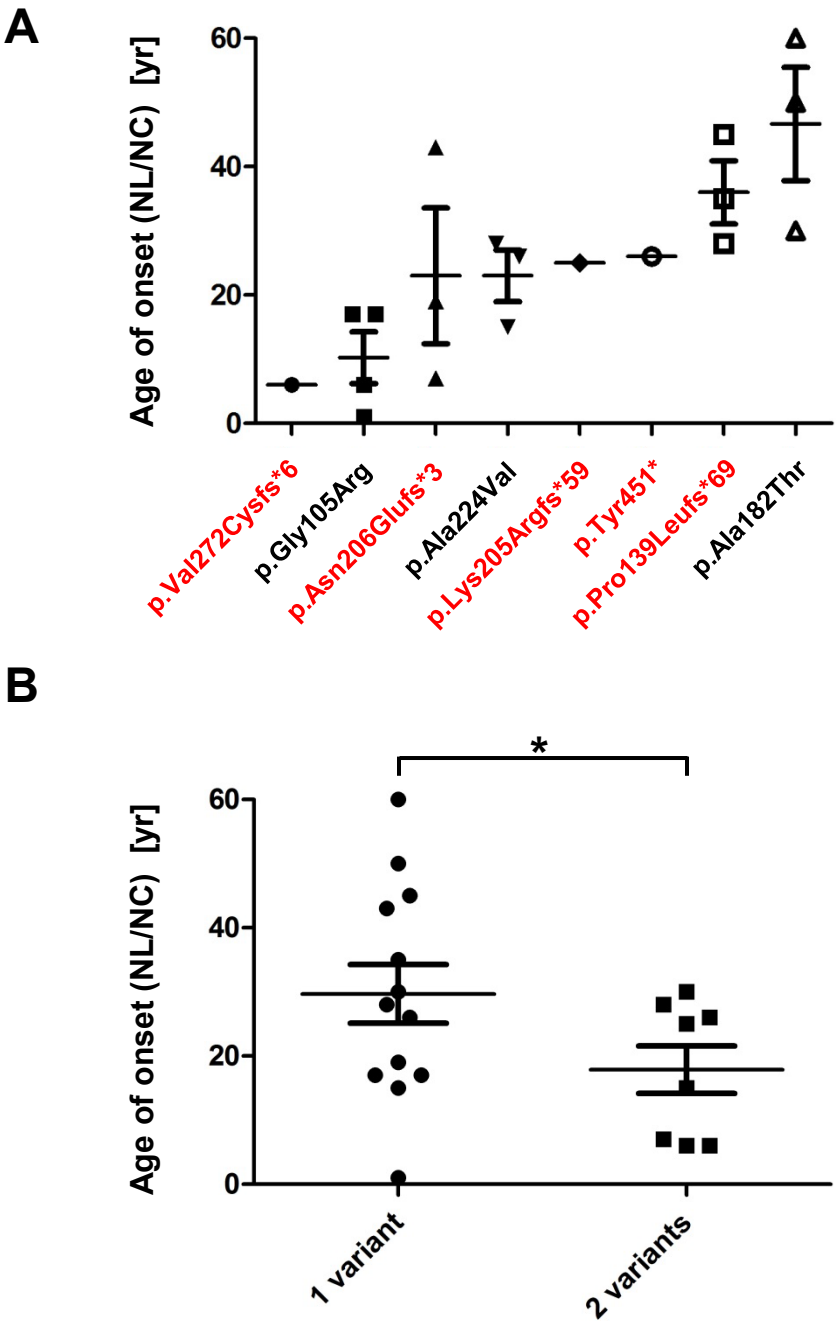

Figure S1. Correlation between median age of onset and mutated alleles detected in *SLC7A9*. (A) Five truncating (red) and three missense alleles (black) sorted by median age of onset. Note that there is no correlation between the presence of a truncating variant and median age of onset in the affected individuals. **(B)** In contrast, the presence of two mutated variants in *SLC7A9* results in a significantly earlier age of onset compared to 1 mutated variant (*p=0.029, unpaired Student's t-test). NL, nephrolithiasis; NC, nephrocalcinosis; yr, years.

