The Craniotomy Atlas

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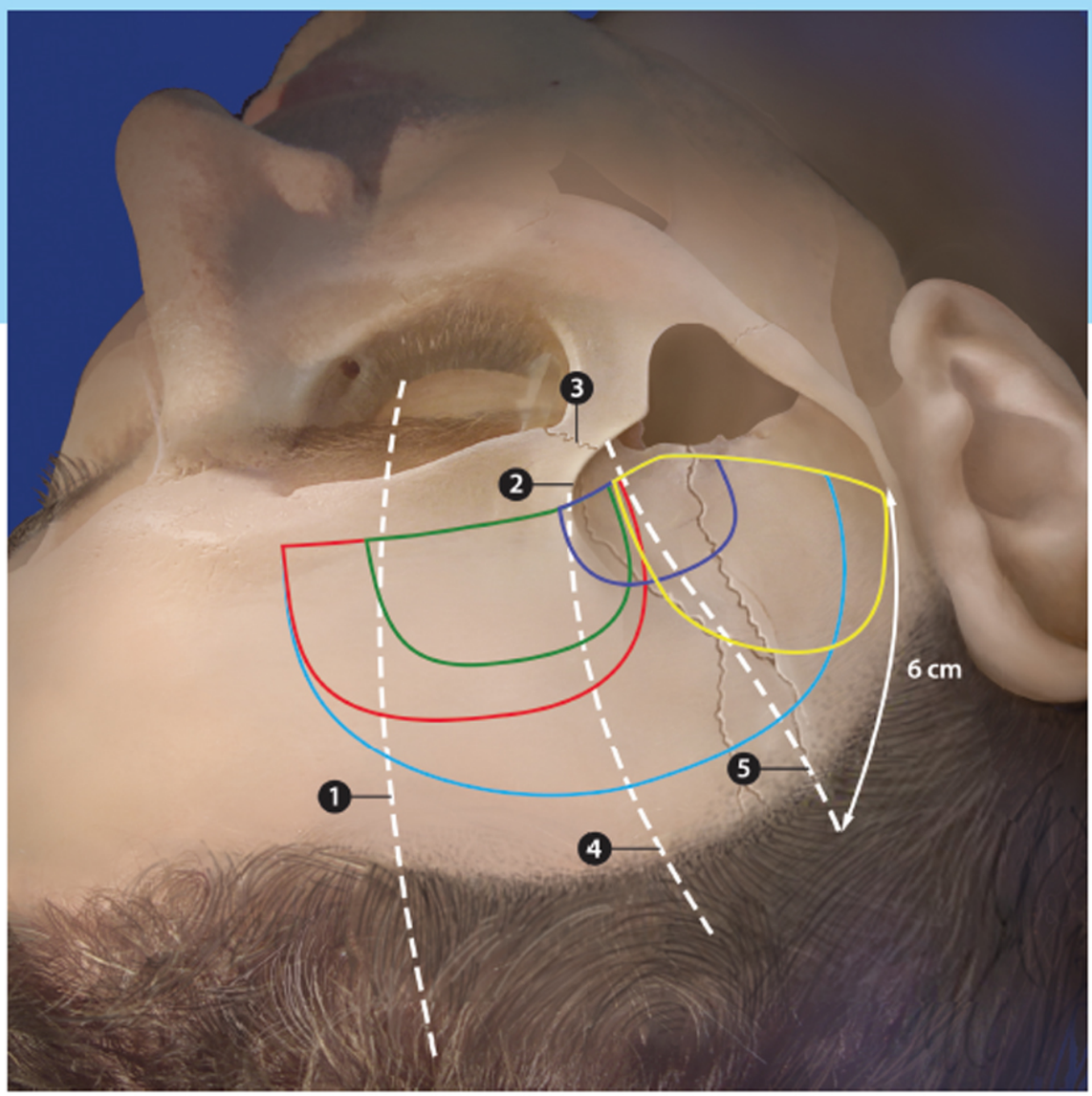

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The Craniotomy Atlas

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To my wonderful wife, Katrin; my children, Tanja, Max, and Clemens; my parents; my family, who are my life.
To my residents, who always inspire me.
To my colleagues, who are mentors, teachers, and friends.
To those who help to take care of my patients, making me feel grateful for their efforts.
To my patients, who trusted me and who were my reason to strive for excellence.

Andreas Raabe

Contents

Foreword

The Craniotomy Atlas, edited by Professor Raabe, is intended to be a resource for residents and new neurosurgeons with the goal of providing precise instructions for performing common neurosurgical exposures. Professor Raabe and his coauthors have used high-quality operative photographs accompanied by excellent illustrations to compile an atlas that far exceeds expectations. The beautiful step-by-step compilation for each approach will make this volume an essential companion for every neurosurgical resident and a useful reference for the new neurosurgeon. The precision and attention to detail that we have come to expect from Raabe has reached a new high in this book. With the introduction of intraoperative indocyanine green angiography to the neurosurgical community, Andreas Raabe had already cemented his place as a foremost contributor to our specialty—with this book, he will have created the neurosurgical primer that every resident will own and study.

