Biophysical review's 'meet the editors series'—a profile of Naranamangalam R. Jagannathan

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Standing next to MRI scanner

Early days

The sight of physicians performing their rounds in a hospital ward (replete with stethoscopes around their neck and resident doctors in tow) completely fascinated me when I was very

young. Due to this, my initial ambition was to become a medical professional. However, it seemed that God had some other plans for me, and so my journey led me towards a career in biomedical science. In the famous Hindu scripture, Bhagavad Gita, it is said “whatever happens, happens for good”, and this was definitely true in my life. In what follows, the pathway through which my career and life has played out is outlined.

My life journey started like this. When I was a 10-month-old child (still in the arms of my loving mother!), the dreadful polio virus caught hold of me, leaving me with post-polio residual paralysis (called as PPRP) of both the lower limbs. Because of this, I only started walking at 5 years of age with the requirement of calipers in both legs. Life was difficult to start with, but I managed with the very strong help and support of my parents, sisters, and brother and then later my own family after marriage. After schooling, my first choice was to enter medicine, with engineering being a close second. Medicine was effectively ruled out as I did not study the necessary biology course, and so I pursued the engineering pathway. However my father, cognizant of my health condition, suggested that a desk job might suit me best and impressed upon me the possible benefits of a bank job. After much discussion, I ended up compromising by taking science as a pre-university course. Later, I joined the famous St. Joseph's College (an affiliate college of the University of Madras, where Prof. G. N. Ramachandran and other great scientists of India studied their degree course) at Tiruchirappalli in South India to do my BSc and MSc degrees in Physics and passed out in the mid-1975. At this point of time, my father strongly felt that I should go for a bank job, to which I dutifully applied a few months before graduating. After passing the all India written examination, I was selected for a personal interview at the banking office in Chennai. However, after a few months, my name sake (except for a small difference in the first initial, “A” instead of “N”) and contemporary from the same college (he took an MSc in Mathematics while living

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opposite to my dormitory) was the one to receive appointment from the bank as a “probationary officer.” I took this coincidence in a positive way thinking that something else was held in store for me! This gave me an opportunity to argue with my father that I should be allowed to go for PhD, which he reluctantly agreed. Thereafter, I moved to Madras (now known as Chennai) to join the famous biophysics laboratory created by Prof. G. N. Ramachandran¹ at the University of Madras to do my PhD with Prof. R. Srinivasan. My doctoral topic was on wide-line NMR studies of biological molecules (including some instrumentation work) along with the structure determination of an organic compound by X-crystallography. My senior at the University of Madras was Dr. S. Ganapathay, now a retired senior scientist from National Chemical Laboratory, Pune, always helpful, taught me the basics of NMR and allowed me to use the wide-line NMR equipment that he built for my work and to make some modifications.

Soon after the defense of my PhD in September 1982, I went to the Department of Chemistry, University of British Columbia, Vancouver, Canada, to do post-doctoral work (with Prof. F. G. Herring) in NMR of polymers (both solid and liquid state). I returned to India in April 1986 and took up a position as Senior Scientific Officer at the Solid State and Structural Chemistry Unit under the famous Prof. C.N.R. Rao FRS at the Indian Institute of Sciences, Bangalore. After an year, I contemplated doing another post-doctoral position. Hence in the late 1987, I moved to the Department of Chemistry, Colorado State University, Fort Collins, USA, and joined the laboratory of Prof. Gary Maciel. The 1 year at Fort Collins was very useful as I was able to learn a lot of fundamental aspects of NMR instrumentation allowing me to build a custom probe² to conduct high-resolution proton NMR of solid samples using magic angle spinning and multiple-pulse NMR. This period of my working life was both challenging and also intensely interesting as up to that point I had relatively little exposure to the development of instrumentation methods and practical use of high precision metal-lathe based engineering.

