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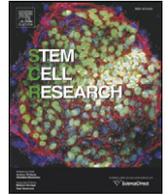
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Lab Resource: Stem Cell Line

Induced pluripotent stem cells (iPSCs) derived from a patient with frontotemporal dementia caused by a P301L mutation in microtubule-associated protein tau (MAPT)



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ABSTRACT

Skin fibroblasts were obtained from a 57-year-old woman diagnosed with frontotemporal dementia. The disease is caused by a P301L mutation in microtubule-associated protein tau (MAPT). Induced pluripotent stem cells (iPSCs) were established by electroporation with episomal plasmids containing *hOCT4*, *hSOX2*, *hKLF2*, *hL-MYC*, *hLIN-28* and *shP53*. iPSCs were free of genomically integrated reprogramming genes, contained the expected c.902C>T substitution in exon 10 of the *MAPT* gene, expressed the expected pluripotency markers, displayed *in vitro* differentiation potential to the three germ layers and had normal karyotype. The iPSC line may be useful for studying hereditary frontotemporal dementia and TAU pathology *in vitro*.

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Resource table

Name of stem cell construct	H251 C3
Institution	Bioneer A/S
Person who created resource	Mikkel Aabech Rasmussen, Bjørn Holst
Contact person and email	Bjørn Holst, bho@bioneer.dk
Date archived/stock date	July 1, 2012
Origin	Human skin fibroblasts
Type of resource	Biological reagent: induced pluripotent stem cell (iPS); derived from a MAPT P301L mutation carrier
Sub-type	Induced pluripotent stem cell
Key transcription factors	Episomal plasmids containing <i>hOCT4</i> , <i>hSOX2</i> , <i>hL-MYC</i> , <i>hKLF4</i> , <i>hLIN28</i> and <i>shP53</i> (Addgene plasmids 27077, 27078 and 27080; Okita et al. 2011)
Authentication	Identity and purity of cell line confirmed by integration analysis, sequencing of mutation, pluripotency analysis, karyotyping and <i>in vitro</i> differentiation (Figure 1).
Link to related literature (direct URL links and full references)	http://brain.oxfordjournals.org/content/138/11/3345.long
Information in public databases	Link to any data or information about this resource in a database if applicable

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Resource details

Fibroblasts were obtained from a 57-year old woman diagnosed with frontotemporal dementia and heterozygous for a P301L mutation in microtubule-associated protein tau (MAPT). iPSC-derived neurons from a patient with a P301L mutation were recently shown to undergo faster maturation and display altered mitochondrial transport and contorted processes compared with controls (Iovino et al. 2015). Reprogramming was performed by electroporation with three episomal plasmids containing *hOCT4* with or without a short hairpin to TP53 (*shp53*), *hSOX2* and *hKLF4*, and *hL-MYC* and *hLIN28* (Okita et al. 2011). This method had previously been used to establish integration-free iPSC from an 18-year old healthy male (Rasmussen et al. 2014). Four weeks after reprogramming, an average of 20 colonies per 1×10^5 fibroblasts (0.02%) emerged with the inclusion of *shp53*, whereas, no colonies were observed without *shp53*. Integration analysis with plasmid-specific primers showed that *hOCT4*, *hSOX2* and *hLIN28*, present on each of the three plasmids, had not integrated into the genome (Fig. 1A) and sequencing confirmed the presence of a c.902C>T substitution in one of the alleles of exon 10 in the *MAPT* gene corresponding to a P301L mutation (Fig. 1B). Pluripotency analysis showed that transcription from the endogenous pluripotency genes *NANOG*, *POU5F1* (*OCT4*), *TDGF1*, *DNMT3B*, *GABRB3* and *GDF3* were between 100 and 10,000 times upregulated compared with fibroblasts (Fig. 1C) and

immunocytochemical (ICC) analysis demonstrated the presence of the pluripotency markers OCT4, NANOG, TRA1-60, TRA1-81, SSEA3 and SSEA4 at the protein level (Fig. 1D). Finally, *in vitro* differentiation followed by ICC analysis with the mesodermal marker smooth muscle actin (SMA), the endodermal marker alpha-feto protein (AFP) and the ectodermal marker beta-III-Tubulin (TUJ1) demonstrated the differentiation potential into all three germ layers (Fig. 1E).

