://www.omim.org/entry/248450) [608980](https://www.omim.org/entry/608980) | [4] |
| *FREM2* | FRAS1-related ECM protein 2 | G(0), R(0), A (+) | [617666](https://www.omim.org/entry/617666) [123570](https://www.omim.org/entry/123570) | [4] |
| *GFRA1* | GDNF family receptor alpha-1 | G(+), R(0), A (+) | n/a | [6] |
| *GRIP1* | Glutamate receptor interacting protein 1 | G(0), R(0), A (+) | [617667](https://www.omim.org/entry/617667) | [4] |
| *HOXA11* | Homeobox protein Hox-A11 | G(0), R(0), A (0) | n/a | [7] |
| *HPSE2* | Heparanase 2 | G(+), R(+), A (+) | [236730](https://www.omim.org/entry/236730) | [8] |
| *ITGA8* | Integrin alpha-8 | G(+), R(+), A (+) | [191830](https://www.omim.org/entry/191830) | [9] |
| *REN* | Renin | G(+), R(+), A (+) | [267430](https://www.omim.org/entry/267430) | [1] |
| *TRAP1* | Heat shock protein 75 kDa, mitochondrial | G(0), R(0), A (0) | n/a | [10] |
| *VWA2* | von Willebrand factor A domain-containing protein 2 | G(0), R(0), A (1) | n/a | [11] |
|  |  |  |  |  |
| **Autosomal dominant (n = 33)** | | | | |
| *BMP4* | Bone morphogenetic protein 4 | G(0), R(0), A (+) | n/a | [12] |
| *BNC2* | Zinc finger protein basonuclin-2 | G(0), R(0), A (+) | [618612](https://www.omim.org/entry/618612) | [13] |
| *CHD1L* | Chromodomain-helicase-DNA-binding protein 1-like | G(0), R(1), A (0) | n/a | [14, 15] |
| *COL4A1* | Collagen alpha-1(IV) chain | G(0), R(0), A (0) | n/a | [16] |
| *CRKL* | Crk-like protein | G(0), R(0), A (+) | n/a | [17] |
| *DSTYK* | Dual serine/threonine and tyrosine protein kinase | G(0), R(0), A (+) | [610805](https://www.omim.org/entry/610805) | [18] |
| *EYA1* | Eyes absent homolog 1 | G(+), R(+), A (+) | [113650](https://www.omim.org/entry/113650) | [19] |
| *FOXC1* | Forkhead box protein C1 | G(0), R(0), A (+) | n/a | [20] |
| *GATA3* | Trans-acting T-cell-specific transcription factor GATA-3 | G(+), R(+), A (+) | [146255](https://www.omim.org/entry/146255) | [21] |
| *GREB1L* | GREB1-like protein | G(+), R(+), A (+) | [617805](https://www.omim.org/entry/617805) | [22, 23] |
| *HNF1B* | Hepatocyte nuclear factor 1-beta | G(+), R(+), A (+) | [137920](https://www.omim.org/entry/137920) | [24, 25] |
| *MUC1* | Mucin 1 | G(+), R(+), A (?) | [174000](https://www.omim.org/entry/174000) | [26] |
| *NRIP1* | Nuclear receptor-interacting protein 1 | G(+), R(0), A (+) | [618270](https://www.omim.org/entry/618270) | [27] |
| *PAX2* | Paired box protein Pax-2 | G(+), R(+), A (+) | [120330](https://www.omim.org/entry/120330) [616002](https://www.omim.org/entry/616002) | [28, 29] |
| *PBX1* | Pre-B-cell leukemia transcription factor 1 | G(+), R(+), A (+) | [617641](https://www.omim.org/entry/617641) | [30–32] |
| *REN* | Renin | G(+), R(+), A (+) | [613092](https://www.omim.org/entry/613092) | [33] |
| *RET* | Proto-oncogene tyrosine-protein kinase receptor Ret | G(0), R(+), A (+) | n/a | [34] |
| *ROBO2* | Roundabout homolog 2 | G(+), R(+), A (+) | [610878](https://www.omim.org/entry/610878) | [35] |
| *SALL1* | Sal-like protein 1 | G(+), R(+), A (+) | [107480](https://www.omim.org/entry/107480) | [36] |
| *SIX2* | Homeobox protein SIX2 | G(0), R(+), A (+) | n/a | [12] |
| *SIX5* | Homeobox protein SIX5 | G(0), R(0), A (0) | [610896](https://www.omim.org/entry/610896) | [37, 38] |
| *SLIT2* | Slit homolog 2 protein | G(0), R(0), A (0) | n/a | [39] |
| *SON* | Protein SON | G(1), R(1), A (1) | [617140](https://www.omim.org/entry/617140) | [40] |
| *SOX17* | Transcription factor SOX-17 | G(0), R(0), A (0) | [613674](https://www.omim.org/entry/613674) | [41] |
| *SRGAP1* | SLIT-ROBO Rho GTPase-activating protein 1 | G(0), R(0), A (0) | n/a | [39] |
| *TBC1D1* | TBC1 domain family member 1 | G(0), R(0), A (+) | n/a | [42] |
| *TBX18* | T-box transcription factor TBX18 | G(+), R(0), A (+) | [143400](https://www.omim.org/entry/143400) | [43] |
| *TBX6* | T-box transcription factor TBX6 | G(+), R(0), A (+) | n/a | [44, 45] |
| *TNXB* | Tenascin-X | G(+), R(0), A (0) | [615963](https://www.omim.org/entry/615963) | [46] |
| *UMOD* | Uromodulin | G(+), R(+), A (+) | [609886](https://www.omim.org/entry/609886)  [162000](https://www.omim.org/entry/162000)  [603860](https://www.omim.org/entry/603860) | [47] |
| *UPK3A* | Uroplakin-3a | G(+), R(0), A (+) | n/a | [48] |
| *WNT4* | Protein Wnt-4 | G(0), R(0), A (+) | n/a | [49] |
| *ZMYM2* | Zinc finger MYM-type protein 2 | G(+), R(0), A (+) | n/a | [50] |
|  |  |  |  |  |
| **X-linked recessive (n = 1)** | | | | |
| *ANOS1* | Anosmin-1 | G(+), R(+), A (+) | [308700](https://www.omim.org/entry/308700) | [51] |

**1**Level of evidence as determined by three parameters:   
(**G**) “Genetics”: Convincing clinical genetic data (i.e. convincing segregation in large kindreds, > 3 unrelated affected individuals, *de-novo* variants) are available in the original publication, on OMIM.org, or the HGMD database (http://www.hgmd.cf.ac.uk/),   
(**R**) “Replication”: Additional unrelated individuals published by at least one other laboratory, and   
(**A**) “Animal model”: Animal model data supporting causality of CAKUT phenotype.  
*Comment: The assessment of the level of evidence was conducted applying objective criteria. A low level of evidence in this assessment, of course, has limitations, one being the extreme rarity of these conditions.*

**2OMIM** accession numbers referring to a CAKUT phenotype.

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