Ricardo Ramina, Paulo Henrique Pires Aguiar, Marcos Tatagiba (Editors)

Samii's Essentials in Neurosurgery

Ricardo Ramina, Paulo Henrique Pires Aguiar,
Marcos Tatagiba
Editors

Samii's Essentials in Neurosurgery

With 550 Figures and 37 Tables

Springer

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Mainz


Nordstadt Hannover

MHH Hannover


INI Hannover

Foreword I

It is a privilege to write a foreword for the Festschrift of a dear friend, who also happens to be a living legend.

In 1969 in Japan, we were examining the usual international meeting papers, often geographically and politically selected, when suddenly we came across some excellent scientific papers by a group of young investigators from Mainz Germany, led by a young neurosurgeon named Madjid Samii. The papers dealt with peripheral nerve physiology. They described important basic research and the findings have stood the test of time. I felt intrigued and felt that I should get to know this man, who has since become one of my best friends, if not my best friend. I went to him, introduced myself and we started talking. We have been in conversation ever since.

Madjid Samii rapidly became a world-leading, world-class neurosurgeon. He has boundless energy, a will to succeed, and a talent for doing everything well. He went to the Nordstadt Hospital in Hannover as Chairman of Neurosurgery in 1977, and developed a superior neurosurgical training program, some of the fruits of which you will see in this volume. He and his wife, Mahschid, raised two fine children. They are now grandparents and are happy in this phase in their lives.

Professionally, Madjid was President of the German Society of Neurological Surgery for 2 years between 1996 and 1998. Also in 1996, he combined the Department of Neurosurgery at the Nordstadt Hospital and the Hannover School of Medicine. When he was nominated for President of the World Federation of Neurological Societies, I told him he should not do this because he was too busy and too much important work would otherwise not be done. However, his energy succeeded and he was able to show that he could stay busy and productive as a neurosurgeon, teacher, investigator, and lecturer while he did an extraordinary job as President of the World Federation.

On retirement from the neurosurgical department chair, he became President of the International Neuroscience Institute (INI) in July of 2000. He has continued to work productively in the INI and continues to do new work and to train excellent people.

Madjid Samii is one of the best technical neurosurgeons I have ever known, if not the best. Any neurosurgeon can learn from him. He has created a system of sharing information that puts many other professors to shame.

This is the professional side. How about the personal side of Madjid? He is a generous, giving man. He gives gifts to people, but more importantly, gives the gift of himself to friends and acquaintances. He has a talent for hospitality that is remarkable. He is fun to be around and although quiet and reserved, he is able to spin a wonderful story and to share with others his wisdom and his joy in life. He astoundingly, and despite his ego (which one needs to be a good neurosurgeon) also listens, and therefore, one can have a real conversation, a dialogue, with Samii. It has been my pleasure to have had many such dialogues, to have spent much time with him, to have learned from him, and to have tried to teach him as we have matured (I cannot say grow old) together. I treasure his friendship, I am amazed at his contributions, and I am impressed by his energy level.

If one is to be a leader, especially an innovative leader, and most especially in a surgical field, several factors are operant. That person must understand, but usually cannot fully comprehend what a serious effect he has on others. To put this another way, we do not know the importance of what we do when we do it. We may not understand this at any time or for some time. We often do not understand the proper use of new technology until it becomes old technology.

We must command the respect of others, and to do this demands an attitude of seriousness without self-absorption and ego. We must have the ability to have others work with us as much as for us. We must have organizational skills. Without these, we can accomplish nothing and all the best ideas and talent in the world will be wasted.

We must decisively do the right thing in any situation, despite the fact that this is often more difficult, and despite the consequences. This is most serious, most important, and most constructive in the long run. We must have the ability to walk in high places without fear and with the understanding of relationships. We must not be seduced by false technology and gimmickry. Speaking for neurosurgery, one can look at lasers gathering dust, capricious use of focal irradiation, and misinformed use of monocular endoscopy for neurosurgical procedures as examples.

As neurosurgeons, we must understand that operative technique is important. Simplicity and economy of movement are paramount to excellent understanding of

three-dimensional anatomy and pathology and treatment thereof. We must be able to separate dogma from claptrap, as underlying dogma has frequently been lost in the development of surgery over the years. We must be paragons of virtue to our students, residents, and associates. We must be absolutely honest in all our approaches.

In all of the above, Dr. Madjid Samii stands as a towering figure, able to comprehend, organize, develop, and teach neurosurgery to others. Witness the superb group of people doing superb work in this volume. They are not necessarily a reflection of Dr. Samii's own work, but they are developments of thinking, of operative technique, and of management principles, which have, with Dr. Samii's blessing, gone beyond and beside his superb level of practice and teaching. This writer is proud to be a friend of Dr. Samii's, to be a comrade in the field of microneurosurgery, and to have written a foreword for this magnificent volume.

Peter Janetta

Foreword II

The first time I was confronted with a brain tumor was when I was a medical student at the Pathological Institute of Nordstadt Krankenhaus in Hannover, Germany, while observing Professor Erdmann performing an autopsy of a patient who had been operated by Dr. Brunngraber, chief of the Neurosurgical Department of the Nordstadt Krankenhaus. At that time, in the early 1960s, I could not imagine how this event would influence my life or how this special place, Nordstadt Krankenhaus, would influence the world of neurosurgery. Guidelines for the treatment of neurosurgical pathologies and development of leadership would arise from that hospital.

This book reflects all of the teachings and the neurosurgical techniques initially introduced and developed by Madjid Samii. The chapters herein are presented by his earlier coworkers, co-operators, pupils, and friends, each one an expert and master in his or her own right; following the motto of the famous poet Hans Sachs from Nuremberg:

"Ehret Eure Meister, dann bannt Ihr böse Geister" (Honor your master and banish your bad spirits).

Standing on shoulders of their teachers, senior neurosurgeons are, over time, able to further develop and improve on their results.

Madjid Samii became involved with peripheral nerve surgery, including peripheral nerve regeneration by autologous transplantation, at the University of Mainz, Germany. For a short time I was also interested in this field, but following the orientation of my teacher, Frank Marguth, at the University of Munich, Germany, I changed to pituitary surgery and neuroendocrinology. Madjid Samii continued with peripheral nerve surgery. Frank Marguth was a good friend of Kurt Schürmann, Samii's teacher in Mainz.

Madjid Samii accepted with great enthusiasm a call to work in Hannover. From the beginning he was able to convince the local authorities that something special and extraordinary could be created here.

I discovered the skull base "from and around the sella turcica" following the advice of one of the pioneers of skull-base surgery, Patrick Derome, from Paris, France. Madjid expanded his interests in neurosurgery from the peripheral nerves to the cranial nerves. He was one of the founders of an interdisciplinary and international study group on skull-base surgery, and later of national and international societies. These organizations have become important structures of teaching worldwide.

It was the facial nerve that led Madjid Samii to worldwide success with acoustic neurinoma surgery. His unsurpassed (probably unsurpassable) series of more than 3500 operated acoustic neurinomas started in Nordstadt Krankenhaus, Hannover. In the beginning these surgeries were very time consuming, lasting from the morning until evening. Today, almost daily, Madjid Samii is resecting such tumors in about 1 hour. After experience with more than 4000 surgeries for pituitary adenomas, that is also the time I need to totally remove such a tumor. The techniques he has taught his pupils, the authors of this book, will also be passed on to their pupils.

My congratulations to Madjid on his more than 40 years in neurosurgical practice and on his 70th birthday. All my best wishes to a brilliant leader and friend, who with continuous enthusiasm and total dedication to neurosurgery fulfils his global responsibility to his medical field and even more to his patients. He has introduced to neurosurgery new ways, environments, and structures, both locally and internationally, and is the best of all at the International Neuroscience Institute in Hannover.

Ad multos annos! To Madjid and his teaching generation.

