Stereo Operative Atlas of Micro Ear Surgery

Pu Dai
Dong-yi Han
Vincent C Cousins
Yue-shuai Song
Editors

PEOPLE'S MEDICAL PUBLISHING HOUSE

Springer

Stereo Operative Atlas of Micro Ear Surgery

Pu Dai • Dong-yi Han • Vincent C Cousins
Yue-shuai Song
Editors

Stereo Operative Atlas of Micro Ear Surgery

Springer

Editors
Pu Dai, MD, PhD
Department of Otolarygngology Head
and Neck Surgery
Chinese PLA General Hospital
Beijing
China

Dong-yi Han, MD, PhD
Department of Otolarygngology Head
and Neck Surgery
Chinese PLA General Hospital
Beijing
China

Vincent C Cousins, BMedSci, MBBS, FRACS
Department of Otolarygngology Head
and Neck Surgery
Alfred Hospital
Melbourne
Australia

Yue-shuai Song, MD
Department of Otolarygngology
Head and Neck Surgery
Beijing Friendship Hospital
Capital Medical University
Beijing
China

ISBN 978-981-10-2088-9 ISBN 978-981-10-2089-6 (eBook)
DOI 10.1007/978-981-10-2089-6

The print edition is not for sale in China Mainland. Customers from China Mainland please order the print book from:
People's Medical Publishing House

Library of Congress Control Number: 2016962211

Printed on acid-free paper
Springer Singapore Heidelberg New York Dordrecht London

This Springer imprint is published by Springer Nature
The registered company is Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #22-06/08 Gateway East, Singapore 189721, Singapore.

Preface

Auditory perception is one of the most important human senses and this is self-evident to all mankind. Structural and functional lesions causing hearing loss are mostly located in the middle and inner ear, which makes them the main targets in microsurgery of the ear and lateral skull base. The temporal bone contains many important structures which are small and delicate and have complex relationships, thus representing one of the most intricate and complicated areas in the human body. Visualization of these structures and their spatial relationships is beyond the ability of the unaided eye, making our understanding of ear anatomy a difficult task. The invention and application of the zoom stereo binocular microscope have opened a new chapter for microsurgery, providing excellent stereo vision and stimulated further development of modern otology.

Microsurgery of the ear is still known as a challenging field due to its delicate nature and its demands of meticulous technical ability. Young trainees starting in the field are faced with significant difficulty in acquiring the surgical knowledge and techniques of the ear and lateral skull base procedures they see demonstrated by their experienced otology and neurotology mentors. This is in part due to the inability of observers to have the same stereo vision as the operating surgeon.

Generally, beginners gain their surgical knowledge of the ear and lateral skull base by studying anatomic drawings, photographs, videos, etc. The learner's personal understanding, spatial imagination, and 3D imaging of the anatomical relationships need to be synthesized in the mind. Inevitably, an incorrect impression may often be generated during this process.

Traditional textbooks cannot provide the 3D features of a surgical field to learners. The trainee has the difficult task of learning and comprehending 3D information based only on 2D images. This has stimulated a drive to develop an innovative method to change this sometimes ineffective learning method.

Twenty years ago, we began to consider reproducing the anatomy and surgical field of ear surgery using computer technology with the aim of providing effective technological support for anatomical research, teaching, and microsurgical training. In the early stages, we achieved computer-aided 3D reconstruction from serial sections of the temporal bone, and this laid the foundation for 3D morphological research of the ear. Based on this technology, we obtained paired stereoscopic images of reconstructed structures with different rotating angles observed with a stereoscope to generate real 3D images. Building on this experience, we collaborated with Dr. You-jun Yu from Foshan Hospital, to publish our first 3D atlas, the *stereoscopic Anatomic Atlas of Temporal Bone* in 2006. That book contains 76 pairs of stereoscopic images and readers can obtain vivid stereovision of anatomic fields with a custom-made stereoscope, which improves the efficiency of learning temporal bone anatomy.