Materials and methods

Unless otherwise stated, consumables and reagents were purchased from Sigma-Aldrich, St. Louis, MO, USA.

Establishment of iPSC

A skin biopsy was obtained from a 57-year old woman carrying a P301L mutation in *MAPT*. The study was approved by the regional scientific ethical committee in the Capital Region of Denmark (RH), and written informed consent was obtained from the donor. Fibroblasts were cultured in fibroblast medium, consisting of Dulbecco's Modified Eagle Medium (DMEM) supplemented with 10% fetal bovine serum (FBS), 2 mM L-glutamine and 1% penicillin and streptomycin (Pen/Strep). 1×10^5 fibroblasts were electroporated with a total of 1 μ g of episomal plasmids containing *hOCT4* with or without a short hairpin to TP53 (*shp53*; Addgene plasmids 27077 and 27076, respectively), *hSOX2* and *hKLF4* (Addgene plasmid 27078), and *hL-MYC* and *hLIN28* (Addgene plasmid 27,080; Okita et al. 2011) and cultured in fibroblast medium.

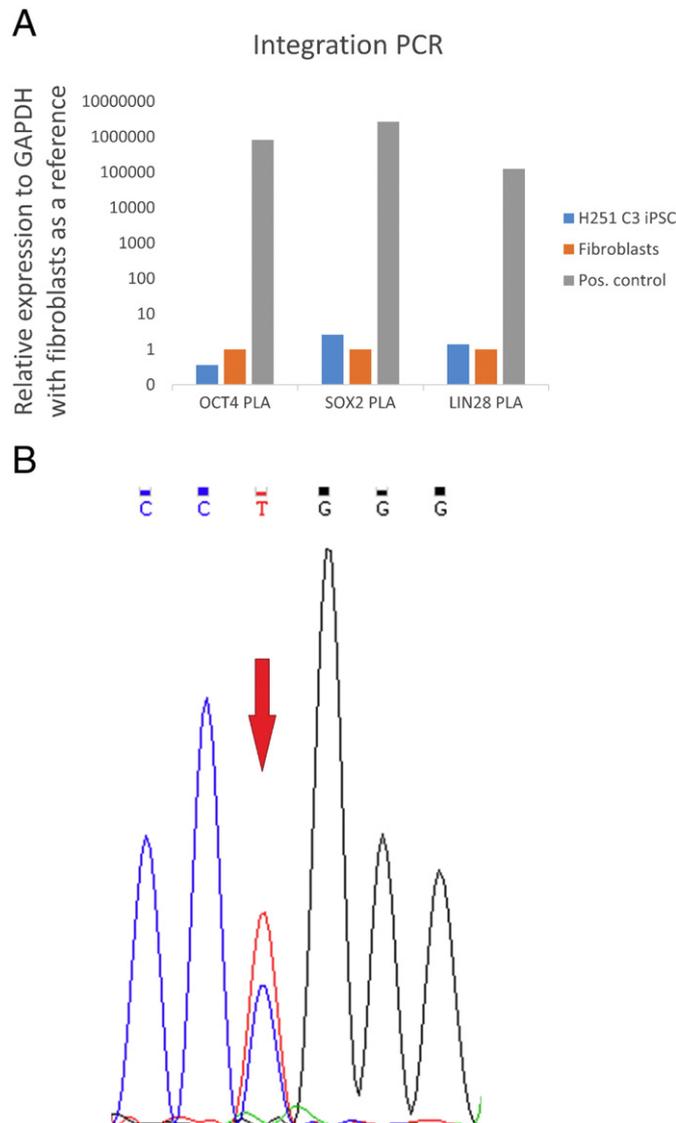
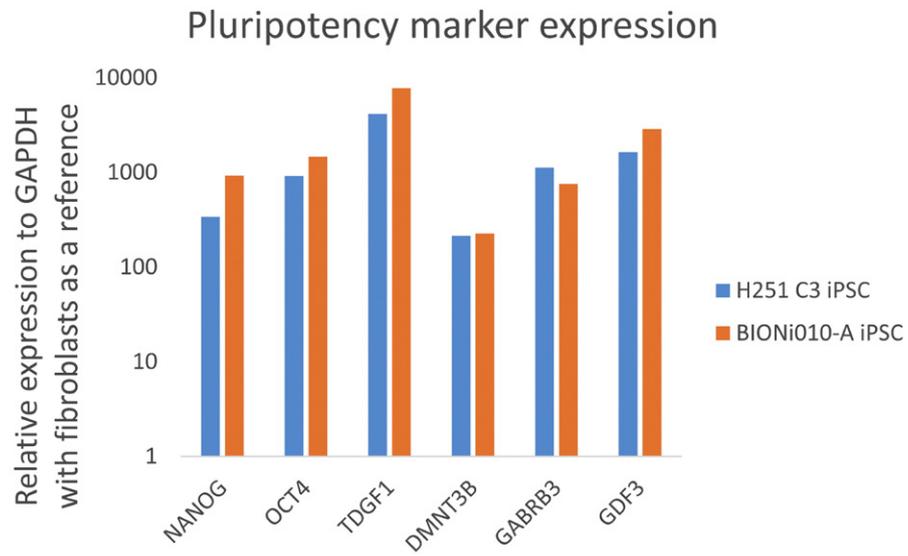
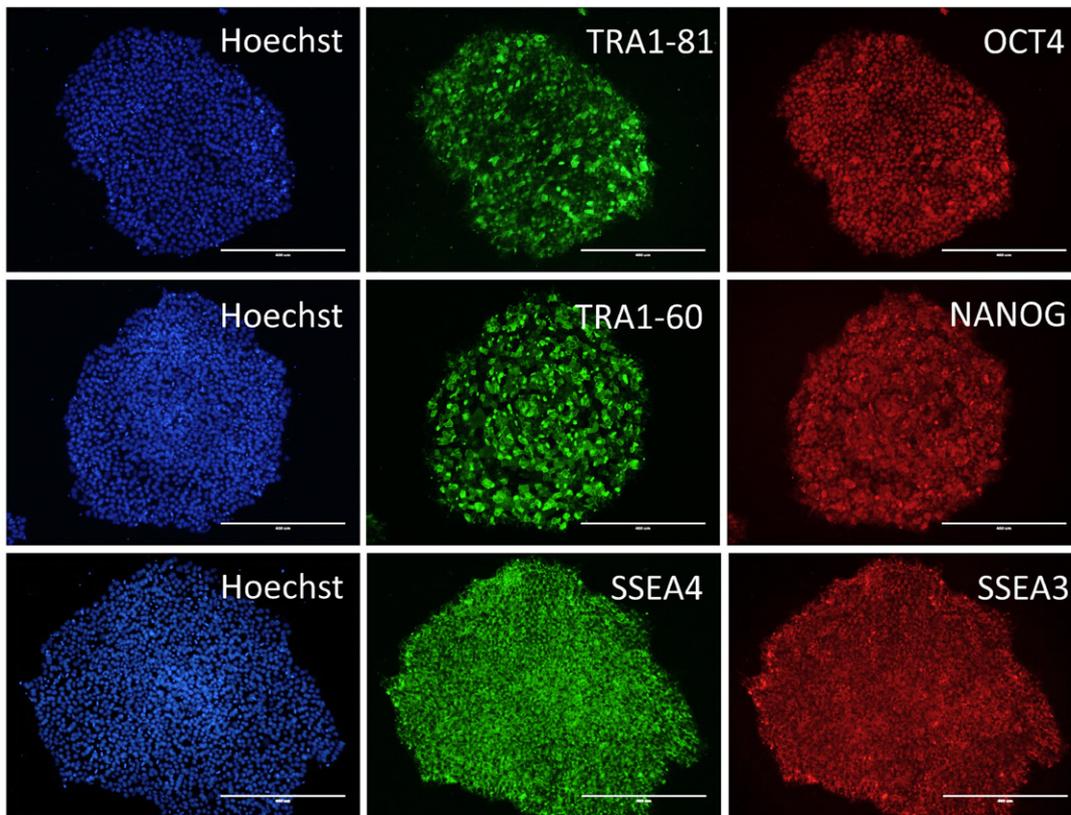