Rudolf Fahlbusch

Preface I

The idea to write a book in honor of Professor Madjid Samii's 70th birthday evolved after talking to several of his former colleagues. This book shares with the readers his method of teaching surgical techniques as well as his management philosophy.

The last 40 years will be remembered among neurosurgeons for the remarkable development of new surgical techniques and technological advances. The introduction of the binocular dissection microscope for neurosurgery was a monumental advance; it opened up new horizons and possibilities for the safe treatment of most neurosurgical diseases. One of the pioneers of this "new era" of neurosurgery is Professor Madjid Samii. Very early in his career he started to use the operative microscope and developed new approaches for peripheral nerves, skull-base surgery, brain tumors, vascular pathologies of the brain and spinal cord, and spine diseases.

Writing about the professional career of one of the best surgeons in the history of neurosurgery is not difficult. Several hundred neurosurgeons had the opportunity to observe his skills as he operated on the most difficult cases in Germany and in many other countries. He is a great teacher. He has trained several surgeons who have since become outstanding neurosurgeons in Germany and the rest of the world. He is a master in the management of all neurosurgical pathologies and his scientific production is extraordinary. I have known him since 1979, initially as a resident, then as his associate ("Oberarzt") until 1986, and finally as a close friend. My first impression of his character as a person and a neurosurgeon goes back to 1979. I had been at the clinic (Nordstadt Krankenhaus) for only a few weeks, and after a "chief visit" he said to all of his staff: "The only real treasures a neurosurgeon can have in his life are his patients." Through the many years that I have known Madjid Samii, I can testify that he practiced what he preached, treating each patient, regardless of his/her status, with the same dedication, respect, and tenderness.

Madjid Samii is a very gentle and elegant person, but at the same time very exigent. He has never tolerated negligence and disrespect, especially with patients. He handles everyone in his clinic with honesty, justice, and a tender heart, and everybody in the clinic trusts him. He also has a special ability to motivate people to work together as a team. In addition to all of the medical colleagues he has worked with during his life, he has also been able to put together a "first-class team" of administrative support (e.g., Frau Plünecke and Frau Krümmel) and nurses (e.g., Schwester Hanna, Schwester Birgit, and especially Schwester Gisela).

Professor Samii feels "at home" and relaxed in the operating theater. For example, he is not concerned if during a very complicated surgery somebody asks him something about the procedure. He will pay attention and answer in a polite way. Some years ago, Professor Yasargil told me that he was surprised at the relaxed way Professor Samii went into the operating room to perform a difficult surgery: "It was like he was going to play golf!" He loves to show and teach his surgical technique and is very proud of his pupils, always giving them his undying support. I remember a situation that arose during a congress of the German Neurosurgical Society in Hannover. At that time, I had just finished my neurosurgical training and was on call. A patient with a difficult ruptured anterior communicating aneurysm came into our clinic and emergency surgery was indicated. Professor Samii had brought six neurosurgical professors from Germany and Austria to visit the clinic, when I started the aneurysm dissection, all of them came into the operating room to observe the surgery. Professor Samii told me I should continue on and clip the aneurysm. It was a difficult case but I succeeded in clipping it very nicely. After the clipping, all of the visitors left the room with the exception of an old professor from Vienna. He came to me and whispered in my ear, "My young man, I would not like to have been in your position today!" Yet I was very confident because I knew Professor Samii would have helped me if I had needed him.

Madjid Samii is a very optimistic person who believes in what he does. Patients love him; he is attentive to their needs and is always trying to do his best to help solve their problems. He is an honest man. In his scientific publications and conferences he has always presented true complication rates and results. He turned 70 years old this year, but his energy is the same as when he was 50. He operates every day, two to three cases a day, he travels to several countries for congresses, he regularly goes to China to operate on patients, and he has many plans for the future. One year ago I was in his home talking with his lovely wife (Mahschid). She "complained" that he was

working as hard as ever. I asked her if he was happy and she answered: "Very happy!" This man is a shining example for future generations of neurosurgeons.

I want especially to thank two people who have made possible the success of this project. The first is my secretary, Mrs. Marli Uchida; she was tireless in contacting all of the authors, organizing the chapters, and helping with the editorial review. The second is Mrs. Stephanie Benko from Springer, Heidelberg (Germany). She worked in a very efficient and professional manner, giving us the essential support to realize this project. Finally, I would like to dedicate this book to all patients around the world who have been, or will be helped by the teachings of Madjid Samii.

Ricardo Ramina

Preface II

"Samii's Essentials in Neurosurgery" is a unique book in its conception. It represents a compilation of 33 chapters written by more than 40 distinguished international neurosurgeons from 10 different countries. This book is covering almost all areas of the modern neurosurgery of the brain, skull base, spine and peripheral nerves including radiosurgery. The chapters are distributed along the book not thematically as usual, but as a novelty, according to the countries where the authors are acting. Each chapter of this book contains a range of information which represents the author's particular view of that field of neurosurgery. However, although living and working in five different continents around the world, all authors have one point mutual: they all have enjoyed at least part of their neurosurgical education with Madjid Samii in Hannover in some period of the last 30 years.

Madjid Samii started his neurosurgical carrier about four decades ago. He benefited himself from the high neurosurgical education of an advanced and prestigious centre at that time, the Department of Neurosurgery at the University of Mainz, directed by Professor Kurt Schürmann. Samii's neurosurgical life was profoundly affected by exceptional developments in several fields of medicine of the last four decades, such as increasing knowledge on anatomy and physiology of the nervous system, and on pathophysiology and outcome of neurological diseases. Major technological advances of operating microscope, computed tomography, magnetic resonance tomography, ultrasound aspirator, intraoperative monitoring, neuronavigation and radiosurgery have deeply changed the treatment strategies in neurosurgery over the last decades. Whereas rapidly using all technological advances Samii's art of neurosurgery remained always focused on the patient's issues. His philosophy can be summarized as being open-minded for multi-disciplinary strategies and for the introduction of new technologies, while maintaining neurosurgery as simple as possible.

The idea to publish this book appeared recently. In 2002, a group of friends and former pupils of Professor Samii founded an international medical society called "Madjid Samii Congress of International Neurosurgeons (MASCIN)". Aim of MASCIN is to revive and give continuity to Samii's ideas on different fields of neurosurgery. He deeply influenced the education of a large number of neurosurgeons all over the world, who are today leading several neurosurgical fields in different countries. The present book "Samii's Essentials in Neurosurgery" represents the summary of MASCIN spirit. In fact, because the single most fundamental aspect of surgical neurology is the systematic assessment of patient's neurological state, the neurosurgeon has played one of the most important roles in the development of the entire field of this neuroscience.

We would like to thank the numerous authors for their encouraging response and remarkable contributions. We thank Springer with Stephanie Benko for the exceptional work. During the preparation of this book it was a great pleasure to get contact to many "old friends" around the world.

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I Madjid Samii's Curriculum Vitae

Madjid Samii, M.D.,
Ph.D. Curriculum Vitae

Madjid Samii was born in Tehran on June 19, 1937 and is of Iranian and German nationality. He is married to Mahschid Samii (since 1961) and they have two children. His hobbies after neurosurgery include music and golf. Professor Samii graduated in medicine and biology from the University of Mainz, Federal Republic of Germany, in 1963. He completed his training at the Neurosurgical Clinic of the University of Mainz in 1970 under Professor Dr. Kurt Schurmann. During his residency period, his scientific work resulted in a monograph on pneumoencephalotomography, experimental work on brain edema and experimental research on the surgical reconstruction of peripheral nerve lesions. In 1970 he was nominated Associate Professor and Vice Director of the Neurosurgical Clinic of the University of Mainz. He was also in charge of pediatric neurosurgery. In 1971 he became Professor of Neurosurgery. In that same year he instigated an annual course to teach his experiences in microsurgery.