Due to technical limitations, the asynchronous manual exposure technique adopted at that time was unable to address the 3D synchronous photography requirement of the dynamic and ever-changing operative surgical field. For this reason, we invented a stereoscopic photo capture system based on a binocular microscope, which can capture surgical scenes of the right and left light paths without interrupting surgical operations (Chinese Patent number: ZL2008 2 0078610.3). The images taken by this system provide the same authentic 3D surgical scene as observed by the operating surgeon. Based on this breakthrough, we set up a 3D image bank of ear microsurgery, collecting some ten thousand pairs of 3D images from hundreds of ear and lateral skull base surgeries. In this book, we have selected 418 pairs of stereoscopic images from 43 operations, covering a variety of common ear and lateral skull base surgeries. Each set of stereo pictures gives a strong sense of layering and depth, with realistic stereognosis when using an inexpensive folded stereoscope designed for the purpose. Even without the stereoscope, observers can achieve stereo vision by staring at the pairs of 3D images for a period of time. The detailed notes and legends accompanying the stereoscopic images help readers better understand the important surgical procedures, including the spatial relationship of key structures and handling skills required. We believe this technology has great potential to change teaching and training methods of ear and lateral skull base microsurgery, and improve the effectiveness of teaching and academic exchange.

We are keen to share this exciting new technological achievement with colleagues around the world. This is our first publication of a 3D atlas of ear and lateral skull base microsurgery. There will inevitably be some deficiencies and errors in this book and we invite your valuable feedback and advice to help improve the stereo atlas of microsurgery and related technology in the future.

Pu Dai
Dong-yi Han
Vincent C Cousins
Yue-shuai Song

Beijing, China
Melbourne, Australia

Contents

1 General Introduction 1
Yue-shuai Song, Song Gao, and Pu Dai

2 Mastoid and Middle Ear Surgery 5
Pu Dai, Yue-shuai Song, Rui-li Yu, Yi Sun, Zhao-hui Hou, Fei Yu, Ming-yu Han, and Bing Han

3 Facial Nerve Surgery 127
Pu Dai, Yong-yi Yuan, and Guo-jian Wang

4 Inner Ear Surgery 151
Pu Dai, Jian-zhong Li, Fei Yu, Song Gao, Yi Jiang, Wei-dong Shen, Jian-dong Zhao, Sha-sha Huang, and Yi-hui Zou

5 Lateral Skull Base Surgery 223
Dong-yi Han, Vincent C Cousins, Guo-jian Wang, Wei-dong Shen, Yi-hui Zou, Jun Liu, Shi-ming Yang, Jia-nan Li, Wei-ju Han, and Pu Dai

Index 283

Contributors

Pu Dai, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Dong-yi Han, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Vincent C Cousins, MBBS, FRACS Department of Ear Nose and Throat Surgery, Alfred Hospital, Melbourne, Australia

Yue-shuai Song, MD Department of Otolarygngology Head and Neck Surgery, Beijing Friendship Hospital, Capital Medical University, Beijing, China

Song Gao, MD Department of Otolaryngology, The 175th Hospital of Chinese PLA, Zhangzhou, China

Xue Gao, MD Department of Otolaryngology Head and Neck Surgery, The General Hospital of the Chinese PLA Rocket Force, Beijing, China

Bing Han, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Ming-yu Han, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Wei-ju Han, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Zhao-hui Hou, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Sha-sha Huang, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Yi Jiang, MD Department of Otolaryngology, Fujian Provincial Hospital, Fuzhou, China

Jia-nan Li, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Jian-zhong Li, MD Department of Otolaryngology Head and Neck Surgery, Fuzhou General Hospital of Nanjing Command, Chinese PLA, Fuzhou, China

Jun Liu, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Wei-dong Shen, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Yi Sun, MD Department of Otolaryngology, Chinese PLA Wuhan General Hospital, Wuhan, China

Guo-jian Wang, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Shi-ming Yang, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Fei Yu, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Rui-li Yu, MD Department of Allergy, Beijing Shijitan Hospital, Affiliated to Capital Medical University, Beijing, China

Yong-yi Yuan, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Jian-dong Zhao, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Yu-hua Zhu, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Yi-hui Zou, MD Department of Otolarygngology Head and Neck Surgery, Chinese PLA General Hospital, Beijing, China

Biographical Information

Pu Dai graduated in Medicine from the Second Military Medical University, Shanghai, China, in 1986 and later completed Otolaryngology training, being awarded a Masters and a Doctoral degree from the Chinese People's Liberation Army (PLA) Medical College, Beijing, in 1991 and 1998, respectively. He has practiced as an Ear-Nose-and-Throat doctor in the same hospital since 1991. He undertook a further two-and-a-half years of postdoctoral training at Georgetown University in the United States from January 2000 to August 2012. His current appointments are Associate Chairman and Full Professor in the Department of Otolaryngology Head and Neck Surgery of the Chinese PLA General Hospital. He has a great deal of experience with ear, skull base, and cochlear implantation surgery. His research has focused on minimal access cochlear implantation surgery, hearing preservation, and the genetics of hearing impairment. He has led most of the pioneering three-dimensional (3D) morphological research on the temporal bone in China since 1990 and published the first 3D atlas of micro ear surgery in the world.

