ATLAS OF ANATOMY

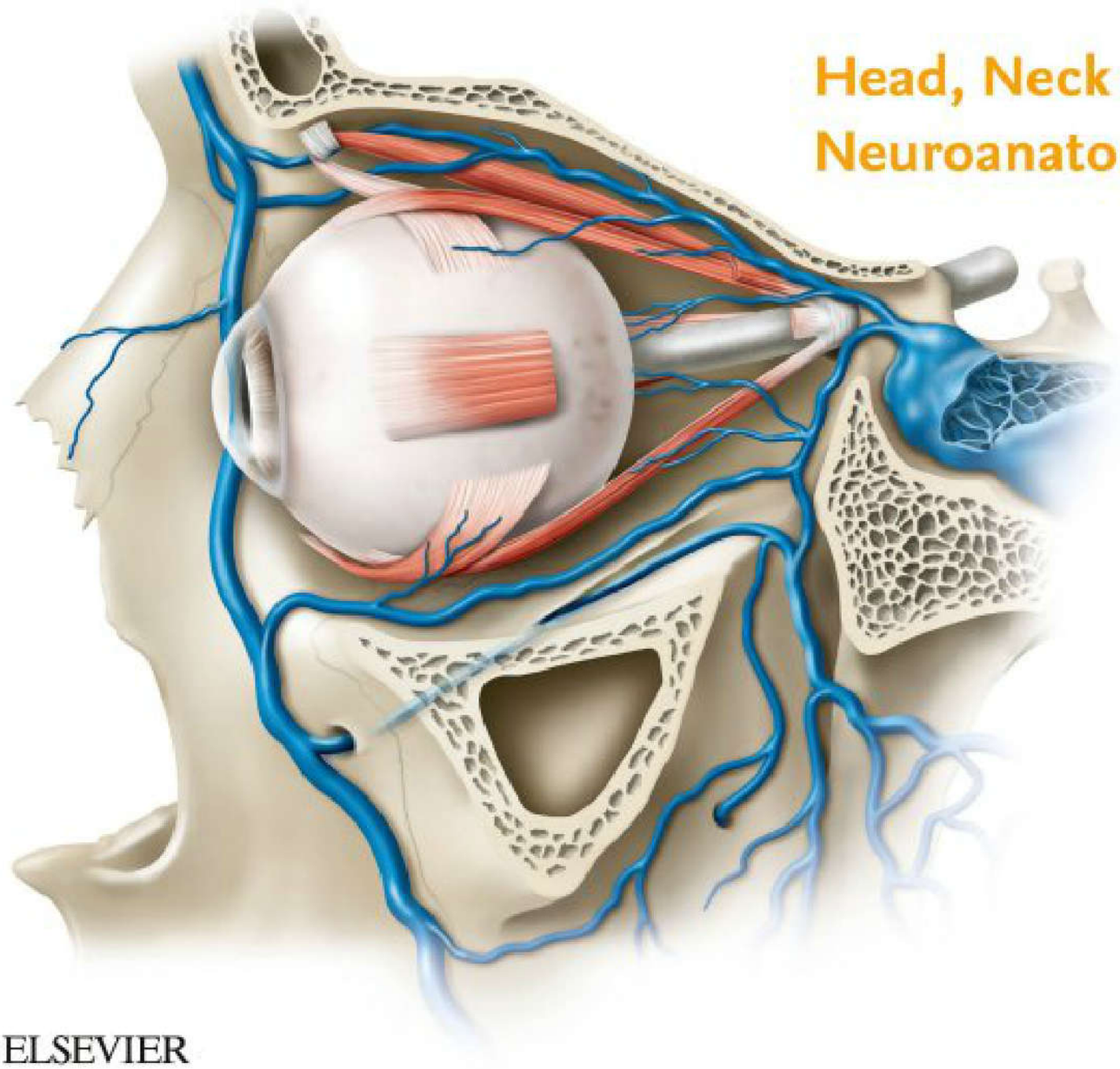
Sobotta

16th Edition

Edited by
Friedrich Paulsen and
Jens Waschke

English Version with
Latin Nomenclature

Head, Neck and Neuroanatomy



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F. Paulsen, J. Waschke

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Friedrich Paulsen, Jens Waschke (Eds.)

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This atlas was founded by Johannes Sobotta + ((Sterbekreuz)), former Professor of Anatomy and Director of the Anatomical Institute of the University in Bonn, Germany.