Important Dates and Facts of his Career

1977	Nominated director of the neurosurgical clinic, Nordstadt Hospital in Hannover.
1977	He established the first microneurosurgical training laboratory in Germany.
1979	Cofounder of the Skull Base Study Group.
1983	First Medical World Telecommunication Conference (over the five continents).
1986	Call for the Chair of Neurosurgery at University of Leiden, The Netherlands.
Sept. 1987	Olivecrona Lecture, Karolinska Institute, Stockholm, Sweden.
Dec. 1987	Call for the Chair of Neurosurgery, University of Mainz.
April 1988	Call for the Chair of Neurosurgery, Hannover School of Medicine (MHH). Accepted.
May 1988	*Federal Republic of Germany Merit Cross First Class Award from the President of the Federal Republic of Germany for the scientific and practical development of neurosurgery and special efforts for the international scientific cooperation in this field.
1988	[+]Award of the Prize of Science of Lower Saxony
1988	Award of Honorary Professor by the Medical School of Military Academy, Beijing, China.
1988	Keith Professorship University of Toronto, Canada.
1986–1988	President of the International Society of Skull Base Study Group
1989	President of the German Society for Plastic and Reconstructive Surgery.
1989	Visiting Professor for life at Medical Faculty of University of California (UCLA) Los Angeles, USA, and Visiting Director of the Skull Base Center at Neurosurgical Clinic of UCLA.
1989	Guest of Honor at the Second Annual Neurosurgery in the Rockies Meeting at the University of Colorado, Denver, Colorado, USA.
1989	Obrador Lecture and Medal, Madrid, Spain.
1989	Penfield Lecture, Banff, Canada.

1990–1992	Re-election as President of the International Skull Base Study Group.
1989	Sano Lecture, Tokyo, Japan.
1991	Founder Member and first President of the German Society of Skull Base Surgery.
1991	Founder Member and first President of Neurobionics Foundation Hannover.
1991	Founder President of the Board of Trustees of the Foundation AWD Children's Aid, Hannover.
1991	Jamieson Memorial Lecture and Medal, Australia.
1991	Guest of Honor of the North American Skull Base Society.
1992	Traffic Security Award Non disputare, sed agere by the Traffic Guard of Lower Saxony.
1992	Lars Leksell Lecture, Charlottesville, USA.
1992	President of International Skull Base Society.
1992	President of the First International Skull Base Congress.
1992	Award of Honorary Professor by Medical School of University of Uruguay.
1993	Honorary Member of the Academia Nacional de Medicina of Brazil.
Sept. 1993	The first Edward Laws Jr. M.D. Lecture, George Washington University, Washington D.C.
1994	Honorary Citizenship of the City Rosario, Argentina.
1994	Doctor Honoris Causa (Honorary Doctor) awarded by Catholic University Rio Grande do Sul, Porto Alegre, Brazil.
1994	President elect of the German Society of Neurosurgery.
1994	Honorary President of the German Society of Skull Base Surgery.
1994	Award of Honorary Professor by Peruvian University Cayetano Heredia, Lima, Peru.
1995	Member of Board of Trustees "EXPO 2000 Hannover".
1995	Award of Honorary Professor by the National University, Lima, Peru.
1995	President of the German Society of Neurosurgery 1996–1998.
Since 1996	Chairman of the Neurosurgical Departments at MHH (since 1996) and Klinikum Hannover Nordstadt (since 1977).
1995	Sir Charles Balance Memorial Lecture and Medal, London, UK.
July 1997	President of the World Federation of Neurosurgical Societies (WFNS), 1997–2001.
May 1998	Award of Honorary Professor by the Pontificia Universidad Javeriana, Bogotà, Colombia.
June 1998	Award of the "Aristoteles Gold Medal" by the University of Thessaloniki, Greece.
March 1999	Award of Honorary Professor of Neurosurgery by The University of Alexandria, Egypt.
April 1999	The Sixth Annual Loyd C. Megison, Jr. Visiting Professorship, Louisiana State University Medical Center, Shreveport, Louisiana, USA.
April 2000	Award of Courtesy Professor in the Department of Neurological Surgery at the University of Florida College of Medicine, Gainesville, USA.
July 2000	President of the International Neuroscience Institute (INI). Inauguration on July 21, 2000.
July 2000	Congress President of the "World Congress on Medicine and Health" July 21–August 20, 2000, Hannover.
August 2000	Award of Doctor Honoris Causa of the University of Antioquia, Medellin, Columbia.
Sept. 2000	European Lecture for Neurosurgery, Opio-Nice, France.
Nov. 2000	Guest of Honor at the Third International Skull Base Congress, Foz do Iguacu, Brazil.
Dec. 2000	Award of the Rudolf Frey Prize for extraordinary achievements in the field of pain therapy.
June 2001	Honorary President of the German Society for Computer- and Robot-Assisted Surgery (CURAC).

Sept. 2001	Honorary President of the WFNS.
2001	Guest of Honor during the 50-year anniversary of the Italian Society of Neurosurgery.
January 2002	Award of Honorary Professor by Harbin Medical University, China
June 19, 2002	Award of the Decoration in Gold to celebrate Professor Samii's 65th birthday and his 25th anniversary as a neurosurgeon in Hannover by the Traffic Guard of Germany.
June 19, 2002	Award from the Brazilian Society of Neurosurgery.
March 2003	Honorary President during the Winter Congress of the Italian Society of Neurosurgery, Madonna di Campiglio, Italy.
April 2003	John L. Kemink, M. D. Memorial Lecture, University of Michigan, USA.
April 2003	The Richard C. Schneider Lecture, American Association of Neurological Surgeons, San Diego, USA.
2003	Inauguration of his statue in the public garden of the capital city of Gilan in Resht, Iran in acknowledgement of his life's work.
2003	In recognition of Professor Samii's 25-year chairmanship of the Neurosurgical Clinic, City of Hannover, the lecture hall of the hospital has been dedicated to his name (Madjid Samii-Auditorium)
2003	McLaughlin-Gallie Visiting Professorship of the Royal College of Physicians and Surgeons of Canada with the award of $10,000. For the first time since 1960, this prize was given to a German and worldwide to a neurosurgeon.
2003	Paul C. Bucy Award for outstanding contributions to neurosurgical education by the University of Chicago, USA.
July 2004	Nomination as President of the China International Neuroscience Institute at the Capital University of Medical Sciences in Beijing, China.
Sept. 7, 2004	First Honorary Ring of the City of Hannover (Garbsen) for outstanding contribution to the fame of the city worldwide.
Oct. 1, 2004	Honorary Membership of the Austrian Society of Neurosurgery during the 40th Annual General Meeting of the society in Vienna, Austria.
Oct. 21, 2004	Honorary Membership and Medal of Recognition of the Polish Society of Neurosurgery by the occasion of the 50th Anniversary of the society in Krakow, Poland.
Nov. 2004	Guest of Honor at the Fourth International Skull Base Congress, Sydney, Australia.
Nov. 25, 2004	Nomination as Honorary Professor by the Capital University of Medical Sciences in Beijing, China.
Nov. 25, 2004	In recognition of his worldwide contribution to skull base surgery, the new established skull base training center at the XuanWu University Hospital of the Capital University of Medical Sciences in Beijing, China has been dedicated to Professor Samii (Samii Skull Base Surgery Training Center).
Apr. 24, 2005	"Walk of Fame", Hannover (Garbsen).
May 2005	Honorary president of the Seventh Congress of the European Skull Base Society/13th Congress of the German Society of Skull Base Surgery.
May 18, 2005	Kurt Schürmann Lecture of the German Society of Skull Base Surgery, Fulda, Germany.
Nov. 11, 2005	Honorary Membership of the Bangladesh Society of Neurosurgeons.
Dec. 2005	Honorary Member of the Society of Nervous System Surgery in Istanbul, Turkey.
2005	Founding Chair of the Accreditation Committee for WFNS Board of Neurosurgery.
June 2006	Honorary Member of the Association of Russian Neurosurgeons in Moscow, Russia.
June 29, 2006	Matson Memorial Lecture, Harvard University of Boston, USA.
2006	Honorary member of the Charity Society for School Constructions in Iran
2006	In recognition of Professor Samii's worldwide achievement, two schools in Isfahan and Rasht, Iran were named after him (Prof. Madjid Samii School).