Journey to biomedical research

While at Fort Collins, I happened to see an advertisement from University of Arkansas for Medical Sciences (UAMS), Little Rock. In short, Prof. Richard A Komoroski of the Department of Radiology was looking for a person (research associate position) with NMR experience to help him to establish an in vivo MR laboratory and initiate research in MRI. Prior to that point, I had been reading articles about MRI and its uses in diagnostics and was fascinated. I applied for the position

and was called for an interview and ultimately selected. So I moved to UAMS in July 1988 and started my work after 3 weeks of training on MRI and pulse programming at the GE technical offices in Milwaukee. Switching from NMR to MRI was not that difficult as I had the basic concepts of NMR, and this made my job relatively easy. Together with a colleague (Dr. Ramaprasad), we three (Komoroski, Ramaprasad, and I) slowly started to establish the in vivo NMR laboratory. While Dr. Ramaprasad was trying to establish a pre-clinical (animal) MR, I was entrusted with setting up human clinical MR research. During office hours, it was very difficult to get time on the clinical MRI scanner to perform research. After all the clinical scans were over (~after 7 p.m.), we could start our research work. This high demand on scanner time frequently meant working until 2 a.m. to conduct our research. During this period, my task was to implement and test various in vivo localization MRS pulse sequences and standardize them on phantoms for later implementation in human subjects. I still remember vividly the day that my first localization technique started to work successfully (of course in a phantom) around 1am in the morning. I immediately called Dr. Komoroski to inform him the good news. It was a very satisfactory feeling as though something great had been achieved!

Creation of facility for biomedical MR research

Due to family reasons, in July 1989, I returned to India to take up a position as a Lecturer at the Department of Crystallography & Biophysics, University of Madras, Chennai. At that time, my research was mainly related to the solid-state NMR of biomolecules. Slowly, I was reconciling myself to the fact that working in a medical school may be an unrealized dream. However in 1992, I received a telex message from AIIMS, the All India Institute of Medical Sciences (one of the premier medical college hospitals in India) located in New Delhi. The message said that I am invited to give a lecture on MRI and specified that AIIMS would provide a travel and accommodation allowance (which was important in those days!). I accepted and went to New Delhi and gave my talk. After the talk, I was asked to meet the Director of AIIMS. Not knowing the reason, I arrived at the chambers of the AIIMS Director at 5:30 p.m. and then waited for more than an hour as the Director was busy in a meeting. At about 6:45 p.m., I was able to enter the chamber of the Director. The first question asked to me was my age, and I replied that I was 35 years old. The Director then told me that they were looking for a more experienced senior person to head a new Department of NMR and associated MRI Facility that was to be established at AIIMS. Up to that point, I did not know why

¹ However, by the time I arrived, he had moved to Indian Institute of Science, Bangalore.

² For the NMR cognoscenti, this was a CRAMPS probe.

I was asked to meet the Director. In any case, I considered it as yet another missed opportunity.

However, if it was my destiny to work in medicine, then I knew that somehow things would fall into place. It turned out that Lady luck did indeed smile upon me once again, when, in 1993, the new Head of the Department of NMR at AIIMS informed that advertisement for the Assistant Professor's post would soon come out and asked me to apply for the same. So goes the story that finally in 1993, I was selected as Assistant Professor and joined AIIMS to start my career in both pre-clinical and clinical research using MRI and MRS. This represents the beginning of my independent career in the discipline of medicine and my chance to work in a medical school—the dream of my early days of life! Even though I could not become a qualified physician, I was happy for the opportunity to work in a medical school.