German Editions:
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Prof. Friedrich Paulsen

Dissection course for students

In his teaching, Friedrich Paulsen puts great emphasis on ensuring that the students in his dissection classes can actually work on body donation cadavers. *'Carrying out dissection yourself is not only extremely important for gaining a three-dimensional understanding of anatomy, forming the fundamental basis of virtually any field of medical science. In dissection classes you will also experience for the first time the touch and feeling of the human body, the organs and individual tissues, but in most cases it will also be your first intensive encounter with issues around death and dying, and the clinical causes of death. You will not only study anatomy, but also learn how to deal with a quite unique and challenging situation as part of a team. Never again will you be in such close contact with your fellow students and teaching staff.'*

Friedrich Paulsen was born in Kiel in 1965 and, after completing his 'Abitur' in Brunswick, he initially trained as a nurse. He then studied medicine at the Christian Albrecht University (CAU) in Kiel. After his house officer training at the Oromaxillofacial Surgery Clinic and a period as resident physician at the ENT Clinic of CAU, in 1998 he moved to the Anatomical Institute of CAU where he graduated as medical doctor in 1997 and further qualified by performing his State doctorate in anatomy in 2001. In 2003 he was offered full professorship at the Anatomy Departments of the Ludwig Maximilians University (LMU) in Munich and the Martin Luther University (MLU) in Halle/Wittenberg. In Halle, he founded a clinical anatomy training centre. After declining yet another professorship, this time at the University of Saarland, he accepted a post at the Friedrich Alexander University (FAU) in Nürnberg as Professor of Anatomy and Head of its Anatomical Institute, a post he has held since 2010. He has continued to decline professorships offered by a number of other renowned universities.

Friedrich Paulsen is an honorary member of the Anatomical Society of Great Britain and Ireland as well as Romania and has been granted numerous scientific awards including the Dr Gerhard Mann Sicca research prize, the Sicca research prize of the German Federation of Ophthalmologists, and the Commemorative Medal of the Comenius University in Bratislava. Additionally, he received several teaching awards.

The key focus of his research is on the innate immune response of the eye surface, and on investigating the causes of dry eyes. Visiting research fellowships have taken him to Spain and the United Kingdom. He is the editor of the journal *Annals of Anatomy* and, as vice-president of Learning and Teaching (until 3/2018), and now People (since 4/2018) also a member of the FAU university administration since 2016.

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Prof. Jens Waschke

Making courses more clinically relevant

For Jens Waschke, one of the most important challenges in the teaching of modern anatomy is how to optimally adapt the courses to meet the requirements of clinical training and subsequent professional practice.

'The clinical aspects of the Atlas give students in the first semesters of medical school a grounding in anatomy and at the same time show them the importance of having a thorough understanding of human anatomy for their subsequent clinical practice, instead of just learning anatomical structures by rote. On the other hand, we prefer to avoid covering highly specialised details that are only needed by a few specialists for occasional diagnostic procedures or surgery, as is the case in other contemporary anatomy books. Since students at the beginning of their training are unable to distinguish between the necessary basics and specialised details, this can cause a mental overload and prevent them from focusing on the essentials.'

Jens Waschke (born in 1974 in Bayreuth) studied medicine at the University of Würzburg, achieving a doctorate in anatomy under Prof. Detlev Drenckhahn in the year 2000. After his intership training in the Anatomy and Internal Medicine Departments, he qualified as a professor of anatomy and cell biology in 2007. Jens Waschke spent nine months as a visiting scholar at the Davis campus of the University of California under Prof. Fitz-Roy Curry in 2003–2004. From 2008 onward he chaired the newly established Department III of the University of Würzburg before being appointed professor at the Ludwig Maximilians University in Munich, where he has been the head of Department I (Vegetative Anatomy) of the Anatomical Institute since 2011. Jens Waschke is heavily involved in the German Anatomical Society as an examiner in specialist anatomy and a member of its Study Commission, and he heads their working group on reducing formaldehyde exposure. He is a representative of the IFAA (International Federation of Associations of Anatomists) and an honorary member of the Anatomical Society of Ethiopia (ASE).

In his research he primarily investigates the biological mechanisms regulating cell adhesion and the external and internal barrier functions of the human body. His research predominantly focuses on the regulation of the endothelial barrier during inflammation, and also the mechanisms behind the impaired cell adhesion seen in diseases such as the blistering skin disorder pemphigus, Crohn's disease and arrhythmogenic cardiomyopathy. The aim is to better understand cell adhesion and to discover new treatment approaches.