Dr. Dai has published more than 40 peer-reviewed journal articles worldwide and 120 journal articles in Chinese. He is the chief editor of four textbooks in the field of Otolaryngology Head and Neck Surgery. Some of his honors include a Second Grade Prize of the National Science and Technology Progress Awards (for controlling birth defects causing severe-to-profound hearing impairment); a Seeking Truth Award; and nomination as a National Distinguished Young and Middle-Aged Specialist. He was the chairman of the Organizing Committee and the conference secretary for the Asia-Pacific Symposium on Cochlear Implantation and Related Science (APSCI) (2015) and became a committee member of APSCI at this meeting.

Dong-yi Han, MD, PhD, is a Professor in the Dept. of Otolaryngology Head and Neck Surgery and the Vice Director of the Institute of Otolaryngology at the Chinese PLA General Hospital. He is also the Past President of the Chinese Otolaryngology Head & Neck Surgery Society.

Prof. Dong-yi Han places a great deal of importance on clinical research in ear microsurgery, otoneurosurgery, and skull base surgery. He has made an intensive study of the anatomy of the middle and inner ear, and of the clinical characteristics of cranial nerve lesions, to improve the ability of patients with severe sensorineural deafness to achieve hearing and speech. He introduced the concept of minimally invasive surgery for all types of surgery for diseases of the ear and improved surgical approaches.

Prof. Dong-yi Han has received several key research grants from the National High Technology Research and Development Program of China (863 Program), the National Science Fund for Distinguished Young Scholars, and the National Natural Science Foundation of China. He has been the first or corresponding author of more than 100 papers published in top journals in China and abroad. He has also trained approximately 20 doctoral students and seven postdoctoral fellows. In recognition of his outstanding achievements, he has been awarded the second prize for National Scientific and Technological Progress, the first prize for Military Scientific and Technological Progress, and the second prize for Scientific and Technological Progress from the Chinese Medical Association.

Vincent C Cousins graduated in Medicine from Monash University, Melbourne, Australia, in 1974.

He completed his advanced surgical training in Otolaryngology Head & Neck Surgery in Melbourne (FRACS) in 1984. He then undertook a Head and Neck & Skull Base fellowship with Professor Donald Harrison in London, England, in 1984/1985, and an Otology fellowship with Professor Dietrich Plester in Tuebingen, Germany, in 1986. He has practiced in Melbourne in Otology and Neurotology since then. He is currently Principal Specialist and Head of the ENT-Otoneurology Unit at The Alfred Hospital, Melbourne, and Adjunct Clinical Associate Professor in Surgery at Monash University.

He is Past President of the Australian Society of Otolaryngology Head & Neck Surgery. He has served the Royal Australasian College of Surgeons as Councillor, Chief Examiner (OHNS), and Board Chair of the Academy of Surgical Educators. He has been awarded Distinguished Service Awards from both of these organizations. He is a Life Member of the Neurotology Society of Australia.

He was Visiting Professor in the Dept. of Otolaryngology, Sun Yat Sen University, Guangzhou, China, from 2003 to 2009. He was the Wong Hua Yuen Distinguished Scholar, Hong Kong University in 2004.

He was appointed as the JLO Visiting Professor of the Royal Society of Medicine, London, UK, in 2007. He is a member of the Executive of the International Federation of Otolaryngological Societies.

His research interests include the Management of Acoustic Neuroma, Paragangliomas of the Head and Neck, Facial Paralysis and Temporal Bone Trauma as well as Outcome Measures and Quality of Life in Otology and Lateral Skull Base Surgery. He has published more than 40 peer-reviewed journal articles and book chapters. He is on the review panel for six international journals. He has a particular interest in surgical education and skills training in Otology and Lateral Skull Base Surgery and has directed and instructed on temporal bone dissection and skull base surgery courses in Australia, Africa, and China. He has been part of the Organizing and Scientific Committees and invited faculty member of numerous international Congresses on Otology and Skull Base Surgery.

