Table S1 Characteristics and Clinical Significance of Target Antigens in the MN Spectrum

Target antigen	Year of discovery	Proportion in MN	Protein type	Autoantibody	Clinical significance	Localization	Pathological features	References
Category I: IMN Core Antigens								
PLA2R	2009	50%-80%	Transmembrane protein	√	Core antigen; Antibody titer correlates with disease activity; Guiding treatment monitoring	Podocyte surface	Globular, granular, subepithelial deposits, predominantly IgG4	[127]
THSD7A	2014	1%-3%	Transmembrane protein	√	Important supplementary diagnosis for PLA2R-negative patients; Partially associated with malignant tumors	Podocyte surface	Linear staining along the podocyte side of the glomerular capillary wall may be observed in normal kidneys; THSD7A-associated MN shows predominantly IgG4 deposition	[27]
Category II: Antigens with a Tendency for Secondary MN								
NELL-1	2019	10%	Secretory protein	√	The second most common antigen in MN; Partially associated with malignant	Podocytes	Predominantly IgG1, with deposits possibly segmental or global	[248]

					tumors, drugs, and autoimmune diseases			
EXT1/EXT2	2019	5%-10%	Glycosyltransferase	×	Often associated with autoimmune diseases (secondary MN)	Along the GBM	Predominantly IgG1, often accompanied by IgA and IgM, with mesangial deposits possibly associated with lupus class III/IV	[29]
NCAM1	2021	7%	Immunoglobulin	√	Prevalent in female patients with systemic lupus erythematosus	Corticomedullary interstitial cells and podocytes	Variable IgG subclass distribution; no consistent IgG subclass predominance identified	[249]
TGFBR3	2021	6%	Transmembrane protein	×	Associated with a specific subset of secondary MN; crucial for modulating systemic immune tolerance	Podocytes, mesangial, and endothelial cells	Diffuse granular deposits; variable IgG subclass distribution with no consistent IgG subclass predominance; IgG4 restriction absent	[250]
NDNF	2023	Rare	Glycosylation, disulfide-bonded Secretory proteins	√	MN in syphilis, especially in young men	Podocytes	Massive deposits, with a hump-like appearance on electron microscopy, predominantly IgG1	[251]

Category III: Neoantigens with Limited Evidence or Special Backgrounds

NEP	2002	＜0.5%	Transmembrane protein	√	A major antigen in neonatal MN; limited relevance in adult MN	Podocyte surface	Predominantly IgG1 deposition: Granular deposits along the GBM, with negative IgG4	[252]
SEMA3B	2020	2%	Transmembrane protein	√	The incidence is higher in pediatric MN	Podocytes	Predominantly IgG1, possibly accompanied by mesangial and tubular basement membrane deposits	[28]
Aldose Reductase	2010	Rare / Case reports	Oxidoreductase	√	Potential new antigen in MN; Partially associated with malignant tumors	Podocyte surface and cytoplasm	Predominantly IgG1. Exposed on the cell surface of unpermeabilized podocytes and colocalizes with IgG4 in subepithelial immune deposits	[253]
PCDH7	2021	2%	Transmembrane protein	√	Primarily found in the elderly population and in patients with MN negative for known autoantigens	Along the GBM	Along the GBM; IgG1- or IgG4-predominant deposition has been reported	[254]
HTRA1	2021	1%-2%	Serine protease	√	Not associated with other diseases	Podocyte surface	Predominantly IgG4, similar to PLA2R	[255]
NTNG1	2022	＜1%	Plasma membrane protein	√	Mutations associated with Rett syndrome and schizophrenia	Podocytes	Predominantly IgG4, similar to PLA2R	[256]

CNTN1	2020	Rare (<20 cases reported)	Neurogluco protein	√	Associated with chronic inflammatory demyelinating polyneuropathy (CIDP)	Along the GBM	IgG4-predominant	[257]
FAT1	2022	Rare	Transmembrane protein	√	Hematopoietic stem cell transplantation-associated MN	Podocyte intercellular junctions	Predominantly IgG4; tubular basement membrane deposits may occur	[258]
PCSK6	2023	2%	serine protease	√	Associated with NSAID use and a subset of autoimmune/neoplastic diseases	Along the GBM	IgG1 and IgG4	[259]