As with any neurosurgical procedure, there are differences among neurosurgeons based on experience and training. For example, with the exception of the sigmoid sinus, I routinely cross all other sinuses by just using the footplate of the drill rather than multiple burr holes. After washing out the bone dust with irrigation, one can look right down the bone cut and verify that the footplate is extradural, and the dura can be separated from the bone by placing sufficient pressure on the underside of the bone while crossing the sinus as readily as with multiple burr holes and any other instrument. Although many roads lead to Rome, I find that this volume, except for a few inconsequential differences, provides the best highway to get there. I congratulate the authors for this detailed, beautifully illustrated, step-by-step guide to performing the routine craniotomies that all residents and neurosurgeons need to master.

Robert F. Spetzler, MD
Phoenix, Arizona
United States

Foreword

There is no doubt among neurosurgeons that a correct and tailored craniotomy, apart from the detailed preoperative planning, represents the decisive first step toward a successful intracranial operation. *The Craniotomy Atlas,* edited by Professor Andreas Raabe and compiled with contributions of a large number of experienced neurosurgeons, is primarily aimed at the neurosurgical resident and younger neurosurgeon. However, as a seasoned and experienced neurosurgeon, who has selected over the years his own armamentarium of favorite craniotomies and surgical variations, I have found it highly interesting to wander through the abundance of beautiful and detailed illustrations as well as the exact and informative step-by-step descriptions of the various craniotomies presented in this atlas. Although there exists a large number of neurosurgical textbooks with detailed descriptions of surgical approaches, these are mostly presented within the context of the underlying intracranial target, mainly a tumorous or vascular lesion.

I am not aware of a comparable and up-to-date compilation of craniotomies, covering all aspects—basic considerations such as positioning and attention to surgical landmarks, routine craniotomies, and elaborate skull base craniotomies and its extensions. The outstanding attention to details presented in this atlas reflects the meticulous way of preparation and performance of every craniotomy by Professor Raabe, as I have seen over the many years during which we have both worked together. Within this context, it is a pleasure and an honor to applaud the editor and his co-authors for this excellent contribution to the art of craniotomy, which will surely stand as a surgical reference for many years to come.

Volker Seifert, MD, PhD
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Preface

Craniotomies are an essential part of brain surgery. They are regarded as important but rather basic procedures that are the prelude to the intradural neurosurgical operation proper. An optimally placed craniotomy provides the basis for a simple or sophisticated intradural approach and a straightforward case. Wrongly placed, it completely changes the operation, making access to the neurosurgical target traumatic or impossible.

Neurosurgeons start with simple craniotomies early on in their training. Junior residents learn how to perform a specific craniotomy from senior residents or attendings. Many textbooks and journal articles describe the various craniotomies in detail and serve as excellent reference sources.

Despite being "mainstream" knowledge, for the first "Frankfurt craniotomy course" that Bernhard Meyer, Peter Vajkoczy, Peter Winkler, and I organized in 2004, there was an overwhelming number of applications for only 20 course seats. The applicants were searching for a systematic collection and teaching of information related to craniotomies. We learned from the course participants that craniotomies are far from being standardized, with numerous variations even within the same department. Since then, yearly courses have been held in Frankfurt and, since 2008, also in Bern and Geneva with an equally high number of applicants for the restricted number of available course seats.

This book is a logical effort to continue this teaching and extend the systematic collection of knowledge about standard and some extended craniotomies and related aspects. I hope that it contributes to a better understanding of the underlying concept and anatomy, greater standardization of the operations, and an improved technique when performing the planned craniotomy.

Andreas Raabe, MD

Acknowledgments

I would like to express my deep gratitude to Anja Giger and Alain Blank, who provided the superb illustrations for this book. Over a period of 3 years, it was always a pleasure to sit together and discuss the details of the authors' photographs and how these should be depicted in the illustrations. Without their artistic skills and their invaluable contribution, this book would not have been possible.

I am specifically grateful to Luisa Tonarelli, who accompanied the development of this book from the very first chapter to the final printed version. Her help, advice, expertise, and hard work were indispensable in bringing this volume to publication.

Finally, I would like to thank Susan Kaplan, Irena Zubak, Janine Abu-Isa, Katharina Lutz, Michael Murek, David Bervini, Johannes Goldberg, Levin Häni, and Jonathan Rychen for their time and advice during the review of the chapters of this book.

Andreas Raabe

Call for Submissions

The techniques and knowledge described in this book reflect the personal views, teaching, and experience of its authors. We know that the content of this book is far from comprehensive. We are also aware that skilled surgeons around the world have their own tricks and modifications of craniotomies, usually derived from personal experience and for good reasons.

Therefore, we invite authors to submit their modification, nuance, or technique in the form of a step-by-step series of photographs with a text description, like the chapters in this book. The topic may range from a craniotomy not yet included in this book to a technical note or a nuance of an already described craniotomy; however, it should be recognized as useful, reproducible, and potentially suitable for routine use. These submissions will undergo peer review by experienced neurosurgeons as well as young residents. If accepted, illustrations will be produced to complement the photographs, and a corresponding chapter will be added to the book.

We are aware that only a limited number of carefully selected additional chapters on a craniotomy or a nuance can be included in this collection. But, despite having arrived in the digital age, we still believe in the educational value of a book, in which a compilation of the most important craniotomies and the related knowledge can be found. All contributions have been peer-reviewed and selected as pearls of wisdom for neurosurgical residents.

Before submitting a manuscript, authors should contact the Editorial Office to request for the technical specifications and to have the topic checked for potential duplication and suitability.