Yue-shuai Song is a junior otolaryngology head-neck surgeon. He graduated from the Nankai University Medical School, in Tianjin, China, in 2009 and later completed his otolaryngology training and was awarded a doctoral degree from the Nankai University Medical School in 2012. He undertook a further 3 years of postdoctoral training at the Chinese PLA General Hospital from 2012 to 2015. He has practiced as an otolaryngology head-neck surgeon in Beijing Friendship Hospital since 2015. He has a great deal of experience with the anatomy of the temporal bone and skull base and has focused his research on cochlear implantation and the three-dimensional (3D) morphology of the temporal bone. He participated in the publication of the first 3D atlas of micro ear surgery and anatomy as vice and chief editor in 2009 and 2016, respectively. Yue-shuai Song has published seven articles in international peer-reviewed journals and seven articles in Chinese journals. He holds six national patents. He is in charge of the anatomy training program in ear surgery at Beijing Friendship Hospital.

General Introduction

1

Yue-shuai Song, Song Gao, and Pu Dai

A Brief History of the Development of Stereoscopy in Ear Micro Surgery

Yue-shuai Song and Pu Dai

Our knowledge of the anatomy of the temporal bone can be dated back to Hippocrates who understood the tympanic membrane to be part of the acoustic apparatus, and Aristotle who recognized the cochlea as part of the hearing organ. Later in 1860 Toynbee studied 2000 temporal bones and published his findings in the classic work Disease of the Ear. So techniques especially modern techniques of dissection have greatly improved our abilities to study the temporal bone, and among them, Computerized Tomography (CT Scanning) has added to this.

The basic threads of three dimensional (3D) spatial shape research of otology came from Newton. In 1879 he suggested reconstructing the temporal bone using contiguous sheets, but this was not available until 1968, when an English engineer Hounsfield invented the first CT machine. With this technique Harada (1988) made some particular observations of the temporal bone, including the external auditory canal, tympanic membrane, carotid artery, vestibule, labyrinth and internal auditory canal. In 1989, Lutz reconstructed the facial nerve and carotid artery and made a 3-D measurement of anatomical structures. He also discussed the anatomical basis of various otologic diseases. In China, the work of Professor Pu Dai (1991) on temporal bone reconstruction based on extensive anatomic data hasn't only expanded the study but also enriched the knowledge of stereo reconstruction in China.

Computer aided temporal bone reconstruction has become a landmark in Medical studies, while it still has some defects, the images which are created by this technique are only an abstraction of the real anatomic structures, far different to real surgical images. Considering this, Professor Dai has further developed a way to capture and save stereo images. He has combined binocular vision theory, the stereoscope and the operating microscope in an ingenious way. This has provided a much more realistic representation of micro ear surgery.

Y.-s. Song, MD (✉)
Department of Otolarygngology Head and Neck Surgery,
Beijing Friendship Hospital, Capital Medical University,
Beijing 100050, China
e-mail: thinkmed@126.com

S. Gao, MD
Department of Otolaryngology, The 175th Hospital of Chinese
PLA, Zhangzhou 363000, China

P. Dai, MD (✉)
Department of Otolarygngology Head and Neck Surgery,
Chinese PLA General Hospital, Beijing 100853, China
e-mail: daipu301@vip.sina.com