Supplemental Table 1. Cohort characteristics of 272 individuals from 268 different families with NL/NC

General / Age of onset						Gender		Ethnicity / Origin						
Inclusion criterion[a]	**Total #**	**Median age of onset (range - yr)**	**# of pediatric individuals (age of onset <18 yr)**	**# of adult individuals (age of onset ≥18 yr)**	**Con-sang-uinity**	**Female**	**Male**	**Western / Northern Europe**	**Eastern Europe / Balkans**	**EA**	**Asia**	**Middle East**	**Southern Europe**	**South America / Hispanic**
NL	256	30 (1-81)	91	165	4	95	161	170	62	17	4	1	1	1
NC	16	8 (1-46)	15	1	2	6	10	4	7	1	2	2	0	0
Total #	272	28 (1-81)	106 (39.0%)	166 (61.0%)	6 (2.2%)	101 (37.1%)	171 (62.9%)	174 (64.0%)	69 (25.4%)	18 (6.6%)	6 (2.2%)	3 (1.1%)	1 (0.4%)	1 (0.4%)

[a]Note that, the inclusion criteria nephrocalcinosis and hypercalcuria refer to isolated conditions without a reported history of stone disease. Another 11 individuals, who primarily presented with kidney stone disease also showed nephrocalcinosis on renal ultrasound or CT scan.
Abbreviations: EA, European American; NC, isolated nephrocalcinosis; NL, nephrolithiasis; yr, years

Supplemental Table 2. Thirty genes, known to cause monogenic forms of NL/NC that were included in the study.

	Gene Symbol[a]	Gene Name	Accession #	Disease entity	MIM-Phenotype #	Mode	Coding Exons	Ref.
1	***ADCY10/SAC***	adenylate cyclase 10 (soluble)	NM_018417.4	Idiopathic (absorptive) hypercalciuria, susceptibility	143870	AD	32	[1]
2	***AGXT***	alanine-glyoxylate aminotransferase	NM_000030.2	Primary hyperoxaluria, type 1	259900	AR	11	[2]
3	***APRT***	adenine phosphoribosyltransferase	NM_000485.2	Adenine phosphoribosyltransferase deficiency, APRT	614723	AR	5	[3]
4	***ATP6V0A4***	ATPase, H+ transporting, lysosomal V0 subunit a4	NM_020632.2	dRTA	602722	AR	20	[4]
5	***ATP6V1B1***	ATPase, H+ transporting, lysosomal 56/58kDa, V1 subunit B1	NM_001692.3	distal renal tubular acidosis (dRTA) with deafness	267300	AR	14	[5]
6	***CA2***	carbonic anhydrase II	NM_000067.2	Osteopetrosis + d/pRTA	259730	AR	7	[6]
7	***CASR***	calcium-sensing receptor	NM_001178065.1	Hypocalcemia with Bartter syndrome / hypocalcemia, autosomal dominant	601198	AD	6	[7]
8	***CLCN5***	chloride channel, voltage-sensitive 5	NM_001127898.3	Dent disease / Nephrolithiasis, type 1	300009 / 310468	XR	14	[8]
9	***CLCNKB***	chloride channel, voltage-sensitive Kb	NM_000085.4	Bartter syndrome, type 3	607364	AR	19	[9]
10	***CLDN16***	claudin 16	NM_006580.3	Familial hypomagnesemia with hypercalciuria & nephrocalcinosis, FHHNC	248250	AR	5	[10]
11	***CLDN19***	claudin 19	NM_001123395.1	Familial hypomagnesemia with hypercalciuria & nephrocalcinosis with ocular abnormalities	248190	AR	4	[11]
12	***CYP24A1***	cytochrome P450, family 24, subfamily A, polypeptide 1	NM_000782.4	1,25-(OH) D-24 hydroxylase deficiency , infantile Hypercalcemia	143880	AR	11	[12]
13	***FAM20A***	family with sequence similarity 20, member A	NM_017565.3	Enamel-Renal syndrome, amelogenesis imperfect and nephrocalcinosis	204690	AR	12	[13]
14	***GRHPR***	glyoxylate reductase/hydroxypyruvate reductase	NM_012203.1	Primary hyperoxaluria, type 2	260000	AR	9	[14]
15	***HNF4A***	hepatocyte nuclear factor 4, alpha	NM_000457.4	MODY + Fanconi syndrome + Nephrocalcinosis (p.R76W)	125850	AD	1	[15]
16	***HOGA1***	4-hydroxy-2-oxoglutarate aldolase 1	NM_138413.3	Primary hyperoxaluria, type 3	613616	AR	7	[16]
17	***HPRT1***	hypoxanthine phosphoribosyltransferase 1	NM_000194.2	Kelley-Seegmiller syndrome, partial HPRT deficiency, HPRT-related gout	300323	XR	9	[17]
18	***KCNJ1***	potassium inwardly-rectifying channel, subfamily J, member 1	NM_000220.4	Bartter syndrome, type 2	241200	AR	2	[18]
19	***OCRL***	oculocerebrorenal syndrome of Lowe	NM_000276.3	Lowe syndrome / Dent disease 2	309000 / 300555	XR	24	[19]
20	***SLC12A1***	solute carrier family 12, member 1	NM_000338.2	Bartter syndrome, type 1	601678	AR	27	[20]