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1 Basics

1.1 Craniotomies Overview

Andreas Raabe and Peter A. Winkler

There are four basic categories of supratentorial and infratentorial craniotomy:

1. Convexity craniotomies may be performed anywhere according to the surgical target and goal of the operation. They range from burr holes and mini-craniotomy to decompressive hemicraniectomy, which is the most extensive variant.
2. Midline craniotomies are used for midline approaches that take advantage of subdural anatomical corridors to reach superficial, deep, or contralateral targets. The supratentorial suboccipital craniotomy with an intradural approach along the falx and the tentorium or an infratentorial suboccipital craniotomy with a supracerebellar approach are possible variants.
3. Skull base craniotomies range from the frontal midline to the foramen magnum, covering the entire skull base. ▶ Fig. 1.1 and ▶ Fig. 1.2 demonstrate the continuum of approaches which are often overlapping and are named according to their location at the skull base.
4. Skull base extensions are added to standard skull base craniotomies. They allow access with angles of approach or to structures that cannot be easily reached with standard skull base craniotomies. Typical skull base extensions are anterior clinoidectomy, removal of the orbital rim or zygoma (orbitozygomatic), transpetrosal approaches, the suprameatal extension after retrosigmoid craniotomy or the far- (enough) lateral extension to the foramen magnum (see Chapter 6, Skull Base Extensions).

Supratentorial skull base craniotomies can be divided according to their location, their frontal and temporal extension (size), and their relation to the sylvian fissure. There is no uniform classification, but the following general rules may serve as a guide to the terminology (see ▶ Table 1.1).

Table 1.1 Systematics of skull base craniotomies—supratentorial

Location	Description
Median frontobasal	Mostly bilateral. Target: medial frontal base, anterior midline.
Frontolateral	Extends 1–3 cm lateral to the midline to approximately the sphenoid wing, but does not cross it. The proximal sylvian fissure is exposed intradurally, and targets within the sylvian fissure, the anterior skull base, and the temporal lobe can be reached. There are mini- and standard sizes. “Frontolateral” is the term that was historically first used for this approach.
Supraorbital	Usually a smaller variant of the frontolateral approach; typically by eyebrow (transciliary) incision, which limits the size of the craniotomy. Extends 2.5–3 cm lateral to the midline to approximately the sphenoid wing, but does not cross it. The proximal sylvian fissure is exposed intradurally, and targets in the sylvian fissure, skull base, and temporal lobe can be reached. Some surgeons use the term supraorbital as synonymous with frontolateral.
Pterional	Extends 1–3 cm lateral to the midline to the anterior temporal region: centered around the “H” of the sutures that form the pterion (see Chapter 2.2, Craniocerebral Topography). The sphenoid wing is always crossed. Typically defined as two-thirds of the craniotomy frontal and one-third temporal exposure of variable sizes (2:1). There is also a mini-pterional variant.
Frontotemporal	Usually a large exposure (1:1 to 2:1 frontal:temporal) centered above the sphenoid wing = sylvian fissure.
Anterior temporal	Sphenoid wing is crossed.
Temporobasal	The exact position varies according to the surgical target: does not cross the sphenoid wing. Typically used for subtemporal intradural approaches. There may be a more anterior and a more posterior variant.