The Department of NMR at AIIMS was created in 1992 under the direction of the planning commission of India to initiate biomedical research and to create human resources in the field of MR research in India. AIIMS was founded as a premier medical institute that provided specialist care to people from all walks of life, from the common man to parliamentarians including the Prime Minister. Prof. P. Raghunathan, an alumni from the University of British Columbia, was the first to head this department. Together with another faculty colleague (who was also recruited at the same time), Prof. Raghunathan and I commenced installation of MR equipment one by one. The first scanner, installed in 1992, was a 4.7 T animal MRI scanner (BIOSPEC) from M/s. Bruker. Using this scanner, we started our work on phantoms, plant products (to learn the technique and to test the RF sequences), and pulse programming. As a consequence of our use of plant phantoms, we also published half a dozen papers on the utility of MRI in agricultural research! Later, our work was focused on various disease models using rats and mice. In 1993, our first clinical 1.5 T MRI scanner from M/s. Siemens (MAGNETOM 63SP) was installed, and by virtue of my earlier exposure in the USA, we were very quickly able to start work on in vivo MRI and MR spectroscopy (MRS as it is called) research in humans. In 1996, we added a Bruker 400 MHz NMR spectrometer to work on metabolomics using blood, tissues, and other body fluids to supplement our in vivo MR work. Thus by 1996, we established a full-fledged biomedical MR laboratory with all necessary accessories and instruments for doing research from molecules to humans via pre-clinical (animal model) research.

In July 1998, Prof. Raghunathan retired, and I was given the temporary responsibility to run the department since I was only an Assistant Professor. In our Institute, the hierarchy in faculty was such that after Assistant, you first become Associate Professor and then Additional Professor. Only after going through these stages could you become a full Professor. So the rumor was that the Department of NMR would be

merged with the Department of Radiodiagnosis/Department of Neuroradiology, or one of the Radiology head's would be made head of the Department of NMR. However, the post of Professor at the Department of NMR was advertised in July 1998, and as I fulfilled all the eligibility criteria (qualifications in physics and publications in MRI and MRS in clinical and pre-clinical research), I applied for the vacant position. Interviews were held in August 1998 for both the post of Associate Professor (which I was due) and also for the full Professor. After an agonizing wait of 3 months, the institute governing body met to approve selections made by the appointment committee. On the night of November 30, 1998, information came that I was appointed as a full Professor at the Dept. of NMR. After 10 days, I was made the Head of the department, a post which I held until my retirement on June 30, 2019.

Upon taking over, first thing I did was to increase the MRI clinical hours to 12 h a day since the out-patient waiting list was reaching more than 3 months. In 2002, we added a second clinical 1.5 T MRI scanner (SONATA) from M/s. Siemens to cater to the ever increasing patient work load. By this time, the first MRI scanner MAGNETOM 63-SP completed 10 years, and hence a replacement by a state-of-the-art 1.5 T MRI scanner (AVANTO, Siemens) was carried out in 2004. In the meantime in 2005, the operating console of the 4.7 T animal MRI scanner was replaced with the latest state-of-the-art computer system for which funds were obtained through a project funded to me by the Department of Science & Technology, Government of India. In 2007, a third clinical MRI scanner (Achieva, Philips) with a field strength of 3 T was added to cater to the demand for patient care. Almost at the same time, I submitted again another proposal to the Department of Science & Technology, Government of India to replace the old 400 MHz NMR spectrometer with a state-of-the-art sophisticated 700 MHz NMR. Eventually, this was purchased in 2008 from Varian. The SONATA 1.5 T MRI scanner completed 10 years of service in 2012, and we planned its replacement with a 3 T MRI scanner. This in 2013, we installed a new 3 T MRI scanner (Ingenia, Philips) replacing SONATA. In 2017, we replaced the AVANTO 1.5 T MRI clinical MRI scanner with a 1.5 T MRI scanner (Aiera, Siemens) and started operating a 24 h per day clinical MRI service. As of the current time, this center at AIIMS, New Delhi, now has 5 MR devices, and research is in full swing in pre-clinical, clinical, in vitro, and ex vivo MR studies of various disease processes.

Pre-clinical and clinical MR research in India

The focus of my research in the last three decades at AIIMS has been on all three fronts of in vivo MR involving pre-clinical, clinical, and metabolomics. My contributions are in the area of clinical applications of molecular and functional

imaging (MRI and in vivo MR spectroscopy) methods in cancer for early diagnosis and for early assessment of tumor response to understand the disease biology, physiology, and metabolism. Specifically, the focus has been in identifying non-invasive biomarkers for early diagnosis, early assessment of treatment response, and prediction of treatment outcome in breast and prostate cancer patients using various MR methodologies with the overarching aim to integrate them into routine clinical workup.