2006	Guest of Honor of the Brazilian Society of Neurosurgery at the 26th Brazilian Congress of Neurosurgery, Florianópolis, Brazil.
Nov. 13, 2006	Iranian scientific award "Chrehayeh Mandegar" for medicine 2006, Teheran, Iran.

Professor Samii has given more than 1000 lectures as Invited and/or Honored Guest of numerous national and international congresses and is an author of over 450 scientific papers and 15 books concerning the central and peripheral nervous systems.

Present Activities

President of the INI at Otto-von-Guericke University
President of the Chinese INI.
Chairman (retired) of the Neurosurgical Departments of MHH and Klinikum Hannover, Nordstadt.
Regular Lectures Chair of Neurosurgery at MHH.
Visiting Professor of Neurosurgery at various universities.

Professor Samii is a Member of the editorial or advisory boards of the following medical journals:
Acta Neurochirurgica Editorial Board
African Journal of Neurosurgical Sciences Editorial Board
Archives of Iranian Medicine Editorial Board/International Board of Consultants
Chinese Journal of Minimally Invasive Neurosurgery Editorial Advisory Board
Chirurgia Neurologica Editorial Board
Critical Reviews in Neurosurgery Editorial Committee (former chairman)
Hong Kong Neuroscience Foundation Charitable Trust Editorial Board
Journal of Operative Techniques in Neurosurgery Editorial Board
Journal of Reconstructive Microsurgery Advisory Board
Journal of Skull Base Surgery Editor Emeritus
Maghreb Journal of Neurosurgery Honorary Board Member
(Morocco-Algeria-Tunisia)
Neuroanatomy Editorial Board
Neurochirugia Comité Editorial Internacional
Neurocirugía-Neurocirurgia Editorial Advisory Board
(Spanish-Portuguese Journal of Neurosurgery)
Neurological Research Associate Editor
Neurosurgical Focus Reviewer
Neurosurgery International Liaison and Advisory Panel
Pan Arab Neurosurgical Journal Advisor
Russian Neurosurgery Editorial Board
Surgical Neurology Editorial Board
Surgical and Radiologic Anatomy Advisor
Türkiye Klinikleri Journal of Medical Sciences Advisory Board
Turkish Neurosurgery and Türk Nörosirürji Dergisi International Advisory Board
Ukrainian Journal of Minimally Invasive and Editorial Board
Endoscopic Surgery

Professor Samii is a member of the following Medical Societies:
Deutsche Gesellschaft für Neurochirurgie
German Society of Neurosurgery
Deutsche Gesellschaft für Schädelbasischirurgie
German Society of Skull Base Surgery
Deutsche Gesellschaft für Neuroradiologie
German Society of Neuroradiology

Deutsche Gesellschaft für Unfallheilkunde
German Trauma Society
Deutsche Gesellschaft für Plastische und Wiederherstellungs-Chirurgie e.V.
German Society of Plastic and Reconstructive Surgery
Deutsche Gesellschaft für Computer- und Roboterassistierte (Founding Member)
Chirurgie e.V. (CURAC; Honorary President)
German Society for Computer- and Robot-assisted Surgery
Gesellschaft zum Studium des Schmerzes für Deutschland, Österreich und die Schweiz e.V.
German-Austrian-Swiss Society for the Study of Pain
European Joseph Society (Facial-Plastic and Reconstructive Surgery)
European Council of the European Skull Base Society (1995)
Sunderland Society (Founding Member)
WFNS
Accreditation Committee for WFNS Board of Neurosurgery (Founding Chair)
Neurosurgery
WFNS Skull Base Committee (Chairman)
WFNS Peripheral Nerve Surgery Committee
WFNS Training Committee
International Skull Base Society (Founding Member and Past President)
International Society of Reconstructive Microsurgery (Founding Member)
International Society of Pituitary Surgeons
Skull Base Study Group (Founding Member and Past President)
Academia Eurasiana Neurochirurgica
World Academy of Biomedical Technologies (Founding Member)
Deutsche Gesellschaft für Hals-Nasen-Ohren-Heilkunde, Kopf- und Hals-Chirurgie
(German Society of ENT Therapeutics, Head and Neck Surgery; Corresponding Member)
Argentine Academy of Neurosurgery (Corresponding Member)
Argentine Society of Neurosurgery (Honorary Member)
Argentine Society of Neurosciences (Corresponding Member)
Bangladesh Society of Neurosurgeons (Honorary Member)
Brazilian National Academy of Medicine (Honorary Member)
Brazilian Society of Neurosurgery (Corresponding Member)
Brazilian Society of Skull Base Surgery (Honorary Member)
Sociedade Brasileira de Neurocirurgia (Honorary Member)
Bolivian Neurosurgical Society (Corresponding Member)
Canadian Society of Neurosurgery (Honorary Member)
Chilean Society of Neurology, Psychiatry, and Neurosurgery (Honorary Member)
Colombian Society of Neurosurgery (Honorary Member)
Dutch Society of Skull Base Surgery (Honorary Member)
The Hong Kong Neurosurgical Society (Honorary Member)
The Neurological Society of India (Honorary Member)
Iranian National Academy of Medicine (Honorary Member)
Iranian Society of Neurosurgery (Honorary Member)
Italian Society of Neurosurgery (Honorary Member)
Gruppo di Microneurochirurgia del Periferico, Italy (Honorary President)
Japanese Society of Neurosurgery (Honorary Member)
Peruvian Academy of Surgery (Honorary Member)
Peruvian Society of Neurosurgery (Honorary Member)
Portuguese Society of Neurosurgery (Honorary Member)
Romanian Society of Neurosurgery (Honorary Member)
Romanian Academy of Medical Sciences (Honorary Member)
Scandinavian Society of Neurosurgery (Corresponding Member)
Society of Nervous System Surgery (Honorary Member)
Spanish and Portuguese Society of Neurosurgery (Corresponding Member)
Neurosurgical Society R.O.C. Taiwan (Honorary Member)
Turkish Neurosurgical Society (Honorary Member)

Society of Neurological Surgeons USA (Honorary Member)
The American Academy of Neurological Surgery (Corresponding Member)
American Association of Neurological Surgeons (AANS) (Honorary Member)
Adjunct Subcommittee on International Associate (Member)
Membership of the AANS
American Society for Reconstructive Microsurgery (Corresponding Member)
The Western Neurosurgical Society USA (Honorary Member)
Sociedad de Neurologia y Neurocirugia del Uruguay (Honorary Member)
Latin American Federation of Neurosurgery (First Honorary Member)
Central European Neurosurgical Society (CENS) (First Honorary Member)
Austrian Society of Neurosurgery (Honorary Member)
Polish Society of Neurosurgery (Honorary Member)
Bangladesh Society of Neurosurgery (Honorary Member)
Association of Russian Neurosurgeons (Honorary Member)

Explanatory Notes

*Federal Republic of Germany Merit Cross First Class: Awarded by the President for "outstanding services and achievements in the interest of the German people and the effort made to stimulate national and international cooperation in the field of neurosurgery".

Annually, the president of Germany selects a few people throughout the country who have contributed exceptionally to their profession with outstanding work. On the day corresponding to the founding of the Federal Republic of Germany, the president celebrates this event in his residence in Bonn and personally awards the Merit Cross.

