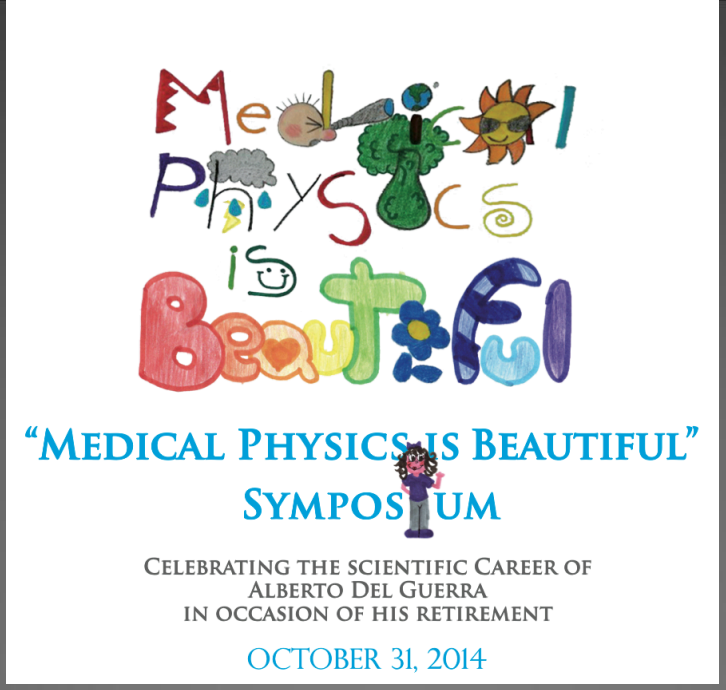


Ultra High Field MR Imaging in Neurodegenerative Diseases: the Imago7 Experience

Mirco Cosottini

University of Pisa
Department of Traslational Research and New Technologies in Medicine and Surgery
Unit of Neuroradiology AOUP
ITALY

STATE UNIVERSITY
OF NEW YORK

DOWNSTATE MEDICAL CENTER

BIOPHYSICAL LABORATORY
• DEPARTMENT OF MEDICINE

George S. Mirick, M.D. -3- September 17, 1969

certain Nuclear Magnetic Resonance Specialties can be persuaded to accept a longer term lease-purchase agreement.

Hopeful that the Health Research Council can help us expand the exciting success of a project it has sponsored from infancy, I remain,

Sincerely yours,

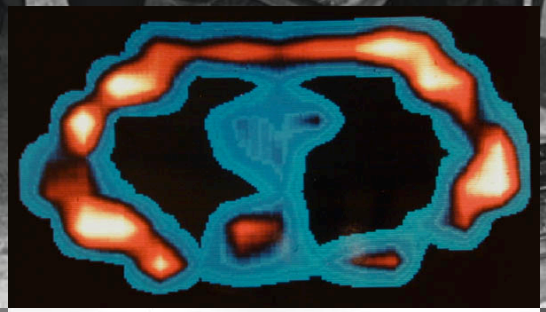
Raymond Damadian

Raymond Damadian
Assistant Professor
Department of Internal Medicine

RD:aj
Enc.

P.S. I am enclosing a first draft of the manuscript we are submitting to Science for publication. I want to mention that our findings have powerful application in anti-cancer technology. Malignant cells have marked alterations in the physical structure of their protoplasm. To the best of my knowledge, it is generally true that all malignant cells have been marked by elevated cell potassium values and depressed Ca^{++} levels. I am very much interested in the potential of NMR spectroscopy for early non-destructive detection of internal malignancies. To the extent that our primary research objectives will permit, I will make every effort myself and through collaborators, to establish that all tumors can be recognized by their potassium relaxation times or H_2O-proton spectra and proceed with the development of instrumentation and probes that can be used to scan the human body externally for early signs of malignancy. Detection of internal tumors during the earliest stages of their genesis should bring us very close to the total eradication of this disease.

[Next article in the field of MRI by another person not published until 1973
(P.C. Lauterbur, Nature 2042, 1973, 190-191)]

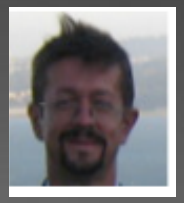


The interpolated image of the Minkoff scan and the first ever MRI scan of a live human being (4:45 AM July 3, 1977).

Research people

IMAGO7

Michela Tosetti
Physicist
IRCCS Stella Maris



Mirco Cosottini
Neuroradiologist
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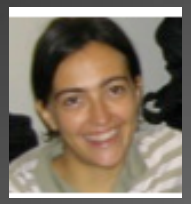

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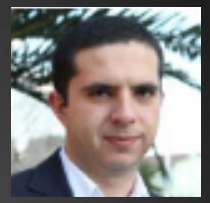

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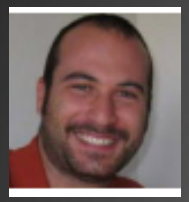

Danilo Scelfo
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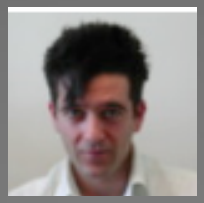

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Maria Evelina Fantacci
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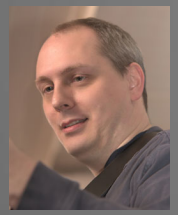

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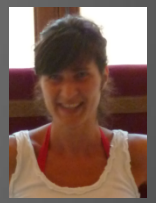

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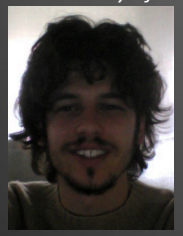
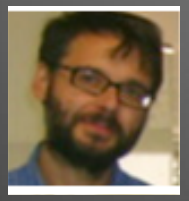
IRCCS Medea

Luca Cecchetti
Psychologist
University of Pisa



Guido Buonincontri
Physicist
CAMBRIDGE



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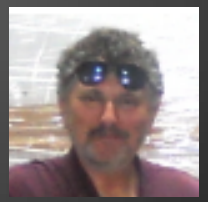

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THE *IMAGO7* RESEARCH FOUNDATION

Scientific Committee (representatives of the Partners)

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Giovanni Cioni Carlo Bartolozzi Alberto Del Guerra Renzo Guerrini Paolo Brambilla