During the late 1990s and early 2000s, we published (along with Profs. V. Seenu, R. Parshad and others) a series of papers that showed that water-to-fat ratio and choline metabolite determined through in vivo MR spectroscopy (MRS) could serve as non-invasive molecular biomarkers for breast cancer that is useful in early diagnosis and early therapeutic assessment for prognosis (Jagannathan et al. 1998; Jagannathan et al. 2001; Kumar et al. 2006). These findings formed one of the earliest reports on the utility of in vivo MRS in a clinical setting. Later, our group developed a method to determine the absolute concentration of choline in vivo (see Fig. 1; Sah et al.

2012). A cut-off value of choline concentration was also worked out for the differentiation of malignant, benign, and normal breast tissues. In 2009, we published a seminal contribution highlighting the use of diffusion MRI for monitoring the response of breast cancer patients at an early stage of treatment (Sharma et al. 2009), which could be achieved in couple of minutes. Our group also demonstrated an association of choline with the various female hormonal status of patients like ER, PR, HER2-nu, and in triple negative (TN) and non-TN breast cancer patients (Sah et al. 2012). Recently, the potential of multi-parametric MR approach using routine MRI, diffusion MRI, and in vivo MRS for early prediction of response of breast cancer patients undergoing therapy was reported by us (Sharma et al. 2017). That study revealed that a combination of all various MR parameters after the third cycle of therapy showed no false positive cases and demonstrated the potential of multi-parametric approach as a better predictor of treatment response in clinical setting.

We also investigated a link between two major molecular pathways involved in breast cancer, namely, the choline and

Fig. 1 **a** and **b** T2- the voxel location from a malignant tumor and the corresponding proton MR spectrum acquired from $20 \times 20 \times 20 \text{ mm}^3$ voxel. **c** and **d** Contrast enhanced axial MR image showing the voxel location from a benign tumor and corresponding spectrum acquired from $10 \times 11 \times 15 \text{ mm}^3$ voxel. **e** and **f** T2-weighted sagittal MR image showing

the voxel location from a normal breast tissues and the corresponding proton MR spectrum acquired from $15 \times 15 \times 15 \text{ mm}^3$ voxel (reproduced with permission from John Wiley & Sons from reference Sah et al. 2012)

Wnt (β -catenin and cyclin D1), using in vivo MRS and ELISA method in 20 breast cancer patients and in 10 benign cases (Agarwal et al. 2017). MRS demonstrated higher concentration of tCho in malignant compared with benign tissues. Also, malignant tissues had higher cytosolic and nuclear β -catenin expressions than benign and non-involved tissues. Within malignant tissues, β -catenin and cyclin D1 expressions were higher in the nucleus than cytosol. Cyclin D1 expression was higher in the cytosolic fractions of benign and non-involved than malignant tissues. These findings explain the molecular mechanism of tCho elevation which may facilitate exploration of additional therapeutic targets for breast cancer observed through in vivo MR spectroscopy.

In addition to breast cancer, my group, along with Prof. Rajiv Kumar of Urology department, was involved in the evaluation of pre-biopsy MR using routine MRI, MRS, and diffusion MRI methods for early diagnosis of prostate cancer in men with raised prostate specific antigen (PSA) levels, especially in clinically challenging cases of PSA in the range 4 to 20 ng/mL, with a aim to avoid unnecessary biopsies (Kumar et al. 2018). This work represents a paradigm shift from the typical protocols followed (especially in western countries) where post-biopsy MR is carried out. A new method for ultrasound-guided biopsy using the suspicious area of malignancy from MR spectroscopic imaging (MRSI) method was developed—see Fig. 2 (Kumar et al. 2007).