Fig. 1. A. Integration analysis. Quantitative PCR (qPCR) on genomic DNA from H251 C3 induced pluripotent stem cells (iPSCs), fibroblasts and a pool of fibroblasts electroporated with episomal plasmids (positive control) with plasmid-specific primers of *hOCT4*, *hSOX2*, and *hLIN28*. Data is shown as the fold change ($2^{-\Delta\Delta Ct}$) with *GAPDH* and fibroblasts as references. B. Sequencing of mutation. Sequencing of exon 13 of the *MAPT* gene in H251 C3 induced pluripotent stem cells showing a c.1216C>T substitution in one of the alleles marked with a red arrow. C. Pluripotency expression analysis. Quantitative reverse-transcriptase PCR (qRT-PCR) expression analyses on cDNA from H251 C3 induced pluripotent stem cells (iPSCs), fibroblasts and the iPSC line BIONi010-A (Rasmussen et al. 2014) as a positive control with the endogenous pluripotency genes *NANOG*, *POU5F1* (*OCT4*), *TGDF1*, *DNMT3B*, *GABRB3* and *GDF3*. Relative expression is shown as the fold change ($2^{-\Delta\Delta Ct}$) with *GAPDH* and fibroblasts as references. D. Immunofluorescence staining. Immunocytochemical detection of H251 C3 induced pluripotent stem cells with the pluripotency markers OCT3/4, TRA1-81, NANOG, TRA1-60, SSEA3, and SSEA4. Scale bars correspond to 400 μ m. E. *In vitro* differentiation. Immunocytochemical staining of plated embryoid bodies (EBs) from H251 C3 induced pluripotent stem cells on day 28 with smooth muscle actin (SMA), alpha-fetoprotein (AFP) and betaIII tubulin (TUJ1). Scale bars correspond to 100 μ m. F. Karyotyping. Representative karyotype of H251 C3 induced pluripotent stem cells.

C



D



E

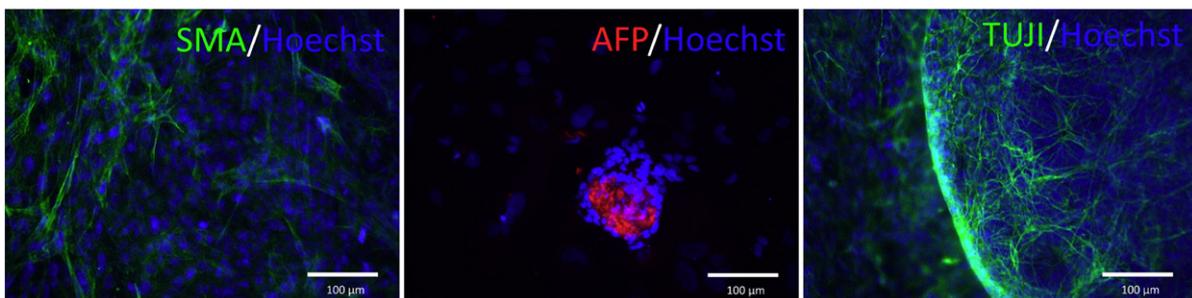


Fig. 1 (continued).