Michela Tosetti Pietro Pietrini Ubaldo Bonuccelli Lorenzo Genitori Paola Grigioni

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Azienda Ospedaliera Universitaria Meyer Firenze

IRCCS Medea Bosisio Parini Lecco

Con il patrocinio di

FONDAZIONE PISA

GE Healthcare

7 Tesla (& 7 Gauss) Reached on Nov 28th 2011, 5pm

General Electric Healthcare MR950 7T Human Research MRI System

7T

3T

1.5T

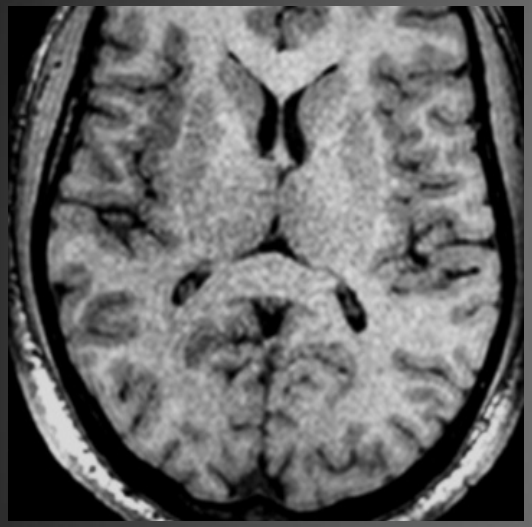
Physical Effects of Higher Magnetic Field Strengths

Variations with field strength

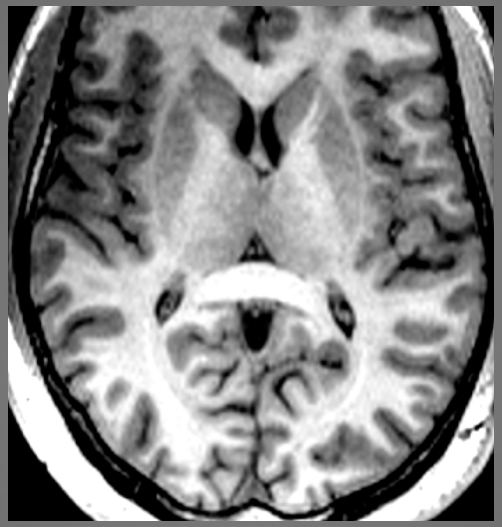
- SNR is proportional to B0
- Chemical shift is proportional to B0
- Shift due to susceptibility differences is proportional to B0
- SAR (W/kg) is proportional to $B0^2$

Field-dependent change of relaxation rates

The signal-to-noise ratio (SNR) increases almost linearly with increasing field strength



1.5T



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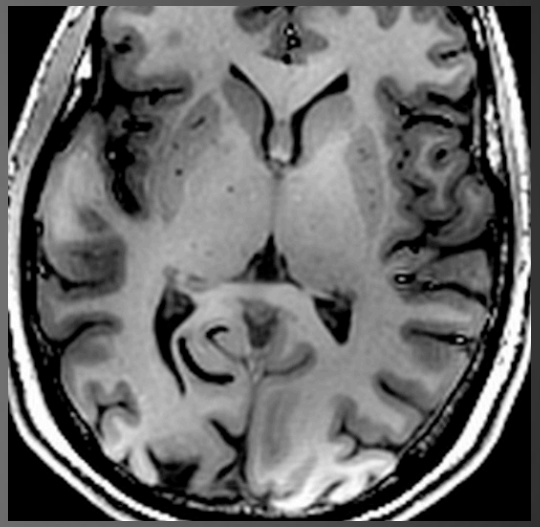
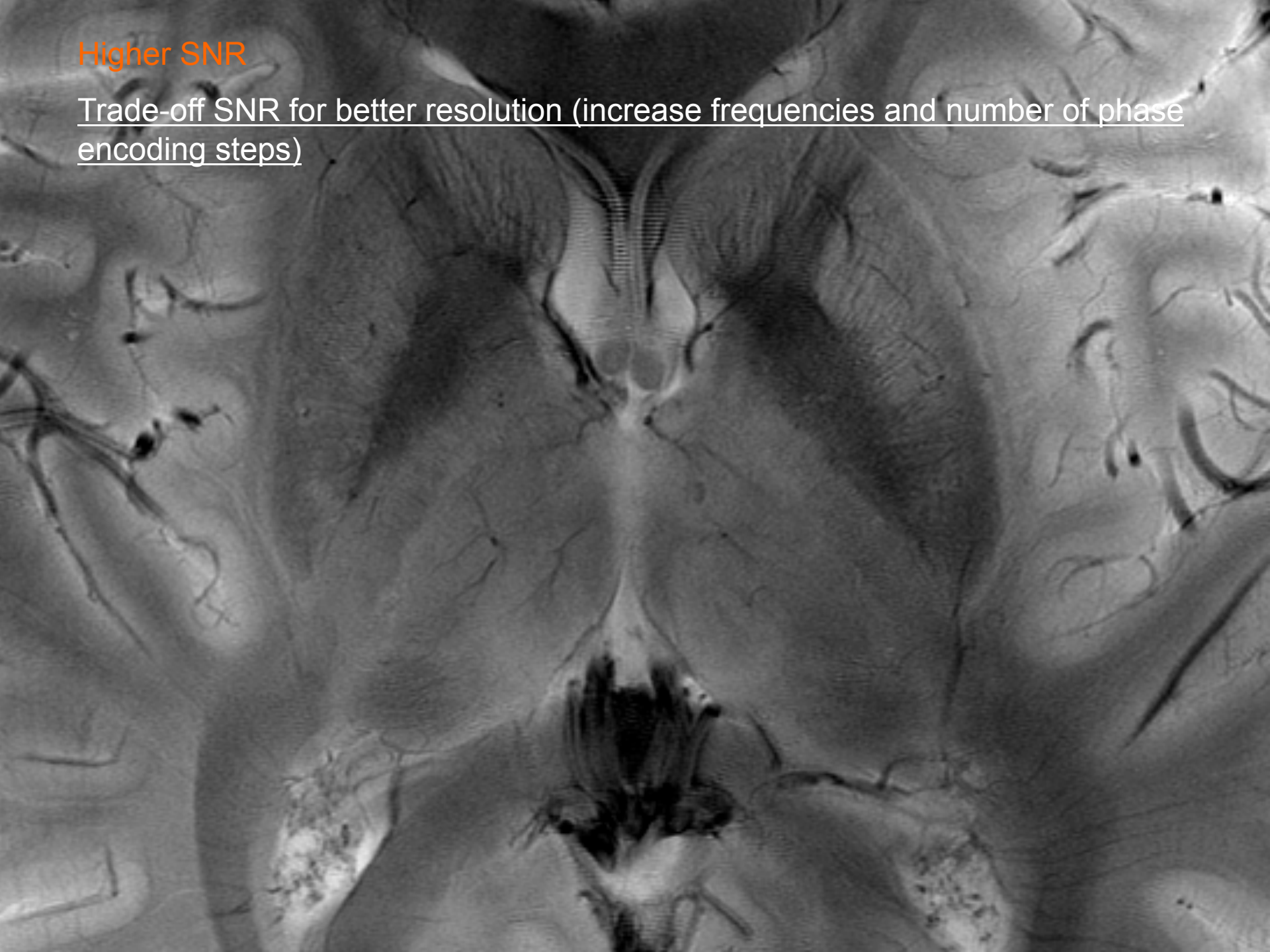