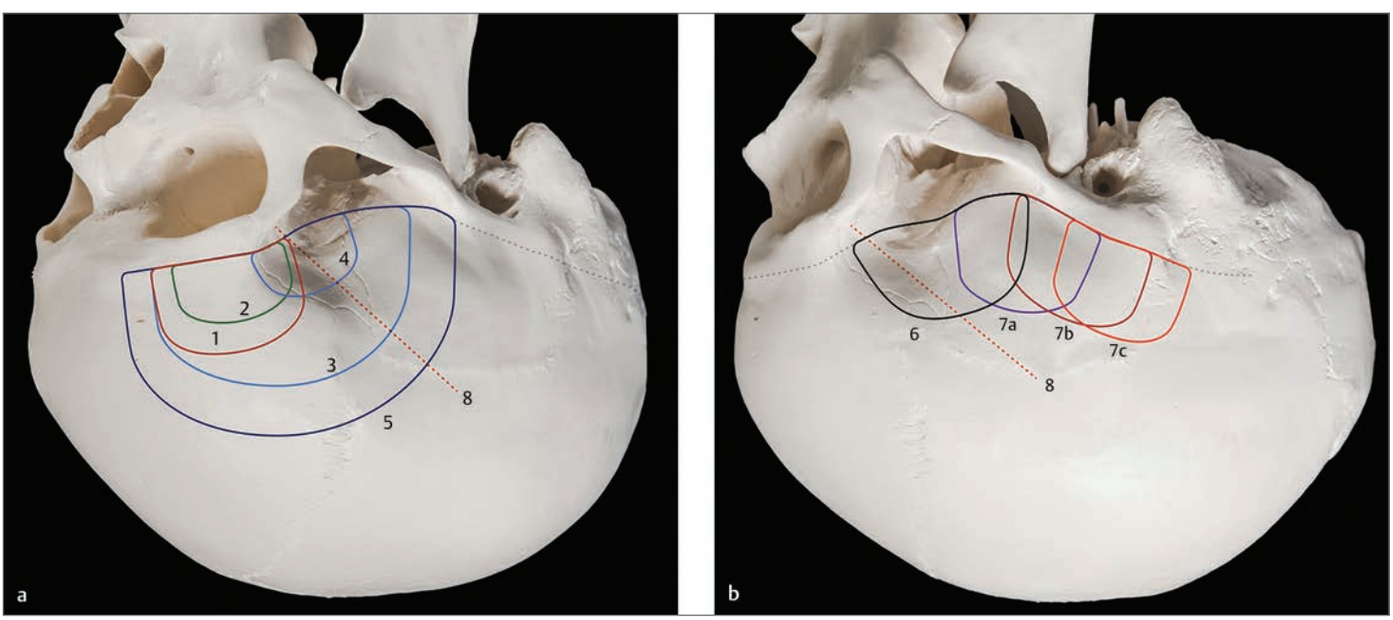

Fig. 1.1 Systematics of skull base craniotomies—supratentorial. Supratentorial frontotemporal skull base craniotomies, 45° view **(a)** and lateral view **(b)**. 1, frontolateral; 2, supraorbital; 3, standard pterional; 4, mini-pterional; 5, frontotemporal; 6, anterior temporal; 7a–c anterior, middle, posterior temporobasal; 8, sylvian fissure/sphenoid wing.

Infratentorial skull base craniotomies are performed along the sigmoid sinus or the foramen magnum (see ▶Table 1.2 for further details).

Table 1.2 Systematics of skull base craniotomies—infratentorial

Location	Description
Suboccipital median infra-transverse-sinus	Midline craniotomy for supracerebellar median or paramedian approaches, e.g., for access to the pineal region or tentorial dural fistulas.
Suboccipital lateral infra-transverse-sinus	These are craniotomies based on the same principle as the midline craniotomies for an intradural approach along the subdural space parallel to the tentorium. Typically, they are used for supracerebellar lateral approaches to the midbrain or other regions. They are horizontally oriented compared to the retrosigmoid craniotomy, with more exposure along the transverse sinus and less along the sigmoid sinus. A modification is the suboccipital far-lateral infra-transverse-sinus craniotomy.
Retrosigmoid	Typically ranges from the transverse sinus to the base of the posterior fossa along the sigmoid sinus to gain access to the cerebellopontine angle. May vary in size and be centered more superiorly or inferiorly: vertically oriented.
Suboccipital median peri-foraminal craniotomy with opening of the foramen magnum	Typically bilateral, there is a mini-version, for example, in Chiari-decompression surgery.
Suboccipital lateral perifo-raminal craniotomy with opening of the foramen magnum	The lateral suboccipital craniotomy with opening of the foramen magnum is the basic craniotomy for the far lateral approach which can be regarded as a skull base extension of the basal suboccipital craniotomy.

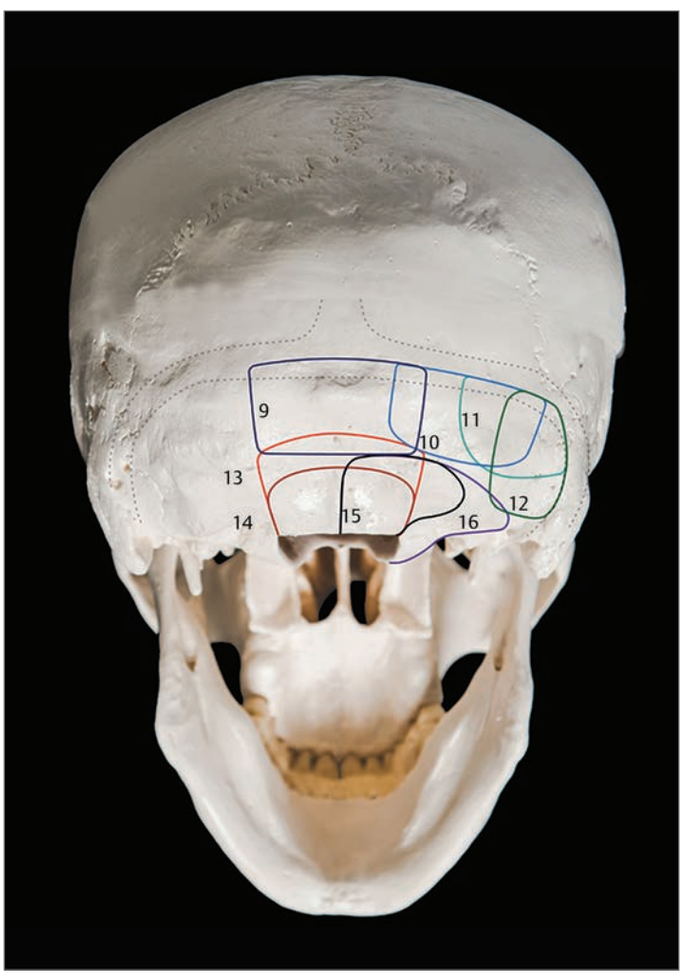

Fig. 1.2 Systematics of skull base craniotomies—infratentorial. Craniotomies of the posterior fossa. 9, suboccipital median infra-transverse-sinus; 10, suboccipital lateral infra-transverse-sinus; 11, suboccipital far-lateral infra-transverse-sinus; 12, retrosigmoid; 13, suboccipital median periforaminal (with opening of the foramen magnum); 14, mini-suboccipital median periforaminal (with opening of the foramen magnum); 15, suboccipital lateral periforaminal (with opening of the foramen magnum); 16, far-lateral extension.