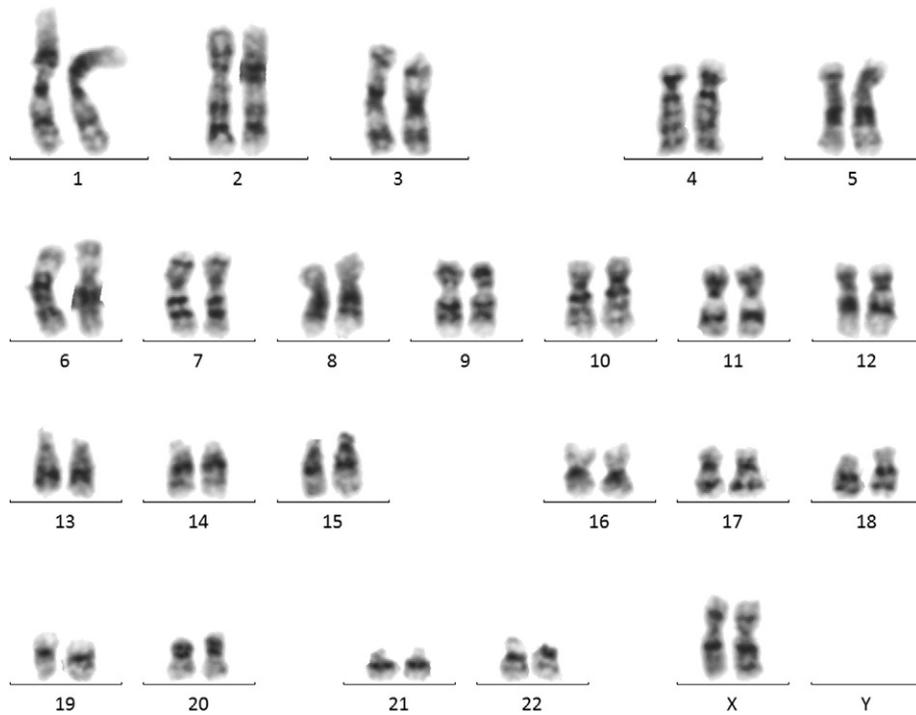


Fig. 1 (continued).

Electroporation was carried out using a Neon™ electroporation device with two pulses at 1200 V for 20 ms (Life Technologies, Carlsbad, CA, USA). One week after electroporation, the fibroblasts were trypsinized and split 1:2 onto hESC-qualified Matrigel-coated dishes (BD Biosciences, Franklin Lakes, NJ, USA) and cultured in mTeSR1 medium (Stem Cell Technologies, Vancouver, BC, Canada) in 5% O₂, 5% CO₂ in N₂. After four weeks, primary iPSC colonies were dissected out manually, transferred to new Matrigel-coated dishes, and cultured in mTeSR1. The iPSC lines were split 1:6 every 5–6 days with Dispase (Stem Cell Technologies, Vancouver, BC, Canada). At passage 10, the iPSC lines were harvested for subsequent analyses or frozen in liquid nitrogen in mTeSR1 containing 10% DMSO.

Integration analysis

DNA was purified from iPSCs, fibroblasts and a pool of fibroblasts electroporated with episomal plasmids as a positive control using the DNeasy Blood and Tissue kit (Qiagen, Hilden, Germany). qPCR analysis was carried out with the primers *OCT4-pla*, *SOX2-pla* and *LIN-28-pla*, which are specific to the three plasmids (Okita et al. 2011) and data was analyzed using the $2^{-\Delta\Delta Ct}$ method relative to *GAPDH* with fibroblasts as a reference (set to 1).

Pluripotency expression analysis.