+The Lower Saxony Prize 1988 for Science for "the dedication, work, achievements and research in the field of neurosurgery". Every year, the Government of Lower Saxony honors one scientist among all sciences with the Prize of Lower Saxony for Science. An unbiased commission from all branches of public and social life proposes, based on their work, achievements, and dedication, selects the candidate who has excelled in his field over national boundaries, and presents him/her to the State Governor. It is therefore a very significant event that this prize is given to the medical field among all sciences. The award ceremony is hosted by the Governor, Minister of Science, and several hundred outstanding local and national personalities. During the ceremony, the biography of the recipient is highlighted and the event receives full coverage by the media.

II Technologic Developments

Chapter

1 The Virtual Operating Field – How Image Guidance can Become Integral to Microneurosurgery

Steffen K. Rosahl and Ramin Shahidi

Contents

1.1 Introduction

In neurosurgery, layers of soft tissue, bone, and parenchyma conceal vital structures, landmarks, and the targeted lesion. Guiding an approach to a lesion with the help of computed tomography (CT), magnetic resonance imaging (MRI), or ultrasound images of the anatomy of a patient enables avoidance of accidental damage and the definition of a clear surgical corridor in individually uncharted territory. Today, surgical image guidance based on three-dimensional (3D) volumetric data has become part of the routine in most neurosurgical centers around the world.

There is a concurrent trend in medical disciplines toward augmenting interventions by virtual reality, the envisioned ideal being a virtual stereoscopic view on the surgical field and beyond before the first cut and throughout the operation [14, 23, 35]. Image-based, stereoscopic virtual reality models are used to plan surgical procedures and for teaching purposes in neurosurgery and temporal bone dissection [11, 17, 19, 20, 34, 38, 41]. However, image guidance in neurosurgery, synonymously termed "neuronavigation," has yet to become an integral part of most neurosurgical procedures. While this would be desirable considering the need to anticipate functional and morphological obstacles in the surgical path in individual cases, there are several prerequisites that will have to be met before navigation in neurosurgery will come to be seen as ordinary as navigation in today's automobiles. This chapter briefly explores the history and current development in the field and offers an outlook into the future of neurosurgical image guidance.

1.2 History

The history of neuronavigation can be traced back to the roots of stereotaxis with a Cartesian coordinate system devised by Clarke and Horsley at the beginning of the last century [1]. Image-guided frameless stereotaxis became feasible through the integration of high-speed computers in the 1990s. The first clinical trials were accompanied by concerns about spatial accuracy and ease of application of the technology in the operating theater. Hardware and software were designed by various research groups and even with the first commercially available systems, data transfer, segmentation of morphological structures, and registration procedures were cumbersome and time consuming. Bone-anchored fiducials under local anesthesia often had to be applied a day before surgery, and scanning protocols for CT had to be adjusted to meet the requirements of the specific navigation system. The acquired data had to be saved to digital tapes or magneto-optical discs, and often tedious pre-processing ensued in order to reformat files to make them readable for the system.

Today, the accuracy of most image-guidance systems, as assessed by target registration error, is well documented and usually acceptable with mean values below 2 mm [4, 16, 22, 29, 33, 44, 48], except for targets located remote to the fiducials used for registration or cases where very few fiducials are valid [46]. MRI images can be corrected for object-induced and spatial distortion [40, 45]. Adhesive skin markers and surface registration have replaced bone-anchored fiducials for most intracranial procedures. Data transfer is made by local area networks that connect workstations in the operating theater directly with those in the radiology department. Workflow control allows for

intuitive use of the navigation software, making the setup in the operating room fast and easy.

1.3 State of the Art

Three-dimensional stereoscopic guidance has been developed with the goal of allowing the surgeon to explore radiological imaging information in situ [10, 12, 13, 23] by overlaying an image onto the microscopic view. It still has a long way to go with computation capacity, accuracy [24], and visual perception of depth in 3D images [15].

However, with improving image quality, coregistration of various image modalities, and 3D volumetric image rendering in real-time, image guidance today is capable of providing nonstereoscopic, color-coded models that match closely the individual anatomy of the real surgical field and relieves the surgeon of the task of mental reconstruction of tri-axial images on a routine basis [3, 35, 39].

Although ultrasound is being employed increasingly for image guidance [2, 6, 18, 21, 30, 36, 42, 43], MRI (1.5 and 3 Tesla), CT, and CT angiography remain the primary imaging technologies to create volumetric data sets.

CT is usually performed in the axial orientation with a slice thickness of 1 mm and an ultra-high algorithm. For arterial and venous CT angiography in tumor patients, the first bolus of 40 ml intravenous contrast medium is sufficient to visualize enhancing tumors. For vessel depiction, it may be followed by a further 60 ml, administered at a fast rate, after an individual delay determined by a bolus test [47].

Today, MRI is usually performed on 1.5 Tesla or 3 Tesla scanners. A higher field strength is superior for functional imaging, but imaging is also more prone to motion artifacts, especially in regions around the brainstem.

Axial T1-weighted 3D magnetization prepared rapid gradient echo (MPRAGE; TR/TE/T1 11.08/4.3/300 ms, flip angle 15°, band width 130 Hz/pixel, effective slice thickness 1 mm, pixel size 1.2×0.9 mm) with or without intravenous contrast medium (0.1 mmol/kg body weight gadolinium-DTPA) are usually sufficient for MRI guidance. This sequence is acquired in just over 7 min minutes.

For improved imaging of the temporal bone and the cortical surface in the temporal fossa, an axial T2-weighted constructive interference in steady state (CISS) sequence (TR/TE/flip angle 17/8.08ms/70°ms, effective slice 0.7 mm pixel size 0.6×0.45 mm acquisition time 7 min 51 s) has been applied in selected cases, especially when the lesion is located in a cistern or in the ventricles. Data can be transferred to an image-guidance system via a local area network or passed onto the system using portable storage media. Navigation software should be capable of rendering high-resolution, pseudo-3D images that can be interactively rotated in real time.

There is no limitation for image guidance with respect to the pathologies involved. Even in an extensive subdural hematoma, it may be helpful in placing several burr holes at precisely determined locations.

The decision making for the surgical strategy including the approach and the stepwise exclusion of the lesion is usually designed by the surgeon in advance. However, in some cases, image guidance may be employed to modify and adapt these strategies to avoid approach-related morbidity or to define an optimal surgical corridor. The

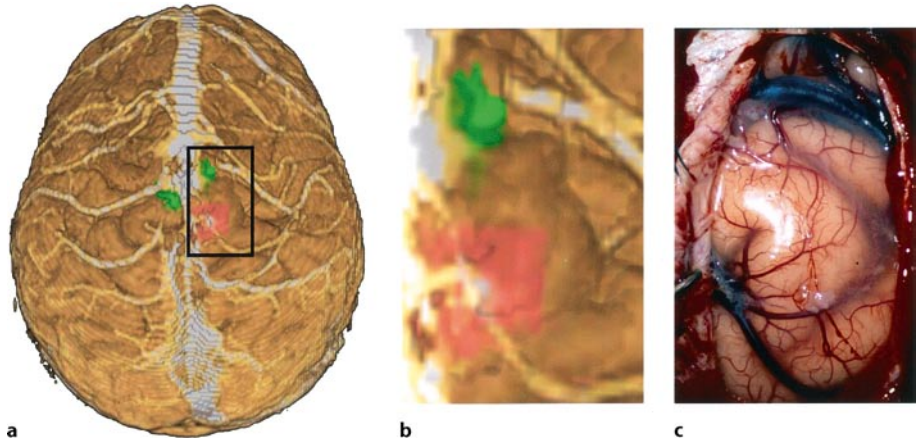

Fig. 1 **a** "Helicopter view" of the lesion and the motor areas for the left (*green*; pushed anteriorly) and right foot (*pink*) in a three-dimensional (3D) rendering created from magnetization prepared rapid gradient echo sequences and functional magnetic resonance imaging (fMRI) on the image-guidance system. **b** The virtual operating field (VOF, "driver seat view") showing the cortical surface and veins, the lesion, and the adjacent motor areas (*shaded*). Note that the latter two are exclusively seen in the VOF, but not in the real field. **c** Only the veins and the cortical surface can be recognized after the parasagittal craniotomy. Image injection of the VOF with a tumor outline and functionally significant areas can greatly enhance the real operating field in cases like this

segmentation and the creation of volumes of interest from the imaging data containing the landmark anatomical structures in the surgical path will usually be carried out by the neurosurgical team and only occasionally by an experienced neuroradiologist. A virtual "fly through" or "fly around" movie may be generated to simulate the major surgical steps in the planned procedure using the individual imaging data of the patient ("helicopter view", Fig. 1a). Again, the surgical strategy may be adjusted whenever an improved surgical approach could be derived from these visualizations.