21	***SLC22A12***	solute carrier family 22 (organic anion/urate transporter), member 12	NM_144585.3	Renal hypouricemia, RHUC1	220150	AD/AR	10	[21]
22	***SLC2A9***	solute carrier family 2 (facilitated glucose transporter), member 9	NM_001001290.1	Renal hypouricemia, RHUC2	612076	AD/AR	13	[22]
23	***SLC34A1***	solute carrier family 34 (sodium phosphate), member 1	NM_003052.4	Hypophosphatemic nephrolithiasis/osteoporosis-1, NPHLOP1 / Fanconi renotubular syndrome 2	612286 / 613388	AD/AR	13	[23]
24	***SLC34A3***	solute carrier family 34 (sodium phosphate), member 3	NM_001177316.1	Hypophosphatemic rickets with hypercalciuria	241530	AR	12	[24]
25	***SLC3A1***	solute carrier family 3 (cystine, dibasic and neutral amino acid transporters, activator of cystine, dibasic and neutral amino acid transport), member 1	NM_000341.3	Cystinuria, type A	220100	AR	10	[25]
26	***SLC4A1***	solute carrier family 4, anion exchanger, member 1 (erythrocyte membrane protein band 3, Diego blood group)	NM_000342.3	Primary distal renal tubular acidosis, dominant / recessive	179800 / 611590	AD/AR	19	[26]
27	***SLC7A9***	solute carrier family 7 (glycoprotein-associated amino acid transporter light chain, bo,+ system), member 9	NM_014270.4	Cystinuria, type B	220100	AD/AR	12	[27]
28	***SLC9A3R1***	solute carrier family 9, subfamily A (NHE3, cation proton antiporter 3), member 3 regulator 1	NM_004252.4	Hypophosphatemic nephrolithiasis/osteoporosis-2, NPHLOP2	612287	AD	6	[28]
29	***VDR***	vitamin D (1,25- dihydroxyvitamin D3) receptor	NM_000376.2	Idiopathic hypercalciuria	277440	AD	11	[29]
30	***XDH***	xanthine dehydrogenase	NM_000379.3	Xanthinuria, type 1	278300	AR	36	[30]
							381	

[a]Gene symbols are underlined whenever putatively causative mutations were detected in the present study. For HNF4A the MIM-phenotype number denotes MODY type 1, as occurrence of Fanconi syndrome and NC has only been shown in the presence of a specific allele (p.R76W).

Abbreviations: AD, autosomal dominant; AR, autosomal recessive; NC, isolated nephrocalcinosis; NL, nephrolithiasis; Ref., reference; XR, x-chromosomal recessive.

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Supplemental Table 3. Coverage and variant statistics for 336 DNA samples and 428 amplicons representing the coding exons of 30 genes known to be mutated in NL/NC/HC.

Coverage statistics [a]

	Total #	Percentage
Median coverage per individual	**261x**	-
- individuals with coverage 0	0	0.0%
- individuals with coverage <10x	1	0.3%
- individuals with coverage <20x	1	0.3%
- individuals with coverage <100x	4	1.2%
Median coverage per amplicon	**264x**	-
- amplicons with coverage 0	9	2.1%
- amplicons with coverage <10x	14	3.3%
- amplicons with coverage <20x	21	4.9%
- amplicons with coverage <50x	35	8.2%

[a] Median coverage per individual/sample was 261x. One individual/sample failed to undergo multiplex amplification (0.3%), highlighted in grey. Median coverage per amplicon reached 264x, with 14 amplicons (3.3%) showing less than 10x coverage in total (highlighted in grey). These amplicons were *FAM20A*-exon1_1, *FAM20A*-exon1_2, *SLC9A3R1*-exon1_1, *SLC9A3R1*-exon1_2, *CA2*-exon1, *CA2*-exon3, *APRT*-exon1, *SLC34A3*-exon2, *SLC34A3*-exon9, *OCRL*-exon1, *CLCNKB*-exon20, *HPRT1*-exon1, *HPRT1*-exon4, and *VDR*-exon2. Note that among failed exons, the first coding exon of a gene was highly overrepresented, presumably due to generally greater GC-content.