1.2 Difference between Approach and Craniotomy

Andreas Raabe

Although often used synonymously, there is a difference between a craniotomy and an approach. Approach is the broader term and is often used for craniotomy and intradural preparation. In this book, we discuss only the steps of the craniotomy, i.e., to reach bony exposure. With a few exceptions, we stay outside the dura. We will therefore mostly use the term craniotomy instead of approach, and generally reserve the latter to describe the dissection and exposure after opening the dura mater. Craniotomy and approach may be different as in the examples given below. However, as already mentioned, the term "approach" often overlaps with craniotomy and intradural preparation.

Examples:

- Supraorbital craniotomy and subfrontal approach.
- Pterional craniotomy and transsylvian approach.
- Temporobasal craniotomy and subtemporal approach.
- Suboccipital lateral craniotomy and supracerebellar lateral approach.
- Median suboccipital craniotomy and telovelar approach.

1.3 Craniotomies We Have Omitted from This Book and Why

Andreas Raabe, Bernhard Meyer, Peter Vajkoczy, and Karl Schaller

This book is intended primarily for young residents, to serve as a guide to understanding the various craniotomies. It describes the most often used craniotomies, but we decided not to include those that are used only very rarely. Therefore, it does not cover highly specialized skull base craniotomies and their extension, such as posterior transpetrosal, translabyrinthine, transcochlear, or combined approaches, nor is it our aim to provide a complete atlas of approaches and extensions.

We acknowledge that these specialized skull base approaches had their place in the heyday of skull base surgery. However, nowadays they are often replaced by a staged procedure or a combination of simpler craniotomies that provide a less invasive strategy with lower morbidity than a technically demanding and more invasive approach. Moreover, radiosurgery and endovascular treatment often complete a less invasive treatment for many patients.

We are also aware that the nomenclature for the craniotomies varies around the world and that experienced surgeons use their own tricks and modifications when performing craniotomies.

1.4 Positioning

1.4.1 Basic Rules

Andreas Raabe and Janine Abu-Isa

Time spent on careful positioning is time well spent. Mistakes in positioning may render any surgical plan, even if it is conceptually perfectly elaborated, impossible. Positioning is the first strategic step for the operation; it is the first digit of the code number to unlock the door to the target of brain surgery. Correct positioning can open the surgical field, achieve gravity retraction, reduce bleeding, and provide the most relaxing position for the surgeon.

Positioning should be highly standardized in each department to improve communication, to save time, and to achieve the goal of the surgery. Use of photographs, step-by-step instructions, and a checklist is recommended.

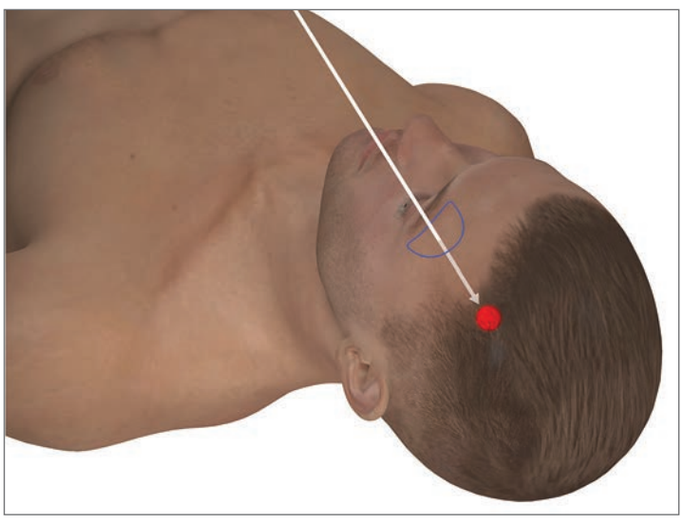

Fig. 1.3 Craniotomy-to-lesion trajectory. This is the first and most important factor determining the position of the head.

The position of the head depends on the following factors (also see ▶Fig. 1.3, ▶Fig. 1.4, ▶Fig. 1.5, and ▶Fig. 1.6):

1. Planned Surgical Trajectory

The surgical trajectory is the line between the craniotomy and the surgical target, i.e., the midline craniotomy and the tumor in the third ventricle, or the subtemporal craniotomy and the midbrain cavernoma, or the convexity craniotomy and the underlying meningioma (▶Fig. 1.3).

2. Position of the Surgeon

The same surgical trajectory can vary according to the preferred position of the surgeon (see below).

3. Gravity Retraction or Drainage

When gravity retraction is a major part of the surgery, it may become the dominant principle, for instance, in contralateral or midline approaches via the dependent hemisphere or when the semisitting position is preferred in some cases for posterior fossa surgery for pineal or cerebellopontine targets.

4. Measures for Avoiding Potential Position-Related Complications

Such measures include positioning to minimize intracranial pressure, venous congestion, and air embolism, as well as improved orientation if only standardized head positions are allowed.

Every head position can be achieved by combining head rotation (▶Fig. 1.4a) with patient's body positioning (▶Fig. 1.4b):

- Rotation of the head from 0° to 60° (this can be tested in the awake patient before surgery: in younger patients a rotation up to 90° may be possible, whereas in elderly patients head rotation may be limited to 30°), with the desired degree of head flexion and tilting.
- Selection of one of five supplemental positions of the patient's body to achieve the final desired head position. These five body positions should be standardized.