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Preface of the 24th German Edition

In the preface of the first edition of his atlas in May 1904, Johannes Sobotta writes: 'Long-standing experience in cadaver dissection classes has prompted the author to ensure that the illustrations of the peripheral nervous system and the blood vessels depict the relevant structures in the same way that the student is accustomed to seeing them on the cadaver, i.e. that they depict the vessels and nerves from the same region together. Furthermore, the atlas alternates between pages of text and full-page diagrams. The latter contain the key illustrations in the atlas, while the former – in addition to sketches and schematic drawings and legends – contain a brief, concise text to help the student find information quickly when using the book in the dissection hall.'

Just as fashions change on a regular basis, so do students' reading and studying habits. The ubiquitousness of multi-media and the ready availability of information and stimuli are surely the main reasons why these habits are changing at a much faster rate than ever before. Publishers and publishing houses must stay abreast of these developments and of students' changing expectations regarding atlases and textbooks they wish to use, as well as ensuring the digital availability of the contents. In addition to interviews with students and systematic surveys, a publisher can sometimes gauge students' expectations from the textbook market itself. Detailed textbooks claiming to be completely comprehensive are increasingly being abandoned in favour of textbooks that didactically meet students' educational needs and cover the contents of their courses and exams – whether they are studying medicine, dentistry or biomedical science. Likewise, although the images in atlases such as Sobotta have fascinated many generations of doctors and medical professionals around the world with their precise naturalistic representations of real dissections, they are sometimes perceived by students as being too complicated and too detailed. This realisation requires us to consider how we can build upon the obvious strengths of an atlas – which in the course of over 100 years of tradition and 23 German editions, has become a benchmark of accuracy and quality – to meet modern didactic concepts without the overall work losing its unique, exclusive characteristic and its originality.

For educational reasons, we have maintained the Sobotta's original concept and chosen to publish the atlas, as it has been since the first edition, in three volumes: General Anatomy and Musculoskeletal System (1); Internal Organs (2); and Head, Neck and Neuroanatomy (3). And while the concept mentioned in the preface of the first edition, i.e. linking the pictures in the Atlas with an explanatory text, may be old-fashioned, it has now come back into fashion – we have simply modernised the concept. Each picture is thus completed with a short explanatory text to introduce the students to the structure depicted and to explain why those particular dissection and depiction methods have been chosen for that particular region. The individual chapters have been systematically structured to follow today's methods of studying, while various illustrations have been updated or replaced. The majority of these new illustrations have been designed from the point of view of the learner, to make it easier to study the key pathways of blood supply and innervation. We have furthermore revised numerous existing illustrations and reduced the number of labels, using bold type to facilitate access to the anatomical content. The numerous clinical practice examples ('Clinical Remarks') show the somewhat 'dry' subject of anatomy at its most vibrant best, demonstrating to beginners how relevant anatomy is for their subsequent professional life and giving them a tantalising taste of their clinical training to come. Another revised feature is the introductory preface to the individual chapters, which sum up the content and the key issues, and include a real-life clinical case. In addition, each chapter ends with a summary of questions which would typically be asked in oral anatomy exams and exam tests. As in the 23rd edition, each chapter contains a brief introduction to the embryology of each body region.

Readers should please note two things:

1. The 24th edition of the Sobotta Atlas cannot replace an explanatory textbook.
2. No matter how good an educational concept is, students still have to put in many hours of intensive studying themselves – a good concept can but make that knowledge more accessible. Learning anatomy is not difficult, but it does take a lot of time; time that is well spent, since everybody – doctor and patient – will benefit from it in the long run. The aim of the 24th edition of the Sobotta Atlas is not only to facilitate your study, but also to make the time you spend studying engaging and interesting, so that the atlas is something you will repeatedly want to pick up and consult, both during your medical training and your subsequent professional career.

Erlangen and Munich, summer of 2017,
exactly 113 years after the first edition was published

Friedrich Paulsen and Jens Waschke

Acknowledgements of the 24th German Edition

The work on the 24th edition of the Sobotta Atlas has once again been a lot of fun, and this intensive involvement has continued to strengthen our sense of pride in the Sobotta.