7T

Higher SNR

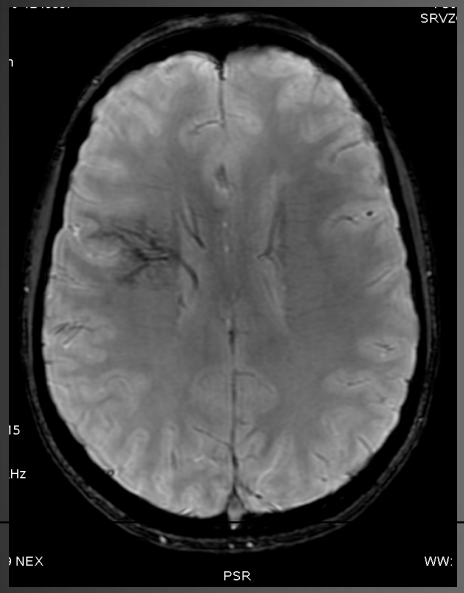
Trade-off SNR for better resolution (increase frequencies and number of phase encoding steps)



Shift due to susceptibility differences is proportional to B0

Use of a T2* weighted SWI sequence at 7T to create magnitude and phase images. Using the field-shift maps, susceptibility maps can be created as a third contrast to characterize brain structure.

1.5T



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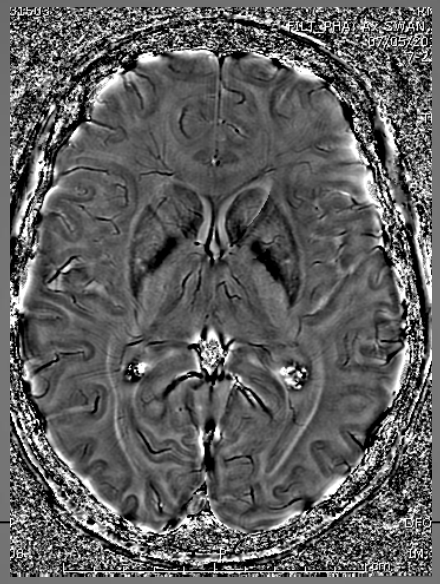
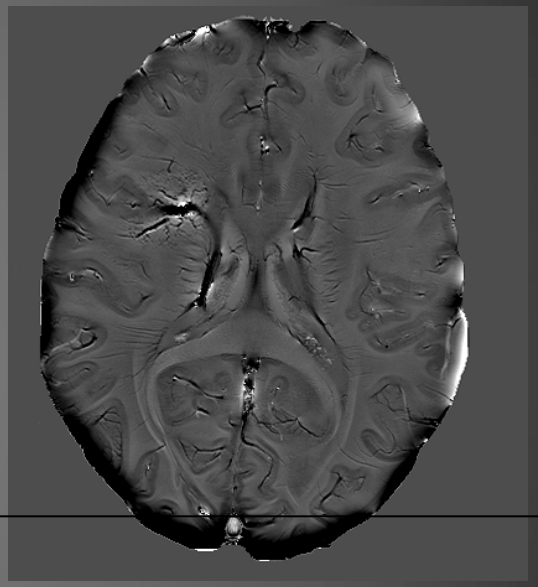
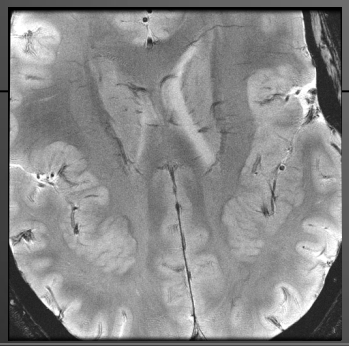


7T



QSM: Thresholded K-Space Division (TKD)-basedSusceptibility Mapping



GRE T2*w magnitude

GRE unwrapped phase

Susceptibility map

*Clinical impact of ultra high-field MRI in **neurodegenerative diseases** diagnosis (PARKINSON - ALS – ALZHEIMER)*

PI **Mirco Cosottini**

REVIEW

Magnetic Resonance Imaging of the Substantia Nigra in Parkinson's Disease

Stéphane Lehéricy, MD, PhD,[1,2,3,4,5]* Michael A. Sharman, MD,[1,2,3,4,5] Clarisse Longo Dos Santos, PhD,[1,2,3,4,5,6] Raphaël Paquin, PhD,[1,2,3,4,5] and Cecile Gallea, PhD[1,2,3,4,5]