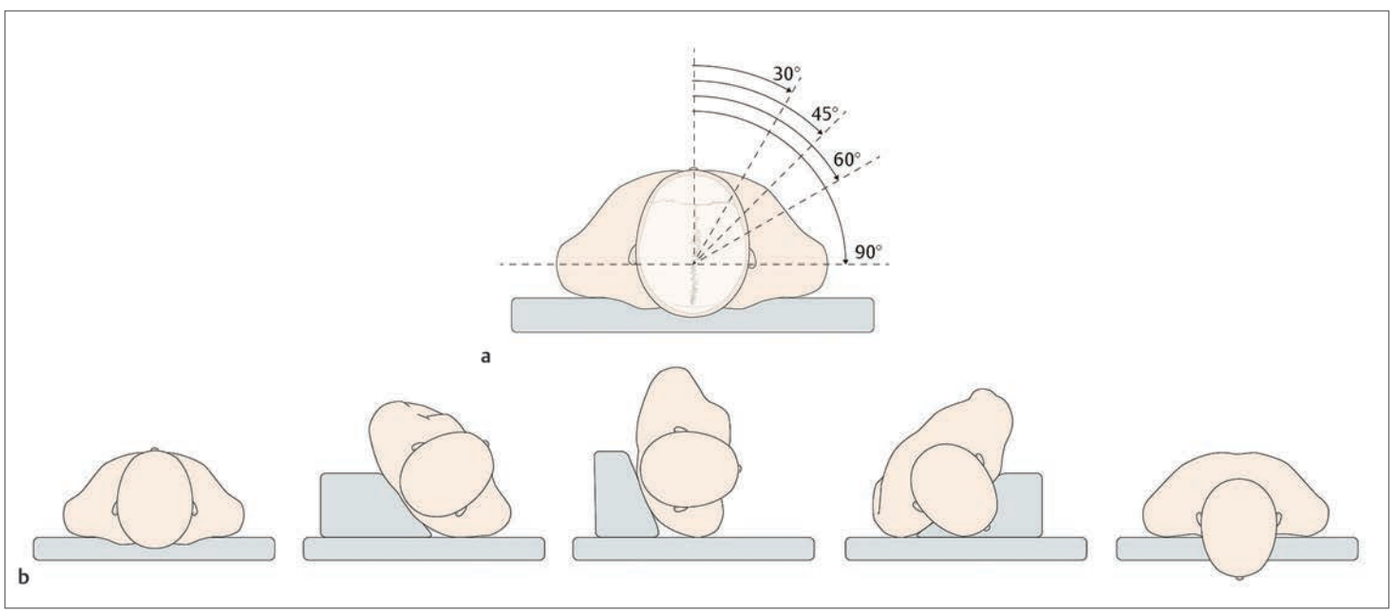

Fig. 1.4 Combining positioning of the head and the body of the patient. Head rotation **(a)** combined with five body positions **(b)** allows the surgeon to gain access to every trajectory. Special positions are also possible (e.g., semisitting).

Except for special positions (e.g., semisitting), one of the following five basic positions are applied (▶Fig. 1.4b):

- Supine: quick and easy.
- Supine oblique (45°) upper body rotation with the pelvis and legs supine: still quick.
- Lateral recumbent: more complicated, takes more time.
- Lateral oblique or park bench (135°): more complicated, takes more time.
- Prone: more complicated, takes more time and should be avoided if possible because of increased venous congestion.

For instance, a horizontal head position can be achieved by combining:

- 90° head rotation and supine body position or
- 45° head rotation and 45° upper body rotation or
- 0° head rotation and lateral recumbent position.