Today, more than ever, an extensive anatomy atlas of the calibre of the Sobotta requires a lot of teamwork with the coordination of the publishing house. The cornerstone of the 24th edition has been laid by Dr Katja Weimann, who extensively coordinated the project. We are very grateful for her hard work. Also, without the long-standing experience of Dr Andrea Beilmann, who has worked on several previous editions of the Sobotta and has been a true pillar of strength for the Sobotta team, many things would not have been possible. We would like to thank her again most profusely for all her help and support. Benjamin Rempe, another member of the four-person team behind the 24th edition of the Sobotta, has contributed to Sobotta for the first time, approaching the task with real passion and enthusiasm. His unique way of motivating the team served as a continual source of encouragement and motivation for the editors. Benjamin: thank you very much. We fondly recall the monthly conference calls in which Benjamin Rempe and Dr Andrea Beilmann helped us carefully craft the Sobotta Atlas and, despite their different approaches, showing a remarkable gift for intuitively adopting a uniform working style. Sibylle Hartl coordinated the project in collaboration with Dr Andrea Beilmann and was responsible for the entire print production. We are truly grateful to her. Without the tenacity and the protective hand of Dr Dorothea Hennessen and Rainer Simader, who were both in charge of the overall management of the 'Sobotta 24th edition' project and who never lost faith in their Sobotta team or the tight schedule, this edition in its present form would not have been possible. Others whom we are similarly grateful to for their involvement in the project and their share of its success are: Dr Antje Kronenberg (editing), the abavo GmbH team (technical image processing and typesetting) and Nicola Kerber (layout design). We would very much like to thank Dr Ursula Osterkamp-Baust for exhaustively compiling the index.

Special thanks to our team of illustrators Dr Katja Dalkowski, Marie Davidis, Johannes Habla, Anne-Kathrin Hermanns, Martin Hoffmann, Sonja Klebe, Jörg Mair and Stephan Winkler, who in addition to updating the existing images also helped us develop a large number of new illustrations.

For their help in producing the clinical images, we would also like to thank Dr Frank Berger, Institute of Clinical Radiology of Ludwig Maximilians University, Munich; Prof. Christopher Bohr, Phoniatrics and Paediatric Audiology, ENT Clinic at Friedrich Alexander University, Erlangen/Nürnberg; Dr Eva Louise Bramann, Ophthalmology Clinic at Heinrich Heine University, Düsseldorf; Prof. Andreas Dietz, Director of the ENT Clinic and Outpatients' Clinic at the University of Leipzig; Prof. Gerd Geerling, Ophthalmology Clinic at Heinrich Heine University, Düsseldorf; Dr Berit Jordan, University Clinic and Outpatients' Clinic for Neurology, Martin Luther University, Halle/Wittenberg; Dr Axel Kleespies, Surgical Clinic, Ludwig Maximilians University, Munich; Prof. Norbert Kleinsasser, University Clinic for Illnesses of the Ear, Nose and Throat, Julius Maximilians University, Würzburg; Dr Hannes Kutta, ENT practice, Hamburg-Altona/Ottensen; Dr Christian Markus, Anaesthesiology Clinic, Julius Maximilians University, Würzburg; Jörg Pekarsky, Institute for Anatomy II, Friedrich Alexander University, Erlangen/Nürnberg; Dr Dietrich Stövesandt, Clinic for Diagnostic Radiology, Martin Luther University, Halle/Wittenberg; Prof. Jens Werner, Surgical Clinic, Ludwig Maximilians University, Munich; Dr Tobias Wicklein, Erlangen, and Prof. Stephan Zierz, Director of the University Clinic and Outpatients' Clinic for Neurology, Martin Luther University Halle/Wittenberg.

Last but not least, we would like to thank our families, who not only were very gracious and understanding of all the time we devoted to the 24th edition of the Sobotta, but who also gave us very helpful suggestions whenever we needed feedback. You have been a true support.

Erlangen and Munich, summer of 2017
Friedrich Paulsen and Jens Waschke

1. List of Abbreviations

Singular:			Plural:		
A.	=	Arteria	Aa.	=	Arteriae
Lig.	=	Ligamentum	Ligg.	=	Ligamenta
M.	=	Musculus	Mm.	=	Musculi
N.	=	Nervus	Nn.	=	Nervi
Proc.	=	Processus	Procc.	=	Processus
R.	=	Ramus	Rr.	=	Rami
V.	=	Vena	Vv.	=	Venae
Var.	=	Variation			

♀ = female
♂ = male

Percentages:
In the light of the large variation in individual body measurements, the percentages indicating size should only be taken as approximate values.