Study	Cases/controls	Field strength	Technique (b-value/Number of directions)	Primary measure	Findings in SN
Volumetry					
Adachi et al, 1999	25/36	1.5	DWI (825/3)	Volume	Reduced
Oikawa et al, 2002	22/22	1.5	PD/T2/STIR	Volume	No change
Minati et al, 2007	8/8	1.5	IR-T1	Volume	Reduced lateral > medial
Menke et al, 2009	10/10	3	DESPOT1	Volume	Reduced
Peran et al, 2010	30/22	3	T2*	Volume	No change
Magnetization transfer					
Eckert et al. 2004	15/20	1.5		MTR	Reduced
Tambasco et al, 2011	22/10			MTR	Reduced
Relaxometry					
Ordridge et al, 1994	7/7	3		R2′	Increased
Michaeli et al, 2007	8/8	4		T1rho	Increased
				T2rho	Reduced
Martin et al, 2008	26/13	3		R2*	Increased in lateral SNc
Peran et al, 2010	30/22	3		R2*	Increased
Diffusion studies			(*b* value, Nb directions)		
Yoshikawa et al, 2004	41251	1.5	DTI (800, 6)	MD	
				FA	Reduced
Chan et al, 2007	73/78	1.5	DTI (800, 12)	ADC	No change
				FA	Reduced
Vaillancourt et al, 2009	14/14	3	DTI (1000, 27)	FA	Reduced
Menke et al, 2009	10/10	3	DTI (1000, 60)	FA	No change
				Connectivity	Reduced (SN-Tha, SN-Pu)
Menke et al, 2010	10/10	3	DTI (1000, 60)	MD	No change
				FA	No change
				Connectivity	Reduced volume of SN
Peran et al, 2010	30/22	3	DTI (1000, 30)	MD	No change
				FA	Reduced

Parkinson disease: diagnostic role

Standard neuroimaging techniques fail in defining normal anatomy of SN and have a marginal role in the diagnosis of PD

ORIGINAL RESEARCH

L. Minati
M. Grisoli
F. Carella
T. De Simone
M.G. Bruzzone
M. Savoiardo

Imaging Degeneration of the Substantia Nigra in Parkinson Disease with Inversion-Recovery MR Imaging

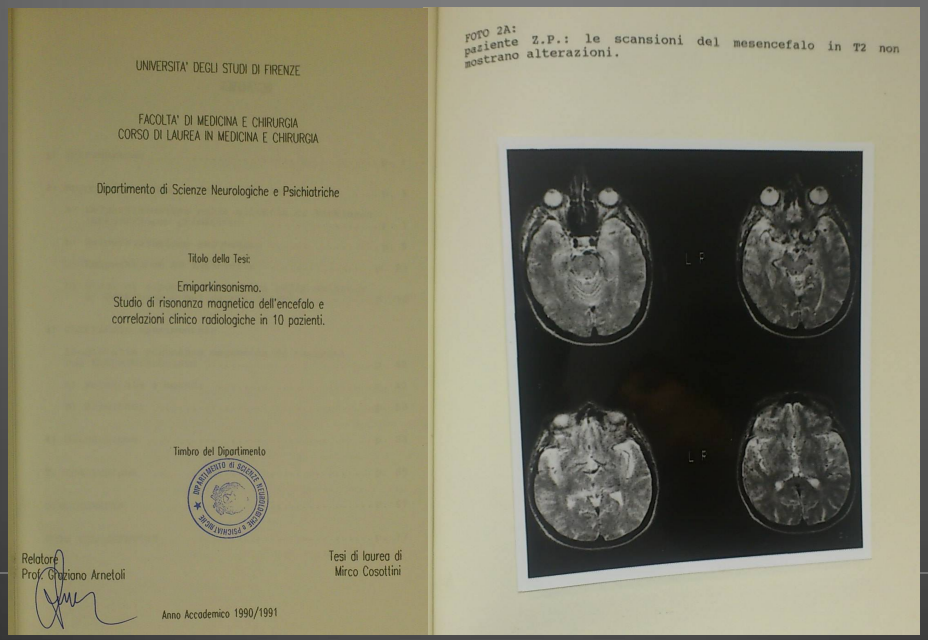
BACKGROUND AND PURPOSE: Visualizing with MR imaging and obtaining quantitative indexes of degeneration of the substantia nigra in Parkinson disease have been long-sought goals. We investigated the potential role of area and T1 contrast measurements in differentiating patients from controls and their age-related changes.

METHODS: Eight patients with Parkinson disease, 8 age-matched controls, and 8 young controls were imaged. We obtained the pixel-wise difference between 2 sets of inversion-recovery images, acquired parallel to the bicommissural plane, with different inversion times. Pixel-intensity ratios between lateral and medial nigral regions, and nigral area and substantia-nigra/midbrain area ratios were computed.

RESULTS: Compared with that of controls, loss of substantia nigra was evident in patients, its borders taking a smoother and more irregular appearance. Patients were characterized by a lateral-to-medial gradient, due to reduced hypointensity of the lateral portion of the substantia nigra and relative sparing of its medial portion. The visible nigral area was significantly smaller in patients compared with matched controls ($P = .04$). The substantia nigra/midbrain area ratio enabled considerably better separation ($P = .0001$). The lateral/medial pixel-intensity ratio was significantly higher in patients compared with matched controls ($P = .01$) and in young controls compared with age-matched controls ($P = .01$).

CONCLUSION: Inversion-recovery sequences may provide a convenient way to visualize nigral degeneration. Relative area and pixel-intensity measurements may integrate other techniques (such as diffusion-tensor imaging on nigrostriatal pathways) in the neuroradiologic diagnosis and follow-up of Parkinson disease by quantitatively assessing the degeneration of the substantia nigra.

… are not able to distinguish the pars compacta and the pars reticulata of SN



UNIVERSITA' DEGLI STUDI DI FIRENZE

FACOLTA' DI MEDICINA E CHIRURGIA
CORSO DI LAUREA IN MEDICINA E CHIRURGIA

Dipartimento di Scienze Neurologiche e Psichiatriche

Titolo della Tesi:

Emiparkinsonismo.
Studio di risonanza magnetica dell'encefalo e correlazioni clinico radiologiche in 10 pazienti.