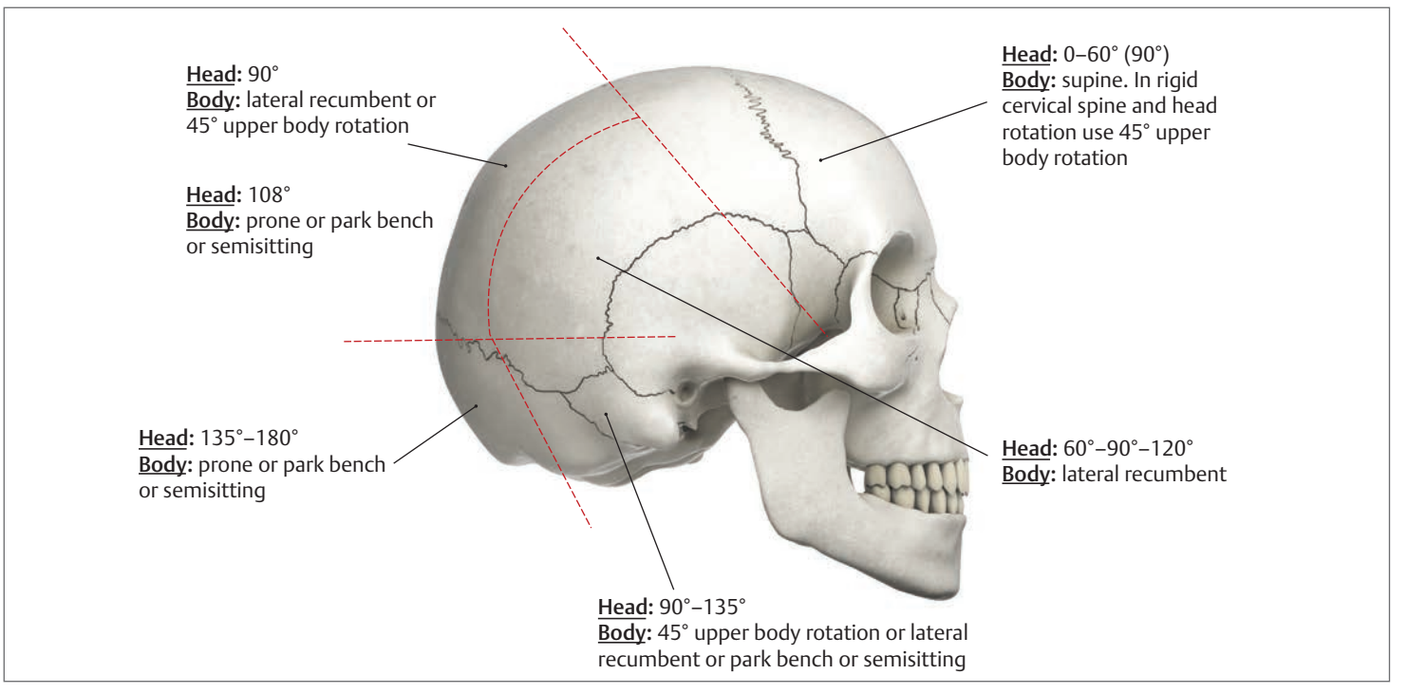

Fig. 1.5 Positioning of the patient's body. Typical positioning for different locations of craniotomies.

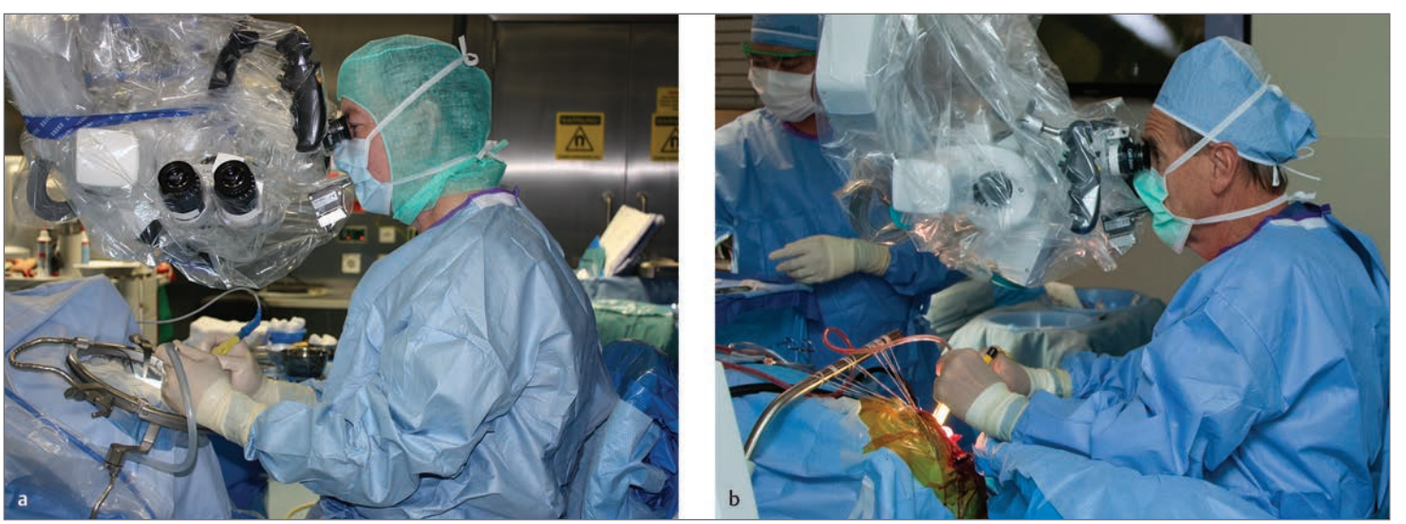

Fig. 1.6 Position of the surgeon. There are two basic positions for the surgeon: the first is more upright, closer to the surgical field and short instruments, and the hands or fingers are supported **(a)**. The second is a somewhat more oblique position with slightly longer instruments, and forearms or elbows supported **(b)**. Both can achieve the goals of a relaxed surgeon, excellent stability, minimized trembling, and soft instrument movements with maximum haptic feedback about resistance of structures and tactile information. Normally, the positioning of the microscope and the patient's head follows the position of the surgeon. Make yourself comfortable and then adjust the microscope and the patient, unless otherwise required by the planned surgical trajectory and the specific goals. (▶Fig. 1.6a is reproduced courtesy of Volker Seifert and ▶Fig. 1.6b courtesy of Robert F. Spetzler.)

1.4.2 Supine

Philippe Schucht

See ▶ Fig. 1.7 and ▶ Fig. 1.8.