2. General Terms of Direction and Position

The following terms indicate the position of organs and parts of the body in relation to each other, irrespective of the position of the body (e.g. supine or upright) or direction and position of the limbs. These terms are relevant not only for human anatomy but also for clinical medicine and comparative anatomy.

General terms

anterior – posterior = in front – behind (e.g. Arteriae tibiales anterior et posterior)
ventralis – dorsalis = towards the belly – towards the back
superior – inferior = above – below (e.g. Conchae nasales superior et inferior)
cranialis – caudalis = towards the head – towards the tail
dexter – sinister = right – left (e.g. Arteriae iliacae communes dextra et sinistra)
internus – externus = internal – external
superficialis – profundus = superficial – deep (e.g. Musculi flexores digitorum superficialis et profundus)
medius, intermedius = located between two other structures (e.g. the Concha nasalis media is located between the Conchae nasales superior and inferior)
medianus = located in the midline (Fissura mediana anterior of the spinal cord). The median plane is a sagittal plane which divides the body into right and left halves.
medialis – lateralis = located near to the midline – located away from the midline of the body (e.g. Fossae inguinales medialis et lateralis)
frontalis = located in a frontal plane, but also towards the front (e.g. Processus frontalis of the maxilla)
longitudinalis = parallel to the longitudinal axis (e.g. Musculus longitudinalis superior of the tongue)
sagittalis = located in a sagittal plane
transversalis = located in a transverse plane
transversus = transverse direction (e.g. Processus transversus of a thoracic vertebra)

Terms of direction and position for the limbs

proximalis – distalis = located towards or away from the attached end of a limb or the origin of a structure (e.g. Articulationes radioulnares proximalis et distalis)

for the upper limb:
radialis – ulnaris = on the radial side – on the ulnar side (e.g. Arteriae radialis et ulnaris)

for the hand:
palmaris – dorsalis = towards the palm of the hand – towards the back of the hand (e.g. Aponeurosis palmaris, Musculus interosseus dorsalis)

for the lower limb:
tibialis – fibularis = on the tibial side – on the fibular side (e.g. Arteria tibialis anterior)

for the foot:
plantaris – dorsalis = towards the sole of the foot – towards the back of the foot (e.g. Arteriae plantares lateralis et medialis, Arteria dorsalis pedis)

3. Use of Brackets

[ ]: Latin terms in square brackets refer to alternative terms as given in the Terminologia Anatomica (1998), e.g. Ren [Nephros]. To keep the legends short, only those alternative terms have been added that differ in the root of the word and are necessary to understand clinical terms, e.g. nephrology. They are primarily used in figures in which the particular organ or structure plays a central role.

( ): Round brackets are used in different ways:
– for terms also listed in round brackets in the Terminologia Anatomica, e.g. (M. psoas minor)
– for terms not included in the official nomenclature but which the editors consider important and clinically relevant, e.g. (Crista zygomaticoalveolaris)
– to indicate the origin of a given structure, e.g. R. spinalis (A. vertebralis).

Colour Chart

- Concha nasalis inferior
- Mandibula
- Maxilla
- Os ethmoidale
- Os frontale
- Os lacrimale
- Os nasale
- Os occipitale
- Os palatinum
- Os parietale
- Os sphenoidale
- Os temporale
- Os zygomaticum
- Vomer

In the newborn the following cranial bones are indicated by only one colour:

- Os nasale, Os temporale, Mandibula
- Maxilla, Os incisivum
- Os occipitale, Os palatinum