Timbro del Dipartimento

Relatore
Prof. Graziano Arnetoli

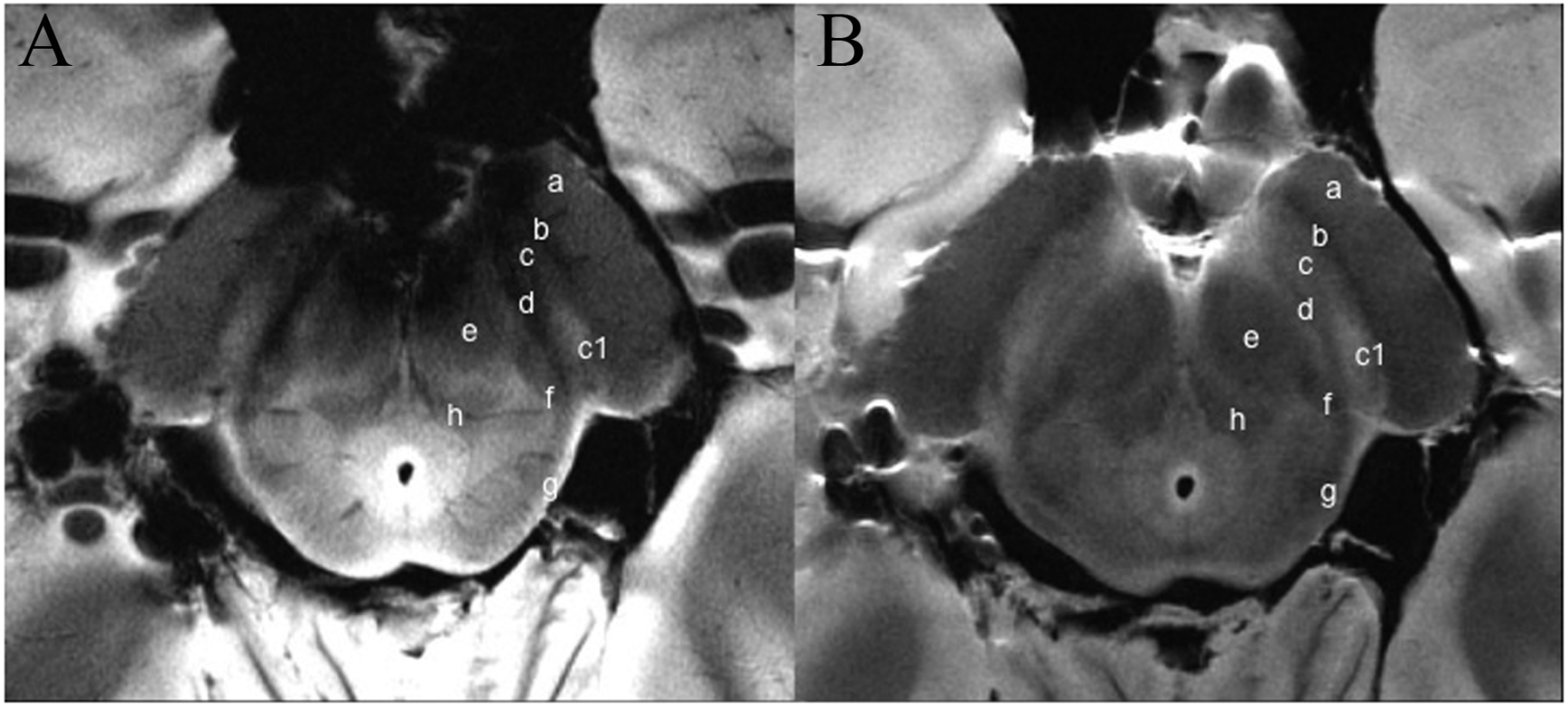
Tesi di laurea di
Mirco Cosottini

Anno Accademico 1990/1991

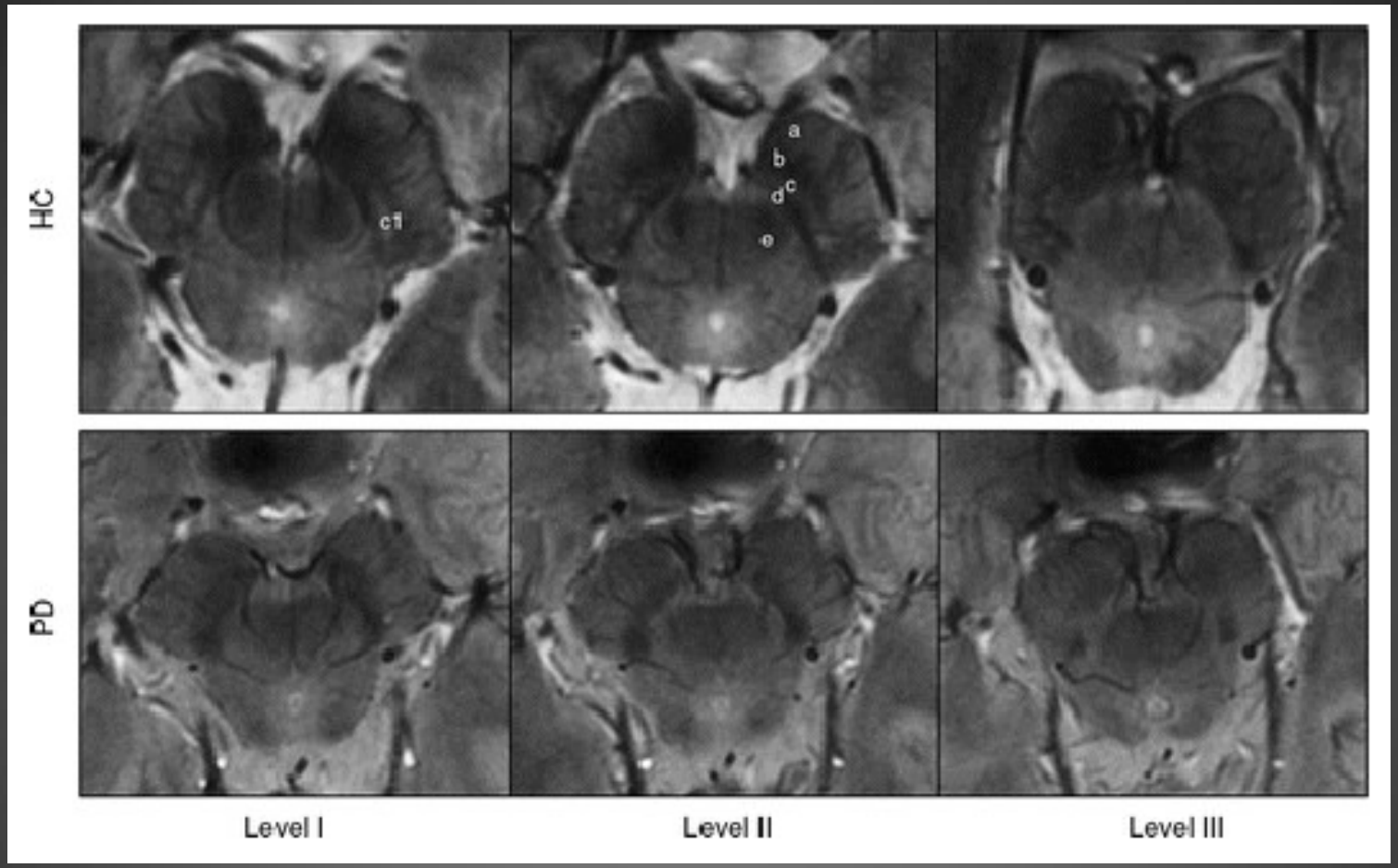
FOTO 2A:
paziente Z.P.: le scansioni del mesencefalo in T2 non mostrano alterazioni.