Several volumes of interest may be selected and color-coded to create a volumetric image that contains all of the anatomical landmarks that would also appear in the real operating field. This image – the "virtual operating field" (VOF) – on advanced image-guidance systems can be interactively rotated to match the orientation of the real surgical field, as seen through the microscope (Fig. 1). Surfaces may gradually be rendered translucent in the image to allow a view of the lesion in relation to more superficial morphologic landmarks (Figs. 1–3, "driver seat view"). The VOF should ideally be zoomed to the size of the real microscopic field, and both views may be displayed on a

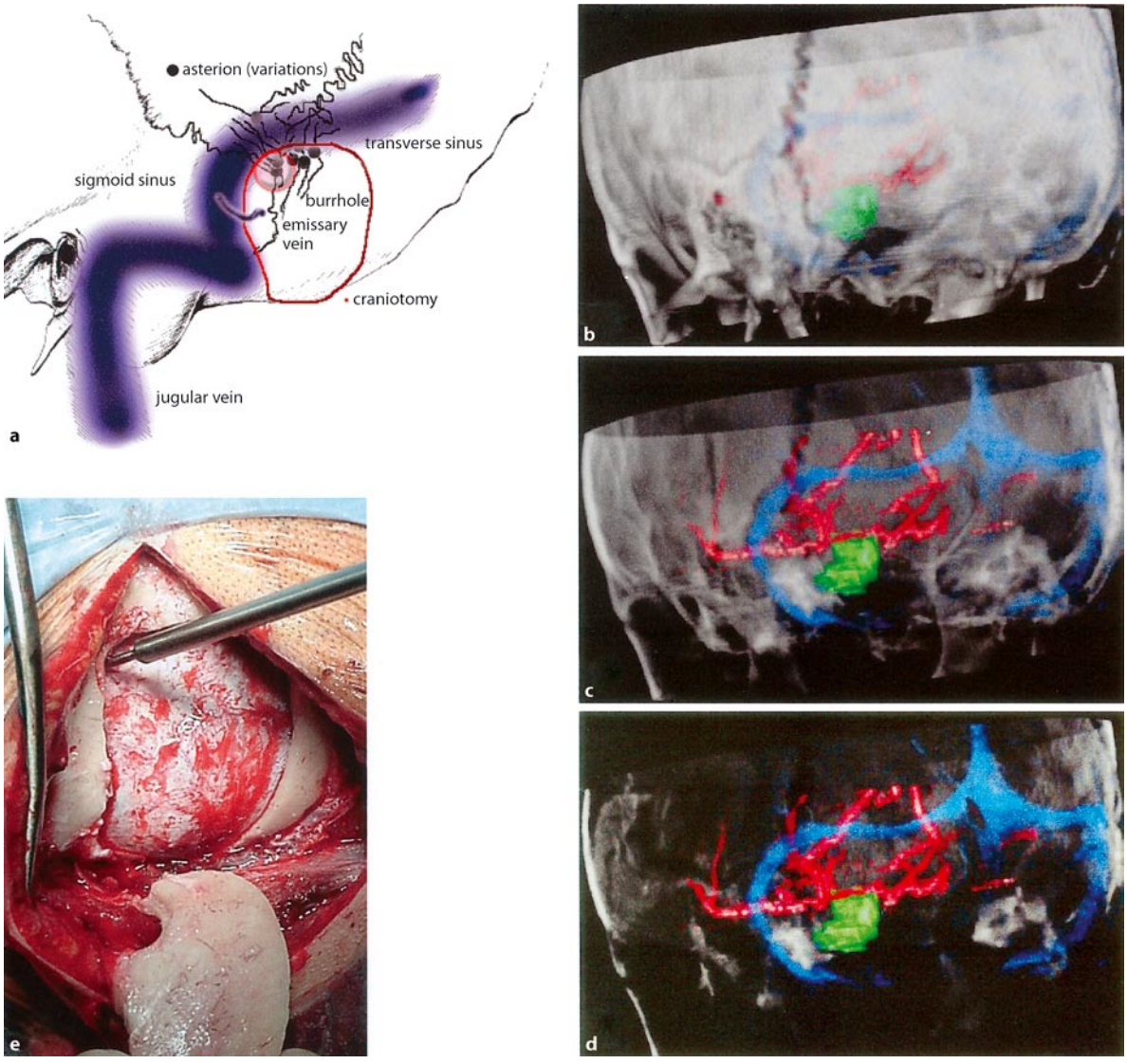

Fig. 2 **a** Anatomical landmarks for the lateral suboccipital approach. Note the variability of the location of the asterion around the sinus transition. **b** 3D rendering of the bone sutures of the posterior fossa with the navigation system. **c,d** Gradual transparency modulation of the bone allows for a look through the posterior fossa. The borders of the venous sinuses (*pink*) become clearly visible so that they can be used as landmarks themselves, replacing the asterion as a historical landmark. The circle of Willis is also shown in the images (*blue*). **e** After a burr hole has been placed just below the transverse-sigmoid junction, an osteoplastic lateral suboccipital craniotomy is carried out

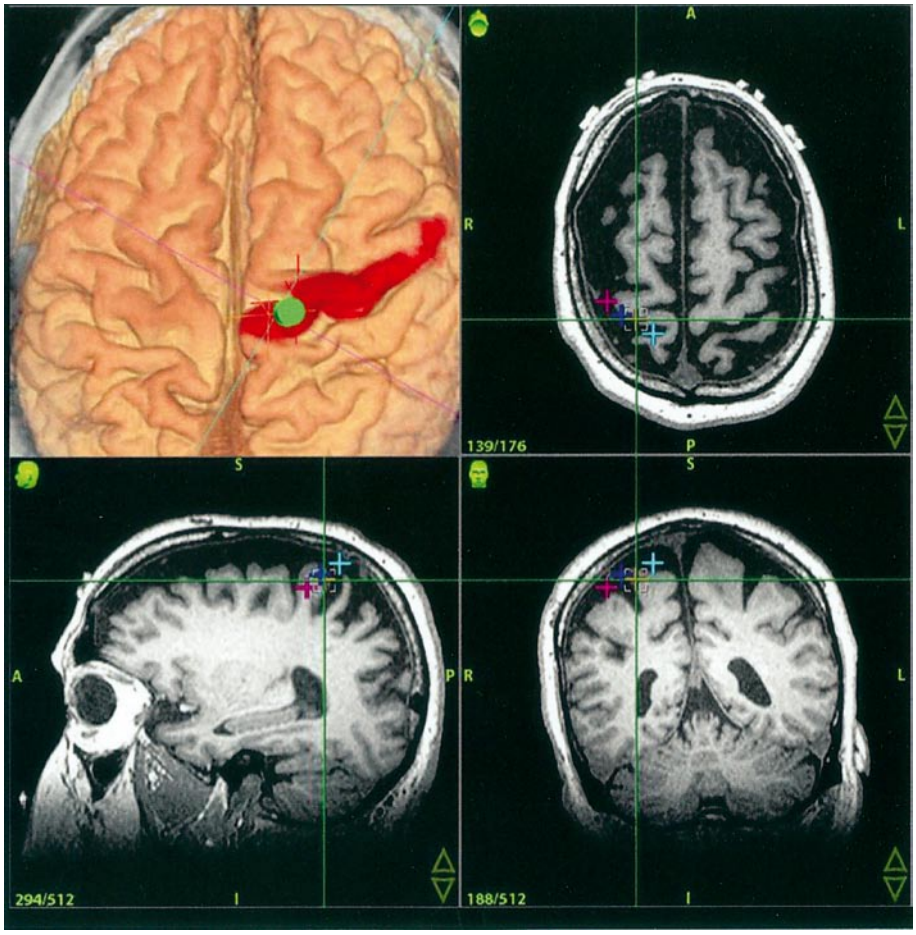

Fig. 3 Image guidance with 3D renderings (upper left) and tri-axial MRI in a patient with intractable thalamic pain during implantation of a motor cortex stimulator. The visualization of the cortical surface with its gyri and sulci is clearly superior in the volumetric 3D rendering. The motor strip has been segmented manually based on fMRI images of the patient. The virtual probe points – just as the real one – to a previously defined electrode location

video monitor or in the ocular of the surgical microscope simultaneously. Depending mostly on the quality of the imaging data and the level of the human computer interface (intuitive software, computer skills of the surgeon), image rendering may take between 15 min and 2 h.