Table of Content

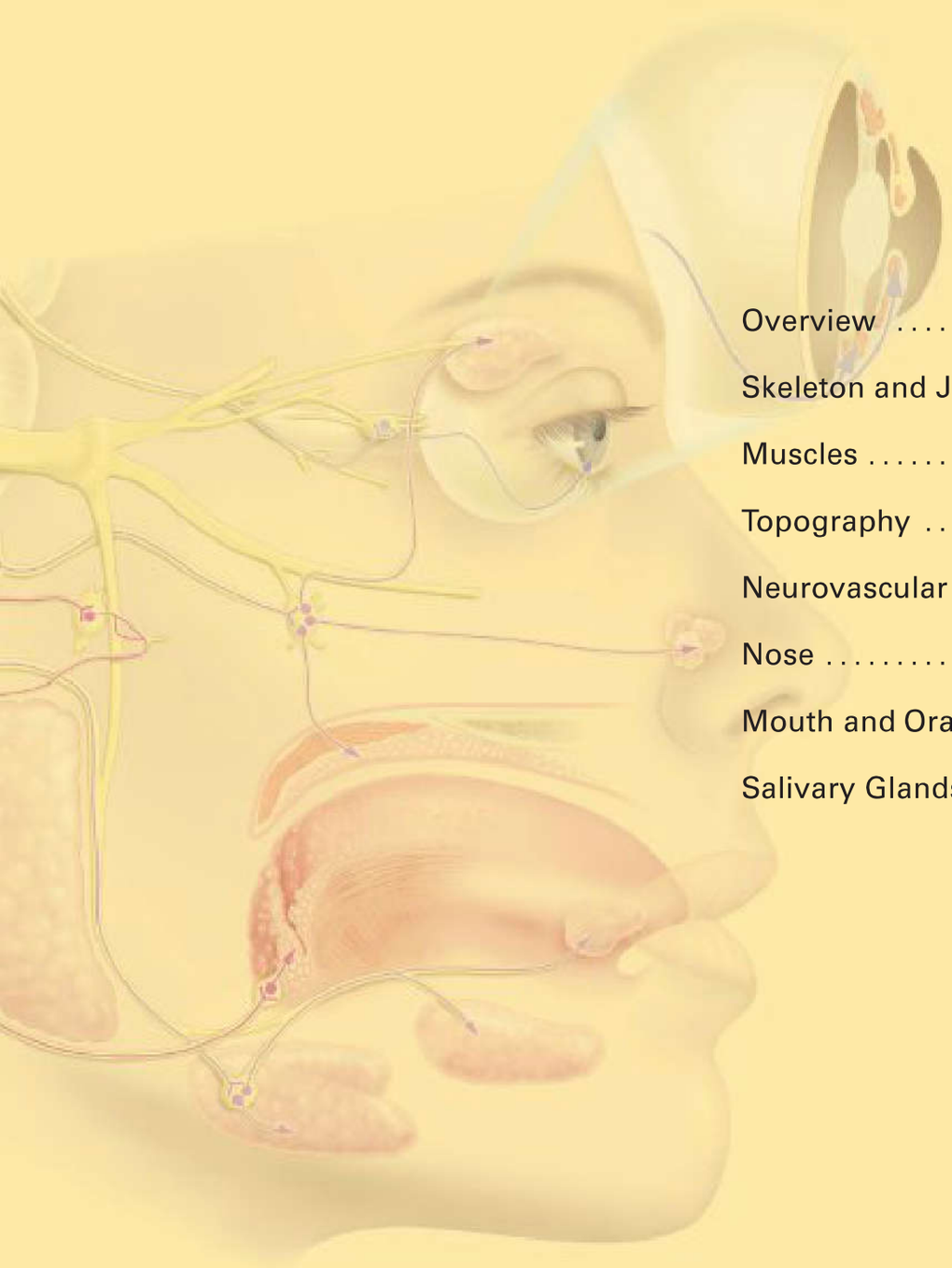
Head

Eye

Ear

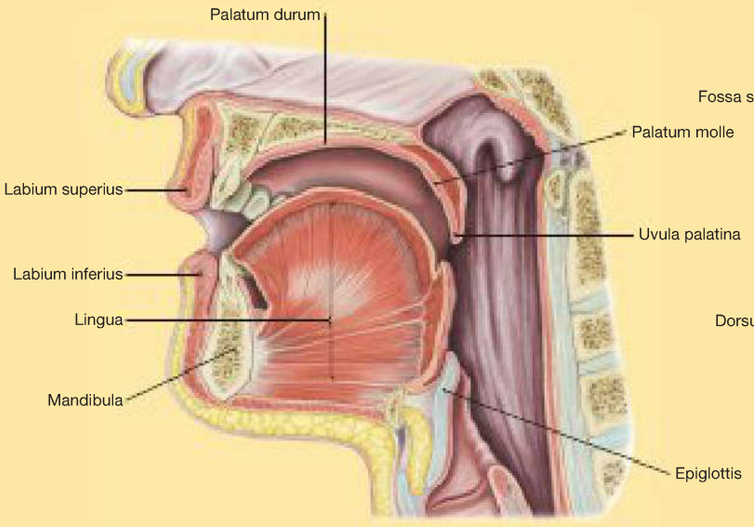
Neck

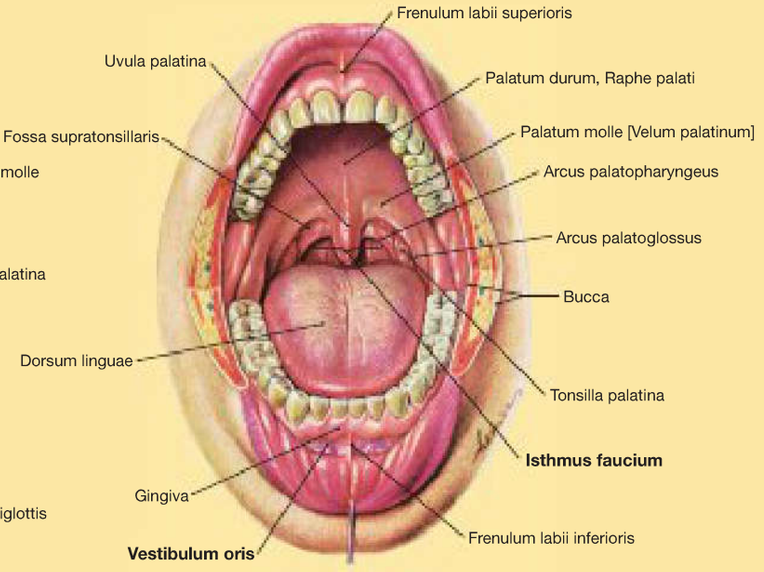
Brain and Spinal Cord



Head

8





Overview

The **head (Caput)** is flexibly connected to the torso (trunk, Truncus) via the neck area. This allows us to direct the sensory organs of our head towards environmental stimuli without having to move our whole body. The bony skeleton of the head is the **skull (Cranium).** Its posterior section, called the neurocranium, encloses essential parts of the central nervous system (brain), while its front section, the viscerocranium, encloses the various major, highly specialised organs of sensory perception: the **eye** (organ of sight), the **ear** (organ of hearing and balance), the **nose** (organ of smell) and the **oral cavity** and **pharynx** (organs of taste). The respiratory tract starts in the nasal cavity and upper part of the pharynx, while the oral cavity and middle section of the pharynx mark the beginning of the digestive tract. Thus, we use our heads both for the **food intake and spatial orientation.** Together with our nose and sinuses, our mouth, pharynx and masticatory apparatus significantly contribute to the shape of our face. We humans additionally use the oral cavity and its organs for **articulation, enabling speech and singing.** The **mimetic muscles,** which do not have their own fascia, insert directly into the skin of the head, thus enabling unique facial expressions to aid our communication with the rest of the world. The Protuberantia occipitalis externa at the back of the skull, the base of the ears and the Mandibula (in order from the back to the front) mark the boundary between the head and neck area.

Main Topics

After studying this chapter, you should be able to:

- describe the cranial bones and cranial development;
- name sutures and fontanelles, including closure;
- describe the basic structure of the skull, its bones and their positional relationship to each other;
- identify the neurocranium, viscerocranium, internal surface of the cranial base and cranial fossae, and be able to explain their structure;
- name the major passageways and structures, foramina, fissures and impressions on the inner and outer surfaces of the cranial base;