Parkinson disease: diagnostic role

SWAN UHF-MRI allowed to define a three layered organization of SN by distinguishing pars compacta ventralis (SNcv) and dorsalis (SNcd) from pars reticulata (SNr).



Parkinson disease: diagnostic role



RSNA Radiology

Original Research
Neuroradiology

MR Imaging of the Substantia Nigra at 7 T Enables Diagnosis of Parkinson Disease

Mirco Cosottini, MD, Daniela Frosini, MD, Ilaria Pesaresi, MD, Mauro Costagli, PhD, Laura Biagi, PhD, Roberto Ceravolo, MD, Ubaldo Bonuccelli, MD, Michela Tosetti, PhD

From the IMAGO7 Foundation, Pisa, Italy (M. Cosottini, M. Costagli); Department of Translational Research and New Surgical and Medical Technologies (M. Cosottini) and Neurology Unit, Department of Clinical and Experimental Medicine (D.F., R.C., U.B.), University of Pisa, Pisa, Italy; Neuroradiology Unit, Department of Diagnostic and Interventional Radiology, Azienda Ospedaliero-Universitaria Pisana (AOUP), Pisa, Italy (I.P.); and Stella Maris Scientific Institute, Pisa, Italy (L.B., M.T.).

Parkinson disease: diagnostic role

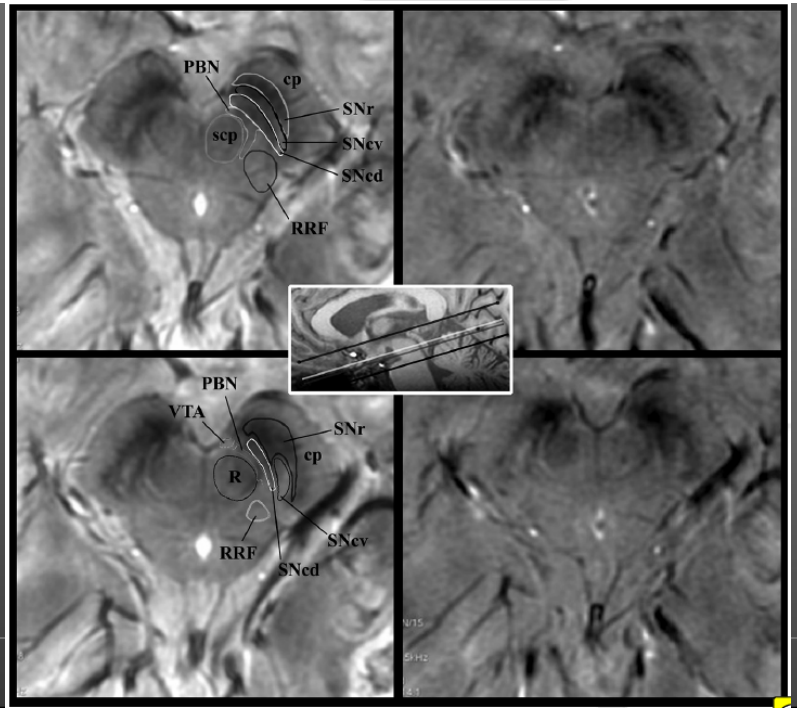
ORIGINAL RESEARCH
BRAIN

AJNR in press

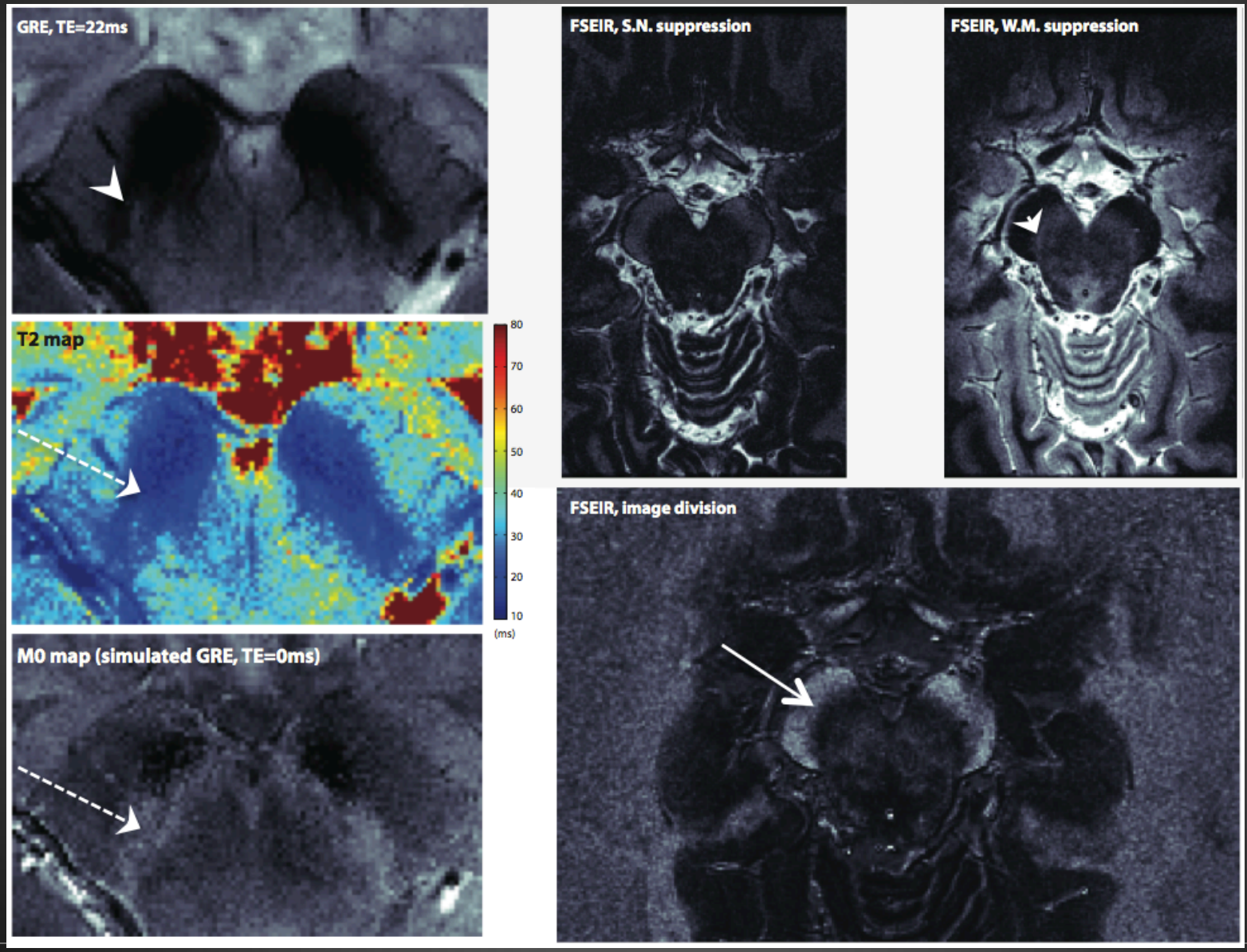
Comparison of 3T and 7T Susceptibility-Weighted Angiography of the Substantia Nigra in Diagnosing Parkinson Disease