In the operating room, the patient's head is registered either with five to ten adhesive skin fiducials and a pointing probe (which may be substituted by the microscope in some settings), or with a device and algorithm for surface detection. Most systems today are based on infrared transmission employing a camera for detection of a digital reference frame and the instruments (Fig. 4).

The digital reference frame may be attached to the head holder, to the operating table, or directly to the head of the patient. It is kept visible by the camera by draping it with a transparent bag or by mounting it sterile on an appropriate extension. After registration, a quick check should be performed to assess the accuracy of the registration by targeting a well-defined landmark (e.g., the nasion or the outer ear canal).

The quality of VOF images related to their closeness to reality will obviously depend on the quality of the primary data set. A contrast-enhanced target located adjacent to the bone and targets located in the middle fossa or at the craniocervical junction may pose difficulties because of decreased tissue contrast and MRI distortion. Also, due to the smaller sulci and the lesser amount of cerebrospinal fluid contained in the subdural space, it is usually harder to depict the surface of the temporal lobe cortex in 3D renderings.

The surgical approach is facilitated by VOF images by showing hidden landmarks like the transverse and sigmoid sinus in a retrosigmoid route (Fig. 2). Gradual modulation of the opacity of surfaces in VOF images allows for visualization of hidden anatomical structures, and for relating those structures to more superficial land-

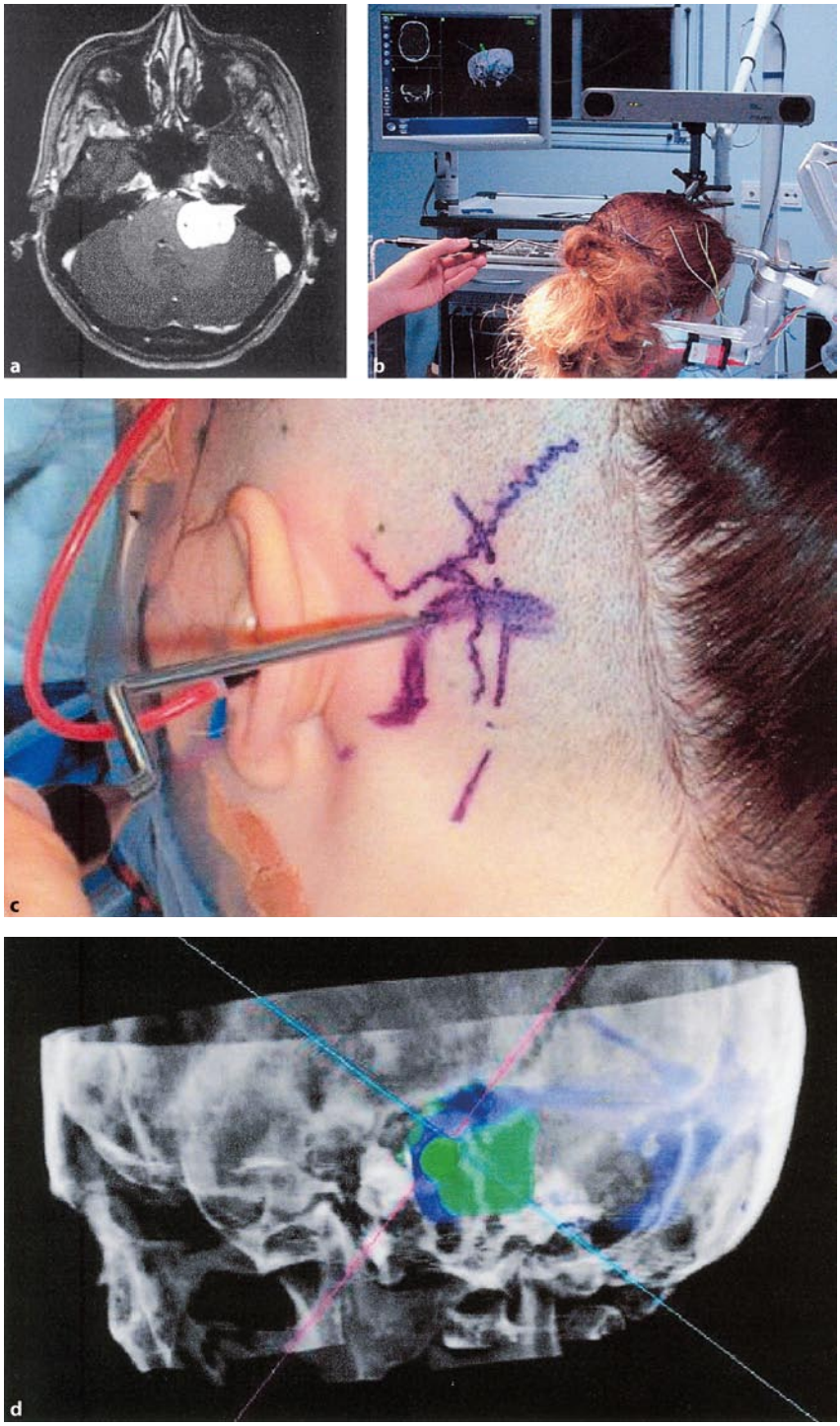

Fig. 4 **a** Gadolinium-enhanced, T1-weighted axial MRI of a vestibular schwannoma on the left side. The primary data for image-guidance in this particular case were obtained from both a MRI and spiral computed tomography. **b** Semisitting position of the patient for the retrosigmoid approach. The infrared camera of the image-guidance system is placed low on the side of the lesion so that it can "see" the probe. **c** The course of the transverse and sigmoid sinuses and the bone sutures meeting at the asterion have been drawn to the skin with a surgical marker. **d** Corresponding image on the navigation screen with the virtual probe pointing to the transverse sigmoid transition

marks that were already within the surgeon's view (like the asterion in Figs. 2 and 4).

With 3D renderings there is no need for the surgeon to mentally reconstruct the surgical anatomy from two-dimensional scans. Compared to tri-axial two-dimensional images, orientation is significantly faster and more comprehensive with VOF images (Figs. 1–3). This becomes more apparent when irregular-shaped structures like the dural sinuses, the basal arterial circulation, the bone of the skull base, tumor borders, and the cortical surface are involved or when the operating field was rotated into an unusual orientation [35].

The advantages of image guidance multiply when functional and/or histological characteristics are added to a VOF. Figure 3 shows how functional image-guidance aids can be in the placement of epidural electrodes for motor cortex stimulation in intractable pain. The morphological outline of the precentral gyrus can be easily and safely traced in 3D images if functional data are available. Precise electrode implantation with this guidance is greatly facilitated, even with the dura remaining closed throughout the procedure [5].