In 2016, a prospective cross-sectional study was carried out by us (Dwivedi et al. 2016) wherein we developed a pre-biopsy multi-parametric MRI (mpMRI; consisting of MRI, diffusion MRI (DWI), dynamic contrast MRI (DCE-MRI),

and MR spectroscopic imaging (MRSI)) based risk score (RS) and a statistical equation for predicting the risk of PCa in biopsy naive men that may help reduce unnecessary biopsies. Multivariable analysis adjusted with positive pathology showed apparent diffusion coefficient (ADC), metabolite ratio (citrate/(choline + creatine)), and PSA as significant predictors of PCa. A statistical equation was derived using these predictors. A simple 6-point mpMRI-based RS was derived for calculating the risk of PCa, and it was shown to be highly predictive for PCa.

Recently, we initiated the use of mpMRI-guided in-bore biopsy (within the MRI bore itself) for increased detection rate of PCa which reduces the limitation associated with TRUS-guided biopsy especially for lesions located in the central and anterior regions of the prostate. Group I consisted of 52 patients who underwent mpMRI-guided targeted in-bore biopsy, while group II had 110 patients who underwent only TRUS-guided 12-core systematic biopsy. Our data suggested that ADC values of the suspicious area from DWI before biopsy may help to accurately target the ROI for biopsy and also to reduce unnecessary biopsies.

Another important work that was carried out with Prof. L.M. Patnaik of Indian Institute of Science, Bangalore was on using wavelet theory as input to neural network self-organizing maps and support vector machines for classification of human brain MR images (Chaplot et al. 2006). This method can be used to classify MR brain images as either normal or abnormal, and we tested this approach on a dataset of 52 MR brain images. Great than 94% classification was achieved using the neural network self-organizing maps and

Fig. 2 **a** Representative T2-weighted sagittal image of prostate of a patient (PSA 8.7 ng/mL) showing the distance from base of the prostate of transverse section containing the suspicious voxel. **b** Voxel grid overlaid over T2-weighted transverse image of the corresponding section showing the distance of the suspicious voxel from midline of prostate **c** MR spectrum obtained from the voxel showing increased choline and decreased citrate. **d** TRUS image of MRSI directed TRUS-guided biopsy of prostate. The needle mark on TRUS image shows the site of biopsy (reproduced with permission from John Wiley & Sons from reference Kumar et al. 2007)

with 98% achieved using support vector machine based analysis. Our study showed that the classification rate was higher for a support vector machine classifier compared with self-organizing map-based approach.

In addition to research on humans, during the 1990s, our group was the first in India to initiate pre-clinical related research using MRI and MRS using animal models of various diseases. Since then, we have been actively involved in pre-clinical MR research of various disease models. A number of projects from my group were related to stroke, multiple sclerosis (MS), and sleep. The treatment of stroke is challenging, and several new therapies demand early and accurate diagnosis. Along with Prof. Y. K. Gupta of Pharmacology department, an animal model of stroke (middle cerebral artery occlusion, MCAo) was used to study the effect of drugs like melatonin (Sinha et al. 2001), endothelin antagonist (Tak-044) (Briyal et al. 2005), rapamycin (Chauhan et al. 2011; Chauhan et al. 2015), citalopram (Gupta et al. 2018), and Indian herbal *Withania somnifera* (ashwagandha) (Chaudhary et al. 2003) using routine MRI and diffusion MRI. Our work indicated that all the above compounds act as neuroprotective agents in stroke and showed evidence of the effectiveness of these drugs in focal ischemia.

Another experimental model work was related to multiple sclerosis (MS), which is a demyelinating autoimmune disorder characterized by an inflammatory process involving myelin. MS is now widely seen in Indian population. The early course of the disease is highly variable and difficult to monitor in humans. The biology and pathology occurring at the early stages of MS were studied in a chemically induced experimental animal model of demyelinating lesion during the complete cycle of de- and re-myelination process using different MR methods like diffusion, relaxation measurements, and MR spectroscopy (Degaonkar et al. 2002; Degaonkar et al. 2005).

In addition, we (with Prof. V. Mohan Kumar and his group) also developed a novel method to study sleep-wakefulness in rats. A non-magnetic stereotaxic holder was fabricated, and a procedure was developed with simultaneous acquisition of electrophysiological recordings (EEG, EMG, and EOG) and fMRI in conscious rats (Khubchandani et al. 2003). These studies helped to localize non-invasively the critical areas of sleep like the involvement of medial pre-optic area (mPOA) and frontoparietal cortex (Khubchandani et al. 2005).