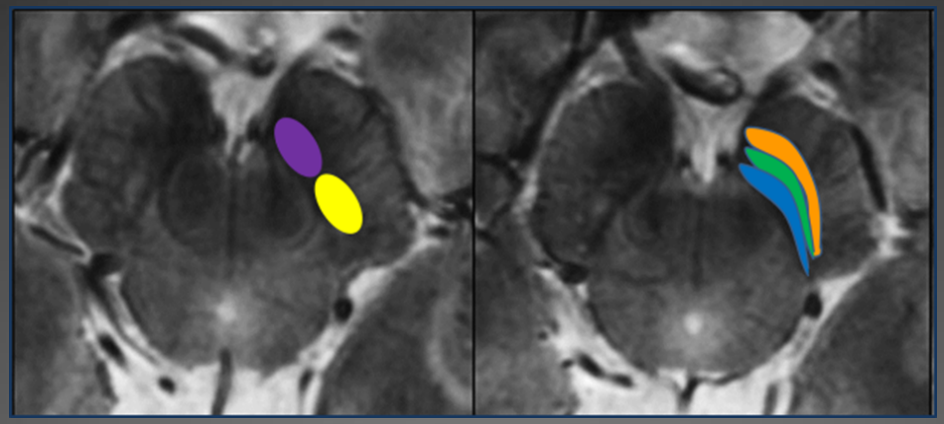
M. Cosottini, D. Frosini, I. Pesaresi, G. Donatelli, P. Cecchi, M. Costagli, L. Biagi, R. Ceravolo, U. Bonuccelli, and M. Tosetti

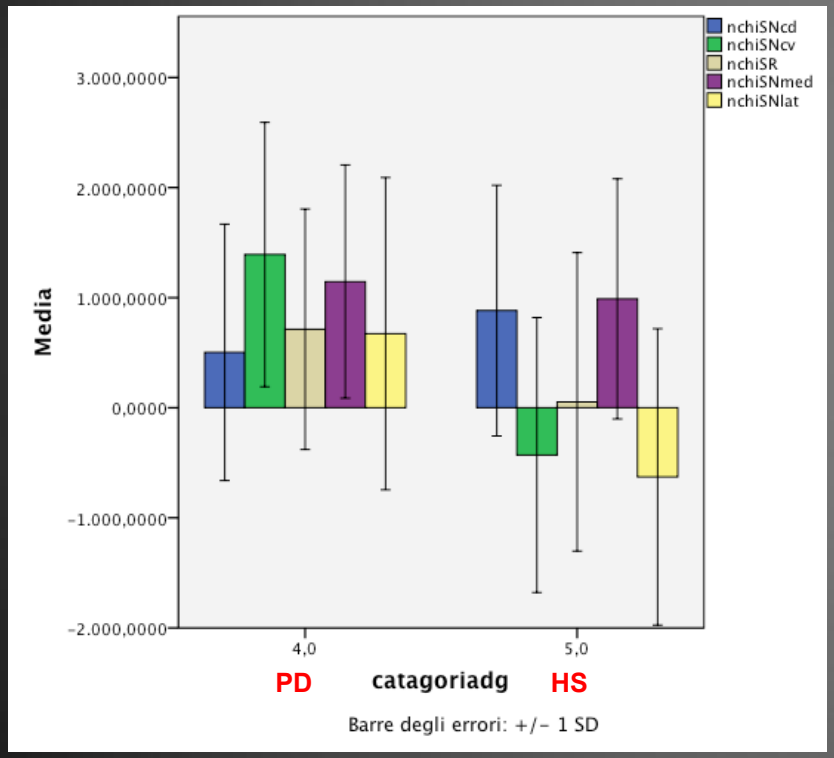
RESULTS: Susceptibility-weighted angiography 7T MR imaging can diagnose Parkinson disease with a mean sensitivity of 93%, specificity of 100%, and diagnostic accuracy of 96%. 3T MR imaging diagnosed Parkinson disease with a mean sensitivity of 79%, specificity of 94%, and diagnostic accuracy of 86%. Intraobserver and interobserver agreement was excellent at 7T. At 3T, intraobserver agreement was excellent for experts, and interobserver agreement ranged between good and excellent. The less expert reader obtained a diagnostic accuracy of 89% at 3T.