Variant statistics [b]

	Total #	Percentage
All variants	13,835	100%
SNV	12,589	91%
DIV	1,246	9%
Retained deleterious variants after filtering	162	1.2%
Sanger confirmed variants	139	1.0%
Disease causing variants	50	0.4%

[b] Total number of variant calls (grey) in 336 DNA samples and percentage of SNV/DIV calls after mapping to the concatenated reference sequence of 30 NL/NC/HC genes. The variant filtering process is described in the 'Methods' section. Abbreviations: SNV, single nucleotide variant; DIV, deletion/insertion variant.

Supplemental Table S4. Clinical characteristics of 41 individuals (40 families) with newly established genetic/molecular diagnoses and their allele frequency compared to the general population.

Gene, Individual[a]	CKD-stage (ESRD at age)	Urine abnormalities	Serum abnormalities	Imaging (US/CT/KUB)	Other	Ethnicity	Nucleotide change	AA change	EVS (All alleles)
SLC7A9									
B208-21	1	cystine↑	-	-	-	Albanian	c.313G>A	p.Gly105Arg	AA=0/AG=4/GG=6499
JAS-C8	1	-	uric acid↑	6 mm calculus RUJ	CaOx stone, normal urinary Ox + Ca2+, CU not quantified	White British	c.313G>A	p.Gly105Arg	AA=0/AG=4/GG=6499
JAS-E5	1	cystine↑	-	NC	urinary tract infections	White British	c.313G>A	p.Gly105Arg	AA=0/AG=4/GG=6499
F1029-21	1	-	-	solitary renal cyst, increased echogenicity	-	German	c.313G>A	p.Gly105Arg	AA=0/AG=4/GG=6499
							c.544G>A	p.Ala182Thr	AA=1/AG=42/GG=6460
JAS-D30	5 (45)	cystine↑	-	-	cystine stones including staghorn calculi	White British	c.313G>A	p.Gly105Arg	AA=0/AG=4/GG=6499
							c.614del	p.Lys205Argfs*59	A1A1=0/A1R=2/RR=6257
JAS-D31	1	cystine↑	-	-	cystine stones	White British	c.411_412del	p.Pro139Leufs*69	A1A1=69/A1R=78/RR=6112
JAS-D47	1	cystine↑	-	-	cystine stones	White British	c.411_412del	p.Pro139Leufs*69	A1A1=69/A1R=78/RR=6112
JAS-D34	1	cystine↑	-	-	cystine stones	White British	c.411_412del	p.Pro139Leufs*69	A1A1=69/A1R=78/RR=6112
JAS-D28	1	cystine↑	-	-	cystine stones	White British	c.544G>A	p.Ala182Thr	AA=1/AG=42/GG=6460
JAS-F41	1	Ca2+↑	-	renal calculus seen on KUB, radioopaque	-	White British	c.544G>A	p.Ala182Thr	AA=1/AG=42/GG=6460
JAS-F50	1	-	uric acid↑	radiolucent stone	cystine not quantified	White British	c.544G>A	p.Ala182Thr	AA=1/AG=42/GG=6460
JAS-D57	1	cystine↑	-	-	cystine stones	White British	c.544G>A	p.Ala182Thr	AA=1/AG=42/GG=6460
							c.614dup	p.Asn206Glufs*3	A1A1=0/A1R=2/RR=6257
JAS-F87	1	Ca2+↑	-	radioopaque stones, large > 15 mm	CaPO- stones	White British	c.614dup	p.Asn206Glufs*3	A1A1=0/A1R=2/RR=6257
JAS-G10	1	cystine↑	-	-	cystine stones		c.614dup	p.Asn206Glufs*3	A1A1=0/A1R=2/RR=6257
JAS-D29	1	cystine↑	-	-	cystine stones	White British	c.671C>T	p.Ala224Val	-
JAS-D55	1	cystine↑	-	-	cystine stones	White British	c.671C>T	p.Ala224Val	-
JAS-F19	1	Ca2+↑ (mild)	PO-↓	tiny bilateral calculi on KUB	-	White British	c.671C>T	p.Ala224Val	-
							c.1369T>C	p.Tyr457His	CC=0/CT=2/TT=6499