- describe the insertion, origin, function and innervation of the muscles of facial expression;
- describe the structure, blood supply, lymphatic drainage and innervation of the scalp;
- name and locate key landmarks in the different areas (face, lateral facial region), systematically identify them and be able to describe the topographic route of neurovascular pathways in the areas, as well as name and visualise in three dimensions the anatomical structures deep within the lateral facial region that are not visible from the outside;
- name major topographic features and explain their clinical relevance;
- outline the origin, route and fibre quality, and the innervation areas of the twelve cranial nerves (→ chapter 12);
- describe the general embryological development of the nose and sinuses;
- describe the external structure of the nose, the bony and cartilaginous structure of the nasal skeleton, and the boundaries of the nasal cavities and their distension;
- describe the blood supply and innervation of the entire nose with respect to its clinical relevance;
- demonstrate the olfactory epithelium and how it is connected to the anterior cranial fossa;
- describe the location, bony structures and openings of the sinuses, and their topographical relationship to other structures;
- explain the embryological development of the oral cavity, masticatory apparatus, tongue, palate and salivary glands;
- describe all structures of the oral cavity, their neurovascular supply, and the routes of nerves and vessels;
- describe the topography and the interrelationship of the structures and organs to each other and to the neighbouring regions, and their functions;
- explain the dental development and the detailed structure of the different teeth, including the different stages of dentition;
- describe the structure and function of the Articulatio temporomandibularis, and the location, function, blood supply and innervation of the masticatory muscles;
- outline the structure, location, function, innervation, vascular supply and lymphatic drainage of the tongue, palate and salivary glands;
- provide an exact explanation of the blood supply to the Tonsilla palatina;
- outline the topography of the floor of the mouth including its compartments, the muscles involved, and the blood supply, innervation and lymphatic drainage.