Multi-parametric MR imaging TARGETED on the brainstem



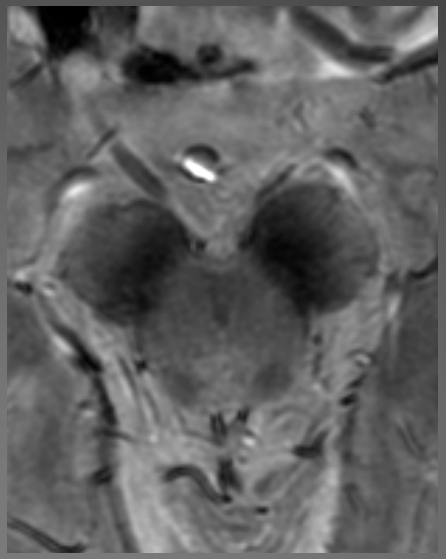




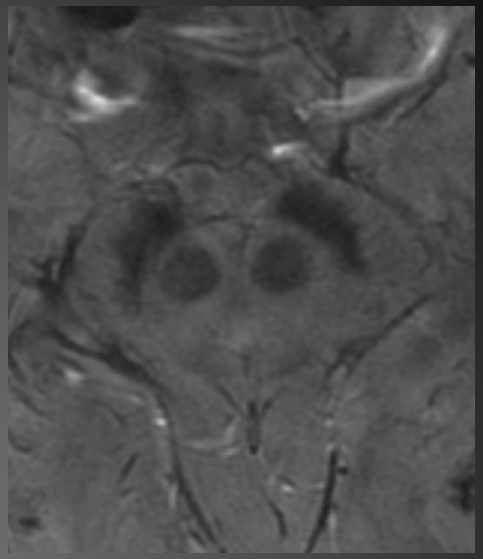
Under submission

Parkinson disease: diagnostic role

MSA

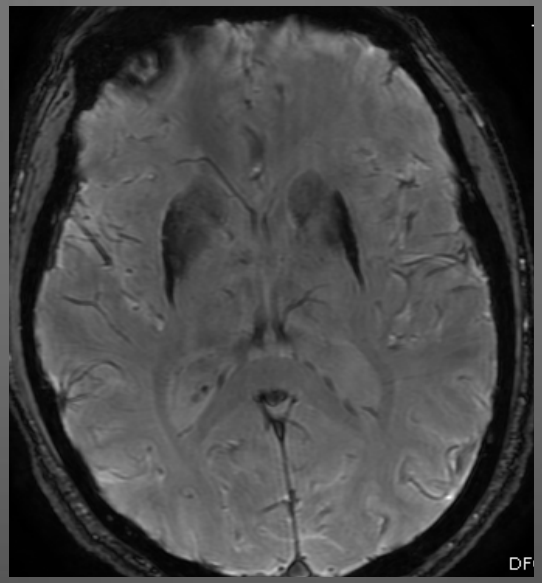


7T



3T

7T



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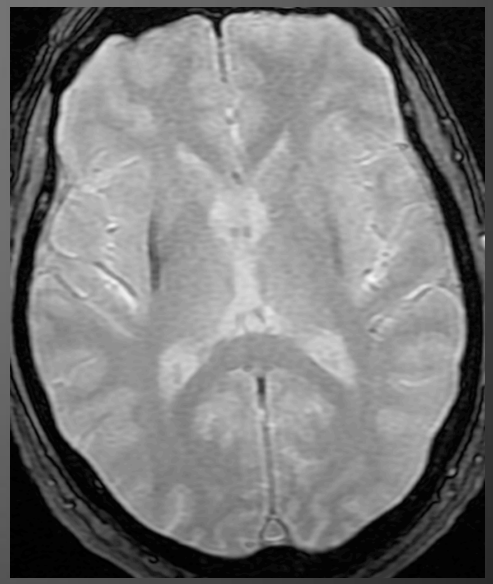
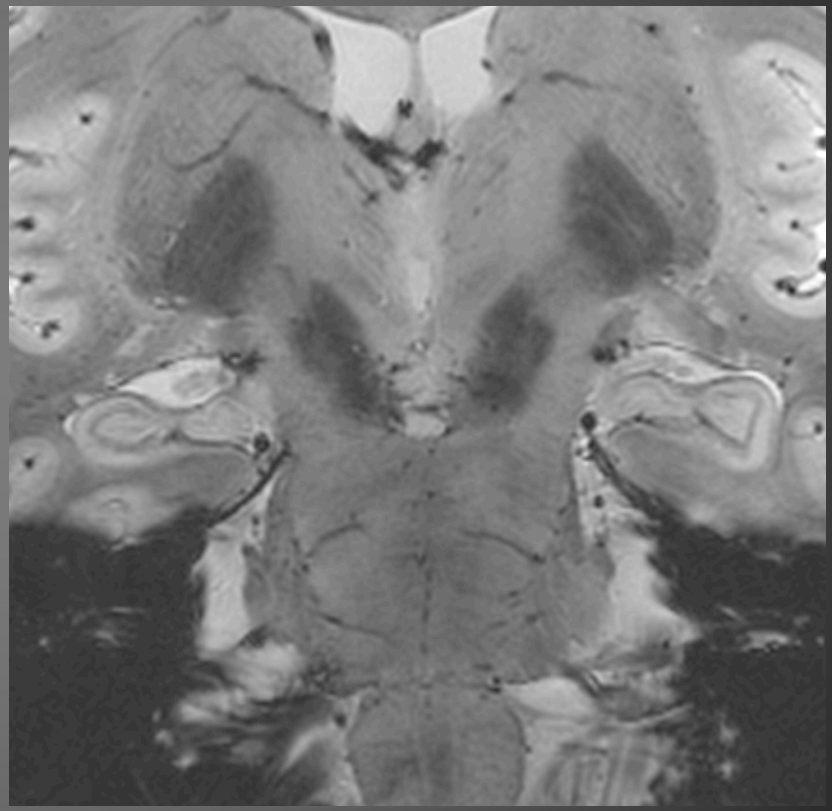


1.5T

Parkinson disease: pre-surgical direct targeting



Conclusions

Due to Physical Effects of Higher Magnetic Field Strengths:

Ultra High Field MR (7T) is a promising tool in the research environment that is under evaluation before clinical application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Nikola Tesla Corner
BRYANT PARK
Avenue of the Americas