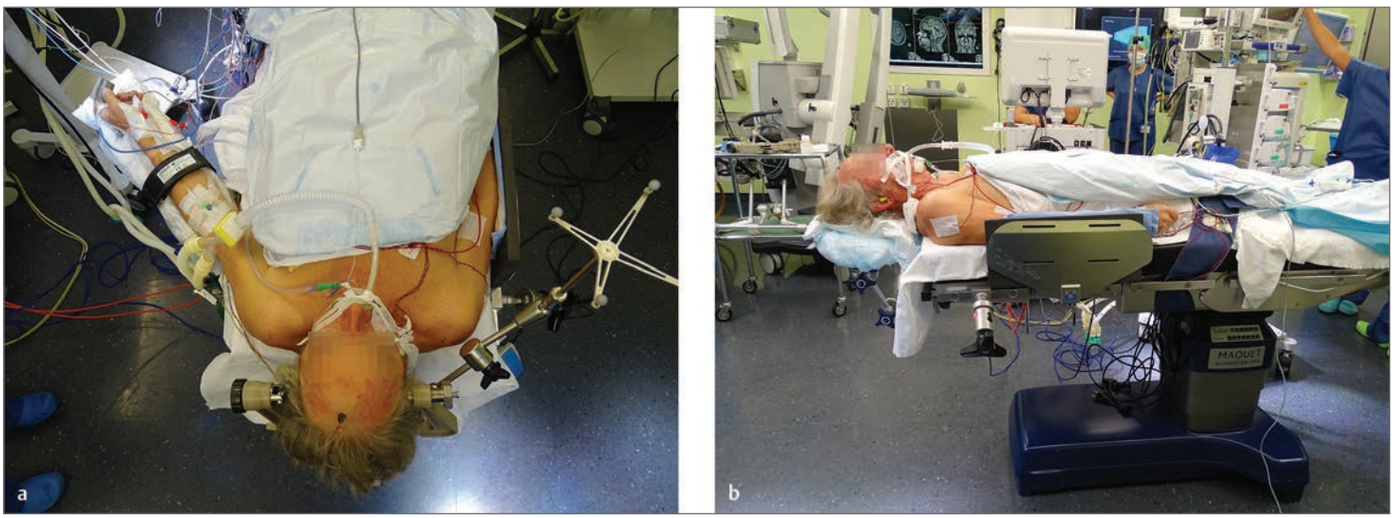

Fig. 1.7 Body position. View from the top **(a)** and the side **(b)**. The supine position is the simplest position. The body and the legs lie straight and the right arm lies parallel to the body. The left arm lies at an angle on a separate armrest to allow insertion of arterial and venous lines and should be loosely fixed.

Attention should be paid to making sure that the body is well cushioned and that the sheets beneath the patient have no wrinkles. In particular in long procedures, incorrect patient positioning may result in decubiti.

Rotating the patient during surgery may give you a better angle of view. For rotating during surgery, prop the patient with additional side pads.

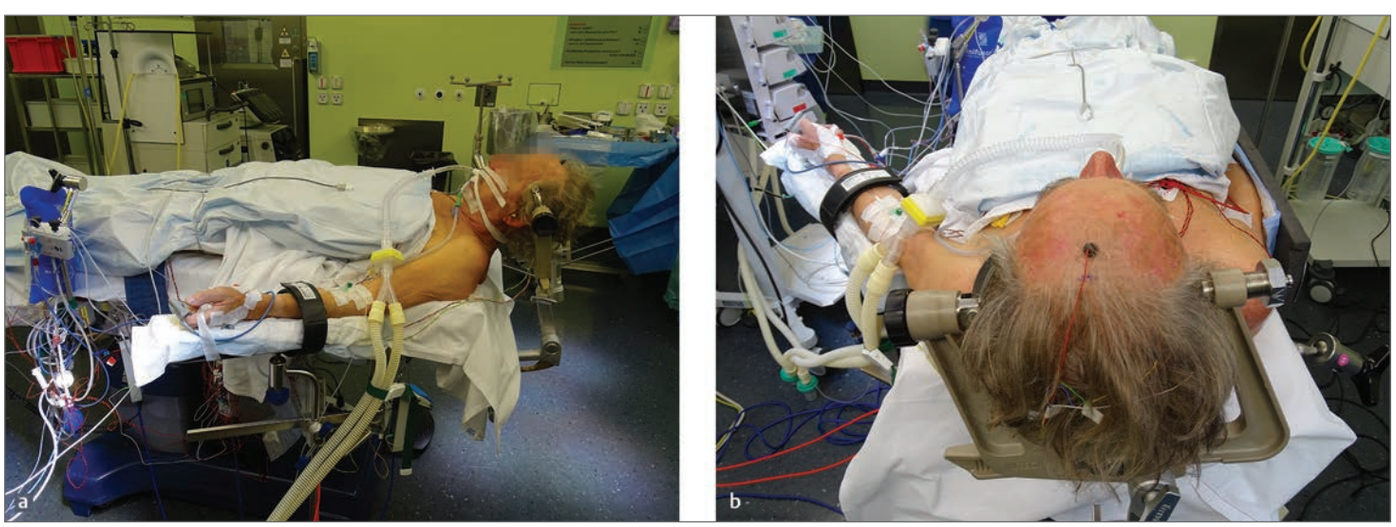

Fig. 1.8 (a, b) Head position. The shoulders should reach the edge of the table. The head is elevated by approximately 5–10 cm in order to facilitate venous drainage

Checklist

- Use side pads to prop the patient if you consider rotating the patient during surgery.
- Cushion the patient well and avoid wrinkles in the sheets to prevent decubiti.
- Elevate the head by approximately 5 to 10 cm to facilitate venous drainage.