B114-21	1	cystine↑	-	bladder stone on US	cystine stones	European American	c.814del	p.Val272Cysfs*6	-
							c.997C>T	p.Arg333Trp	TT=0/TC=2/CC=6501
JAS-E9	1	cystine↑	-	-	cystine stones	White British	c.1353C>A	p.Tyr451*	-
							c.1400-2A>G	3' splice	-
ADCY10									
JAS-F8	1	Ca2+↑	-	-	-	Polish	c.1263C>A	p.Tyr421*	-
JAS-F68	1	Ca2+↑	-	radioopaque renal calculus 6 x 4 mm – suspected NC	CaOx stone	White British	c.1282G>A	p.Asp428Asn	AA=0/AG=1/GG=6502
JAS-F29	1	-	PO-↓	bilateral calculi on CT, 2 small kidney cysts	normal urinary Ca	White British	c.4477del	p.Leu1493Serfs*24	A1A1=0/A1R=3/RR=6257
SLC2A9									
B179-21	1	-	-	-	-	Albanian	c.1343C>T	p.Pro448Leu	TT=0/TC=1/CC=6502
B230-21	1	fractionary uric acid↑, Ca2+↑	uric acid↑	-	-	Macedonian	c.1419+1G>A	5' splice	-
SLC9A3R1									
B224-21	1	Ca2+↑	-	stone on US	normal serum PO-	Macedonian	c.673G>A	p.Glu225Lys	AA=0/AG=31/GG=6472
B109-21	1	-	-	stone on CT	Ulcerative colitis	European American	c.888+2T>C	5' splice site	CC=0/CT=6/TT=6497
SLC22A12									
JAS-F98	1	-	uric acid↑	-	no HC, serum CK↑, muscle pains, CaOx stones	White British	c.431T>C	p.Leu144Pro	CC=0/CT=5/TT=6493
B155-12	1	-	-	-	reported Ca-stones	European American	c.1300C>T	p.Arg434Cys	TT=0/TC=1/CC=6484
SLC4A1									
JAS-E8	1	Ca2+↑	-	NC	-	White British	c.2716G>C	p.Glu906Gln	-
SLC3A1									
JAS-B21[a]	1	cystine↑	-	-	cystine stones	White British	c.1354C>T	p.Arg452Trp	no
JAS-B22[a]	1	cystine↑	-	-	cystine stones	White British	c.1354C>T	p.Arg452Trp	no
JAS-G7	1	cystine↑	-	-	cystine stones	White British	c.1400T>C	p.Met467Thr	CC=0/CT=27/TT=6476
ATP6V1B1									
B214-21	1	Ca2+↑	HCO3-↓	-	no known hearing problems	Gypsy	c.481G>A	p.Glu161Lys	AA=4/AG=294/GG=6205

CLCN5									
B111-21	1	-	-	NC	-	Filipino	c.344G>A	p.Trp115*	no
B167-21	5 (25)	oxalate↑	Mg2+↓	NC	-	Macedonian	c.1009G>A	p.Glu337Lys	no
CLDN16									
JAS-C1	5 (38)	Ca2+↑	Mg2+↓	NC	recurrent stones	Arabian	c.445C>T	p.Arg149*	no
B178-21	2	Ca2+↑	Mg2+↓	NC	-	Macedonian	c.453G>T	p.Leu151Phe	no
CYP24A1									
B223-21	1	Ca2+↑	Mg2+↓	NC	no FTT, no infantile onset (age 12 yr)	Albanian	c.428_430del	p.Glu143del	no
AGXT									
B106-21	1	oxalate↑	-	-	CaOx stones, not responsive to pyridoxin	European American	c.416_418del	p.Val139del	no
							c.846+1G>T	5' splice site	no
SLC34A1									
B168-21	1	oxalate↑ (pyridoxine sensitive)	PO-↓, severe metabolic acidosis	NC	FTT, cow-milk allergy	Macedonian	c.271_291del	p.Val91Ala97del7	A1A1=1/A1R=229/RR=6029
							c.1534C>T	p.Arg512Cys	no
SLC34A3									
JAS-F43	1	-	PO-↓	bilat. calculi on US	-	White British	c.1454G>A	p.Arg485His	AA=0/AG=18/GG=6469
							c.1585A>T	p.Ile529Phe	TT=0/TA=15/AA=6341

[a]JAS-B21 and JAS-B22 are siblings (same family). All other listed individuals are unrelated.

Abbreviations: AA, amino acid; AKI, acute kidney injury; bilat., bilateral; Ca, calcium; CaOx, calcium oxalate; CaPO, calcium phosphate; CKD, chronic kidney disease; CT, computed tomography; CU, cystinuria; ESRD, end-stage renal disease; EVS, Exome variant sever (http://evs.gs.washington.edu/EVS/); FTT, failure to thrive; HC, hypercalciuria; HO, hyperoxaluria; HCO3-, bicarbonate; HU, hypouricemia; KUB, x-ray of kidney, ureter, and bladder; Mg2+, magnesium; NC, nephrocalcinosis; NL, nephrolithiasis; PO-, phosphate; PH, primary hyperoxaluria; RUJ, right pelvicalyceal-ureteric junction; RTX, renal transplant; US, ultrasound; yr, years.