To supplement our in vivo MR research, my group also explored the area of metabolomics using high-resolution NMR spectroscopy of tissues, CSF, blood, and other body fluids in disease processes like breast (Sharma and Jagannathan 2009; Jagannathan and Sharma 2017; Jagannathan 2018; Sharma and Jagannathan 2019) and prostate cancers (Kumar et al. 2014), muscular dystrophies (Sharma et al. 2003a, b), spina bifida (Pal et al. 2005; Sharma et al. 2006), inflammatory bowel disease (Sharma et al. 2010), and axillary lymph nodes of breast cancer patients (Sharma et al. 2004; Seenu et al. 2005). Such studies are

useful to produce metabolic profiles of cancer or tumor cells which in turn are helpful in assessing the associated gene functions, drug development, and biochemistry.

Contribution to biophysical activities—national

Since the discovery of triple helical structure of collagen and the famous phi-psi plot by Prof. G. N. Ramachandran of the University of Madras, biophysics research in India has been growing steadily. The initial protein crystallography work was concentrated at the University of Madras, Indian Institute of Science, Bangalore, and at AIIMS, New Delhi, although it later spread all over India. Prof. M. Vijayan was instrumental in setting up various macromolecular crystallography units across India. At each of these places, there are very active groups of biophysicists working on problems of current interest. In parallel, following the success of NMR applications in structural biology, a high-field NMR facility at the Tata Institute of Fundamental Research, Mumbai, was set up under the leadership of Prof. G. Govil. Later, various centers in India started conducting NMR of biomacromolecules. The application of medical NMR and MRI facility in India was initiated at AIIMS, New Delhi, in 1992 (this work was headed by me). Developments in computational biology, molecular modeling, and bioinformatics took place at IISc, Bangalore, and later at SINP, Kolkata, CCMB, Hyderabad, and the University of Pune. There are several other institutions who are also pursuing biophysics research significantly.

My association with the biophysical activities in India started during my doctoral days, when I was at the Department of Crystallography and Biophysics, University of Madras. But the major breakthrough came in 1996, when I was included as a member of the national organizing committee for hosting the 13th International Biophysics Congress of the International Union for Pure and Applied Biophysics (IUPAB) at New Delhi in 1999. This was organized jointly by the Indian Biophysical Society (IBS), Indian National Science Academy (INSA), and IUPAB at New Delhi during September, 1999. Since then, I have been actively involved in the activities of IBS. In 2007, I was elected as President of the Indian Biophysical Society for a term of 2 years.

Contribution to biophysical activities—international

Prof. Girjesh Govil was instrumental in establishing a platform for cooperation between the scientists belonging to different countries in the Asian region. This helped to give birth to the Asian Biophysics Association (ABA), with its principal members from Australia, China, India, Japan, Korea, Hong

Kong, and Taiwan. The ABA will now include all eligible Asian countries providing a greater scope for cooperation between scientists in the Asian region. The most important outcome of this effort was that India hosted the 7th ABA Conference at New Delhi during January/February 2011, which was attended by over 400 scientists from the member countries including Prof. Ada Yonath, NL. This was organized by me at New Delhi on behalf of IBS, and in the same year, I was elected as President of ABA for a period of 2 years.

My association with IUPAB started in 1996, when I first participated in the 12th International Biophysics Congress at Amsterdam. Since then, I have been attending all the IUPAB congress meetings and served as an elected member of the Executive Council of IUPAB from India for a period of 2 terms (6 years; 2008–2014). I also had the opportunity to serve in some of the task forces of IUPAB. When IUPAB along with the publisher M/s. Springer launched the journal *Biophysical Reviews*, I was invited to become a member of the Editorial Board and later became one of the Executive Editors. In addition to serving as an Executive Editor of *Biophysical Reviews*, I am currently a member of the editorial board of (i) *Magn. Reson. Imaging*; (ii) *NMR Biomed.*; (iii) *MAGMA*; (iv) *Magn. Reson. Insights*; and (v) *Biomedical Spectroscopy & Imaging*. I also served as a member of the Editorial Board of “Spectroscopy – Biomedical Applications” (IOS Press, Netherlands; 2009–2011).