Similar advantages have been reported for subdural placement of electrode grids in patients with epilepsy, for detection of the origin of focal seizure activity [25, 37]. Some brain tumors, even though they reach the surface of the cerebral cortex, do not show any demarcation to normal brain parenchyma (Figs. 1 and 5).

However, if a tumor is well delineated on T2-weighted MRI (Fig. 5), its outline can be mapped or overlaid onto the cortical surface in a VOF. This is especially useful if the tumor is located adjacent to a functionally eloquent area and, therefore, resection has to be restricted precisely to the tumor limits in order to avoid intolerable morbidity. Functional imaging provides further information that would not be available in the real surgical field without neuronavigation (Fig. 1).

The functional anatomy can be shifted or distorted by the tumor. This is especially important when fiber tracking by diffusion tensor imaging is employed. The pyramidal tract may be considerably displaced and then returned to its normal position as tumor resection progresses. Under these circumstances of major brain shift, MRI scans acquired prior to the procedure would not be reliable during surgery. It has been shown that intraoperative functional MRI is feasible with the same protocols that are used outside the operating theater. The combination of neuronavigation and intraoperative functional MRI offers additional safety in these cases [8, 26–28]. Multimodal imaging may also improve the reliability of

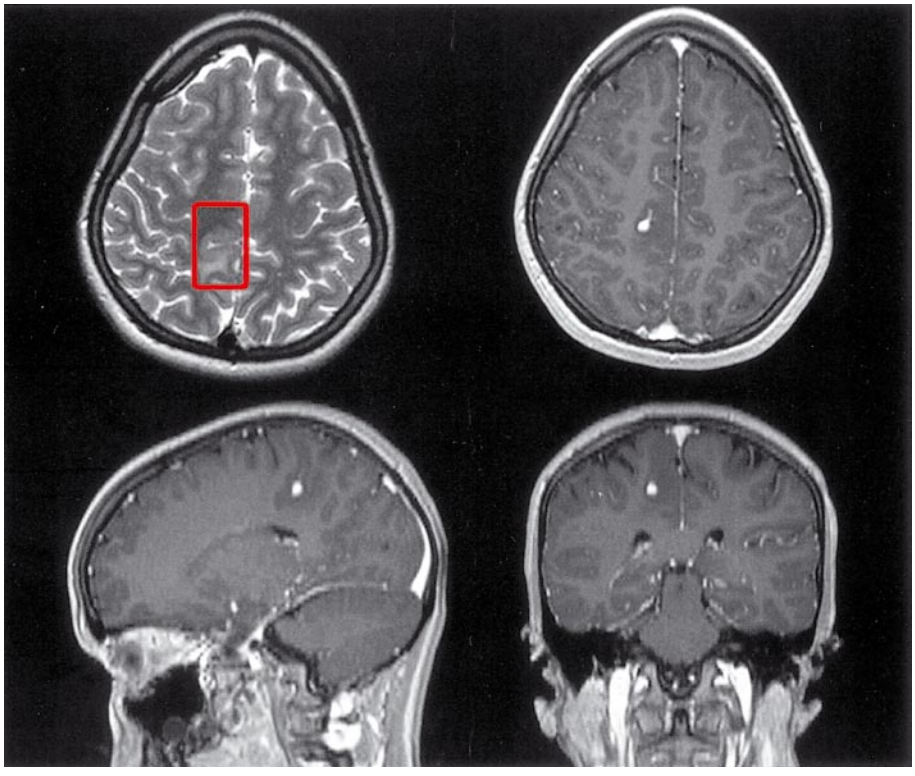

Fig. 5 An infantile desmoganglioma in the right postcentral region of a 14-year-old patient. The T2-weighted MRI (upper left comer) shows that the lesion centers around a sulcus. In the depth, nodular contrast-enhancement in T1-weighted images points to a histologically dubious portion of the tumor

functional information, especially with respect to the language areas of the cortex [7].

Zooming in the virtual images in order to enlarge the detail to the size of the surgical field reduces the amount of information presented at a time to the required minimum, steadying the surgeon's focus of attention (Fig. 1).

Individual, patient-specific anatomy can be visualized in the VOF down to a resolution of about 2 mm for well-delineated structures. In general, all morphological structures that are readily discernable in primary imaging data can be also detected in virtual 3D models of the surgical situs. Using image fusion techniques, bony surfaces, embedded vessels, and different types of soft tissue along the surgical path, both in front of and beyond the lesion, can be identified in a single image, which in turn can be rotated to match the view through the microscope onto the real surgical field.

Stereoscopic images are not obtained as easily, but they have the decisive advantage of conveying information on depth along the *z*-axis [9, 10, 16, 32, 38], which can only be captured in tri-axial images with volumetric pseudo-3D rendering.

Smaller and less discernable structures, such as most cranial nerves, are not well delineated in routine images. Electrophysiological monitoring is still by far the most effective tool for early identification of the cranial nerves.

1.4 Outlook

Microneurosurgery depends on 3D, stereoscopic information on the surgical field delivered through the microscope. A "virtual microscope" operating in 3D space that uses stereoscopic radiographic images of the patient's anatomy would be an ideal instrument to plan these procedures and to obtain on-line information beyond the operating field during surgery. While several problems remain to be resolved [15, 24, 31], true 3D imaging, on a routine basis will probably be performed by taking advantage of stereoscopy in the future.

Overlay of a VOF that virtually matches the surgical field will certainly augment the surgeon's capacities. While anatomical knowledge and experience still remain the most crucial factors affecting the surgical result, virtual reality can provide additional information about elements in the operative field that are beyond the superficial layer and invisible through the operating microscope.

Although now in extensive clinical use, image guidance still is often perceived as an intrusion into the operating room [31]. In our experience, image guidance is best accepted when additional preparation time is minimal and the VOF is adjusted to the size and orientation of the real surgical field containing relevant landmarks without redundant information.

The following list is a brief compilation of essential prerequisites that, according to the literature and to our own experience,, will have to be met in order to turn image guidance into an integral part of most microneurosurgical procedures.

1. Accuracy: Image guidance needs to be precise. Geometric distortions in imaging procedures have to be corrected before the data are taken to the operating room.
2. Easy and speedy applicability: Imaging, data transfer, segmentation, intraoperative setup, and registration combined should require minimal additional time.
3. Image fusion: Multimodal images must be easily coregistered and combined in a single image.
4. Truly stereoscopic 3D images: Stereoscopic visualization improves perception and enhances the ability to understand complex 3D anatomy.
5. Interactivity: The practical benefit of 3D display is increased considerably when the size and orientation of the VOF corresponds to the real microscopic view of the surgical field. Different perspectives of the field (driver's seat view, helicopter view) should be optional. With respect to the limitation of the VOF, less may often be more, since the surgeon will only appreciate relevant information on the surgical field in view under the microscope.
6. Transparency: The possibility of seeing through surfaces by gradually rendering them translucent is advantageous, since landmarks at different depths along the surgical path can be correlated to one another.
7. Integration of the functional characteristics of tissue: Data from functional MRI, including fiber tracking by diffusion tensor imaging as well as, for example, positron emission tomography, electroencephalography, magnetoencephalography, and spectroscopy, should all be made available in images used for intraoperative guidance.
8. Intraoperative correction for tissue shift: In procedures involving major mass extraction or massive drainage of cerebrospinal fluid, an intraoperative update of the images by MRI, CT, ultrasound, or surface tracking should be available.
9. High spatial image resolution: While spatial resolution on MRI has increased over the years, it is difficult to discern objects smaller than 2 mm in size. Since spatial resolution and tissue contrast are crucial for the creation of true 3D images that match the view provided by microscopic magnification, this is an issue that will have to be addressed in the future.

Image guidance based on 3D images will never substitute precise anatomical knowledge and surgical experience, because systematic and accidental technical errors occur and the depiction of anatomical detail is limited by the resolution of imaging techniques. There is little doubt, however, that the VOF will become a very real part of the microsurgical situs and it is hard to see why the two should not be intimately entwined in the near future.