Total RNA was purified from iPSCs, fibroblasts and the iPSC line BIONi010-A (Rasmussen et al. 2014) as a positive control using RNeasy mini kit (Qiagen, Hilden, Germany). Conversion to cDNA was performed with RevertAid First Strand cDNA synthesis kit (Thermo Scientific, Waltham, MA, USA). qPCR analysis was carried out using the TaqMan primers *GAPDH* Hs03929097_g1, *NANOG* Hs02387400_g1, *POU5F1* Hs00999632_g1, *TDGF1* Hs02339497_g1, *DMNT3B* Hs00171876_m1, *GABRB3* Hs00241459_m1 and *GDF3* Hs00220998_m1 (Thermo Scientific, Waltham, MA, USA; International Stem Cell Banking Initiative). Data was analyzed using the $2^{-\Delta\Delta Ct}$ method relative to *GAPDH* with fibroblasts as a reference (set to 1).

Sequencing of mutation

Sanger sequencing of exon 10 of the *MAPT* gene was carried out in an ABI PRISM 310 Genetic Analyzer using the primers MAPT_Ex10Fw tcactcatcgaaagtggagg and MAPT_Ex10Rv cagtgtctcgcaagtgtacg (NM_001123066.3).

Immunofluorescence staining

iPSCs were fixed with 4% paraformaldehyde (PFA) in PBS for 15 min and stained by standard immunofluorescence procedures. The primary antibodies (Table 1) were visualized with the secondary antibodies Alexa 488 or Alexa 594 diluted 1:400 (Life technologies, Carlsbad, CA, USA) and counterstained with Hoechst bisbenzimidazole 33258. Images were acquired on a Leica DMRB-fluorescence microscope (Leica Microsystems, Wetzlar, Germany).

In vitro differentiation

Embryoid body (EB) formation was performed by transferring Dispase-treated clumps of iPSC to ultra-low attachment plates (Corning, Corning, NY, USA) in mTeSR1. After 2 days of culture, the medium was changed to DMEM/F12 containing 20% knockout serum replacement (Life Technologies, Carlsbad, CA, USA), 1× non-essential amino acid, 2 mM L-glutamine, 0.1 mM 2-mercaptoethanol and 1% pen/strep. After 7 days, the EBs were plated on 0.1% gelatin-coated culture dishes and cultured in DMEM supplemented with 10% FBS, 2 mM L-glutamine and 1% pen/strep for up to three weeks. The cells were fixed for 15 min in 4% PFA for ICC analyses with the antibodies TUJ1, SMA and AFP (Table 1).

Karyotyping

iPSCs and fibroblasts were treated for 45 min with KaryoMAX colcemid (Life Technologies, Carlsbad, CA, USA) and harvested in fresh fixative containing 25% acetic acid and 75% methanol. Karyotyping

Table 1
Antibodies used for immunocytochemistry.

	Antibody and host species	Dilution	Company and catalog number
Pluripotency	Rabbit anti-NANOG	1:500	Peprotech, 500-P236
	Goat anti-OCT4	1:500	Santa Cruz, sc-8628
	Rat anti-SSEA3	1:100	Biolegend, 330,302
	Mouse anti-SSEA4	1:100	Biolegend, 330,402
	Mouse anti-Tra-1-81	1:200	Biolegend, 330,702
	Mouse anti-Tra-1-60	1:200	Biolegend, 330,602
<i>In vitro</i> differentiation	mouse anti-Smooth muscle actin (sma)	1:500	DAKO, M0851
	Rabbit anti-Alpha-1-fetoprotein (AFP)		
	Mouse anti-Beta-III-tubulin (TUJ1)	1:4000	Sigma-Aldrich, T8660

was performed on G-banded metaphase chromosomes using standard cytogenetic procedures.

Verification and authentication

Karyotyping was performed at the Center for Applied Human Molecular Genetics, Kennedy Center, Glostrup, Denmark. At least 10 metaphases were analysed per sample with an approximate resolution of 550 to 600 bands per haploid genome. The results showed a normal 46, XX karyotype, free of any discernible abnormalities (Fig. 1F). iPSC line identity and purity was confirmed by sequencing of the *MAPT* gene (Fig. 1B) and ICC with pluripotency markers (Fig. 1D).

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