Participation and active role in MR-related activities—international and national

During my career, I received many awards and honors, both nationally and internationally. To name a few of the national recognitions, I was elected as Fellow of the Indian National Science Academy (INSA), New Delhi; Fellow of the Indian Academy of Sciences (IASc), Bangalore; Fellow of the National Academy of Sciences (NASI), Allahabad; and Fellow of the National Academy of Medical Sciences (NAMS), India. In 2017, I was elected as Vice-President of the Indian National Science Academy (INSA), New Delhi, and the post I held until December 2019. Besides these national awards, in 2010, I was elected as Fellow of International Society for Magnetic Resonance in Medicine, USA (ISMRM) (the first scientist from this part of the globe). I also was a member of the Executive Council of the International Conference of MR in Biological Systems (ICMRBS-2005 to 2014). I also served as a member of the Annual Meeting Program Committee (AMPC – 2007-09); member of the Educational committee (2007–2009); Chapters committee (2010–11; 2014–18), and Young Investigators committee (2014–2017) of the International Society for Magnetic Resonance in Medicine, USA (ISMRM). I was also a member

of the Program Committee for the 2014 World Molecular Imaging Congress (WMIC), Seoul, South Korea.

I established the ISMRM Indian Chapter (affiliated to ISMRM, USA) in the year 2014, becoming its founding President and serving in this role until 2017. I was also instrumental in setting up the Molecular Imaging Society of India (MISI) that is affiliated to the World Molecular Imaging Society (WMIS), USA, and I am currently its Vice-President. I am also currently the Vice-President of the National Magnetic Resonance Society (NMRS) of India. I serve in many national committees on biophysics and imaging and in various government funding agencies. The most satisfying one was being the Chair of the Steering Committee for the Indigenous Manufacture of MRI in India under the Prime Ministers’ initiative of “Make in India” program, wherein the government has funded 5 leading institutions to come up with an affordable prototype MRI for India.

I have published over 250 peer-reviewed research papers, reviews, and chapters in books and had also the opportunity to edit three volumes on MRI and MRS and five special issues for national and international journals: (i) *Cancer metabolism and metabolomics*, *NMR Biomed.*, 2019, Volume 32 (10); (ii) *Prostate MR: Current status, challenges and future directions*, *NMR Biomed.*, 2014, 27: 1–111; (iii) *Tumor microenvironment in cancer treatment and metastasis*, along with Bhujwala ZM, *NMR Biomed.* 2011: 24 (6); 559–764; (iv) *Breast MR*, *NMR Biomed.*, 2009, Volume 22 (1); 1–135; and (v) *MRI and in-vivo NMR*, *Curr. Sci.*, 1999, Volume 76 (6).

During the middle of last year (2019), I retired after 27 years of service from the All India Institute of Medical Sciences, New Delhi, of which 21 years were spent as Head of the Department. Working in AIIMS, New Delhi, was always a challenge since our medical institute caters to people of all walks of life including VVIP’s. This role, in fact, gave me the opportunity and satisfaction of serving the humanity. I have recently taken up assignments at Chennai where I continue to do work on MRI and MRS.

Acknowledgments I would like to take this opportunity to thank all my students, post-doctoral fellows and collaborators for their help and support during my journey all these years. My special thanks to Prof. V. Seenu, Prof. Rajiv Kumar and Dr. Uma Sharma for collaborating with me for the last 3 decades. My research has been generously supported for many years by AIIMS; Science and Engineering Research Board (SERB), Government of India; Department of Science and Technology (DST) Government of India; and Indian Council of Medical Research (ICMR), Government of India. Also I would like to thank SERB, Government of India, for the award of J.C. Bose Fellowship.

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