Clinical Relevance

In order not to lose reference to future everyday clinical life with so many anatomical details, the following describes a typical case that shows why the content of this chapter is so important.

Facial Paralysis

Case Study

In the summer, a 22-year-old trainee visits his GP stating that for several days now he has had increasing problems moving the right side of his face and has had problems when trying to drink. In addition, saliva has been constantly dripping from the corner of his mouth. He also has the feeling that he hears more loudly on the right side. Otherwise, the patient appears to be healthy. He did not have any recent fever, headaches, painful limbs, a bout of flu or a tick bite. His medical history is normal. The young man is not on any medication and does not take drugs. He only drinks alcohol occasionally and in moderate limits; he does not smoke. His family medical history is also normal.

Result of Examination

The first impression of the patient's face as he comes into the examination room immediately indicates facial paralysis as a diagnosis. The right side of his face is visibly 'drooping' (→ Fig. a). The nasolabial fold on the right side has disappeared. When requested, the patient cannot frown, smile or whistle a tune, nor blow out his cheek on the right side. His attempts to close his eyes result in lagophthalmos (his right eye remains open) and in BELL's phenomenon.

BELL's phenomenon: the eyeball automatically turns upwards when closing the eyelid. As the lid cannot be closed, only the white sclera of the eye remains visible.

The doctor tests the facial nerve sensitivity by brushing the patient's cheek; however, this is intact. Because the patient cannot frown on the affected side, the doctor comes to a preliminary diagnosis: idiopathic (no identified cause) peripheral (infranuclear) facial paralysis.

People with central facial paralysis can still wrinkle their foreheads.

The GP refers the patient to an ENT specialist.

The ENT specialist also notes a complete right-sided peripheral facial paralysis. The patient's auricle and facial soft tissue are normal, and his ear canal and eardrum show no signs of irritation on either side. His parotid saliva shows no signs of irritation. The palpation of neck and face gives no indication of any tumour or infection.

Diagnostic Procedure

The ENT specialist conducts an audiometry, which shows no evidence of hearing loss. To exclude other more serious causes (e. g. a tumour), he orders a cranial MRI, blood tests, an electroneurography (ENoG) and an electromyography (EMG). The blood test results are all normal; therefore zoster oticus, a herpes simplex infection and borreliosis can all be ruled out. The ENoG and EMG reveal no signs of major nerve damage. After examination by a neurologist, neurological symptoms can also be ruled out. The MRI shows a slight swelling of the N. facialis [VII] inside the bony canal.

Diagnosis

Idiopathic, right-sided peripheral facial paralysis.

In up to 70% of all cases a peripheral facial paralysis is idiopathic.

Treatment

An outpatient treatment with cortisone infusion quickly shows results; the facial movements have already begun to return to normal by the third day. The forehead branch is the only part of the nerve still not working at this stage.

Further Development

An outpatient follow-up examination four weeks later confirms that his facial movements are perfectly symmetrical again.

Dissection Lab

Look out for the following branches of the N. facialis: N. petrosus major, Chorda tympani and N. stapedius.

Back in the Clinic

Although the patient's facial (mimetic) muscles are becoming increasingly mobile during his cortisone treatment, he has noticed that his right eye always waters when he is eating, so he goes to visit his GP again. The doctor tells him that this so-called crocodile tears syndrome is also referred to as gustatory hyperlacrimation. This harmless irritation syndrome occasionally occurs in the regenerative processes after a facial paralysis. Affected patients experience increased lacrimation (shedding of tears) on one side when eating. Because the regenerating parasympathetic gustatory nerve fibres are growing into the lacrimal gland (Glandula lacrimalis), this results in faulty misconnection and misrouting of the nerve fibres. If the patient suffers with strong subjective symptoms, Botox injections can be attempted as a treatment option.

Fig. a Left: patient as seen during examination; centre: patient when asked to wrinkle his forehead; right: patient when asked to close an eye. [T887]