P. Dai et al. (eds.), *Stereo Operative Atlas of Micro Ear Surgery*, DOI 10.1007/978-981-10-2089-6_1

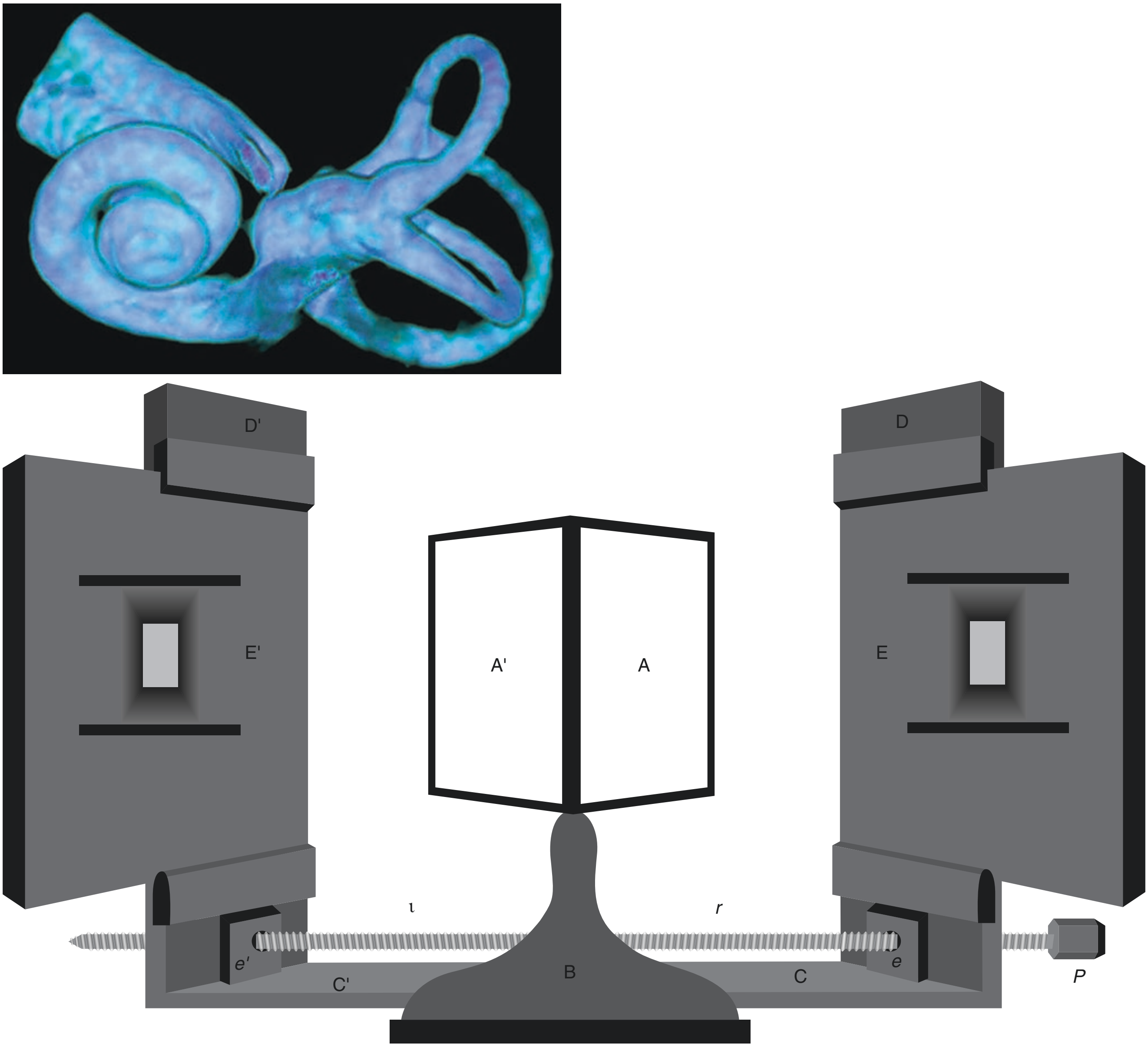

Fig. 1.1 Reconstructed 3D cochlea and reflecting mirror stereoscope
The wheatstone stereoscope (1838): to view images using the stereoscope (Reprint from Volume 68 of the series Intelligent Systems, Control and Automation: Science and Engineering pp 97–130, Springer, 2013)

Stereo Operative Photography of Micro Ear Surgery

Song Gao and Pu Dai

What Is Stereo Images of Micro Ear Surgery and How to Capture Them?

Micro Ear Surgery is routinely performed with the help of the operating microscope which gives true stereo vision through the two eye lens (just like we watch things through our two naked eyes). Traditionally this level of stereo-vision has not been available outside the Operating Room and we have had to bear standard 2D pictures, losing a lot of important spatial information, but now we have used a side-by-side stereoscopic system to address this deficiency. We use two separate Digital Single Lens Reflex (SLR) Cameras attached to an operating microscope to simultaneously capture left and right pictures of the same object as shown in the picture below.

Equipment and Specifications

The following equipment is required to record the ideal paired photographs:

1. Operating microscope with two side ports for attachment of two digital SLR cameras. Each side of the system, including eye-lens and camera, must have the same optical pathway;
2. The two cameras should be controlled by one manual key or pedal so that the left and right photographs are taken simultaneously by two cameras separately;
3. Adequate light: Sufficient light is always very important, especially when you want to capture images of very tiny structures in a very deep situation;
4. Two Hi-Q Digital Single Lens Reflex Cameras, and make sure they share the same settings.

In our department, we use two Canon EOS 5D digital cameras, one Carl Zeiss Pentero microscope with a foot control pedal connecting to it, which is used for image capture. Correct focus is controlled via a video monitor that has the same optical pathway to the right eye-lens.

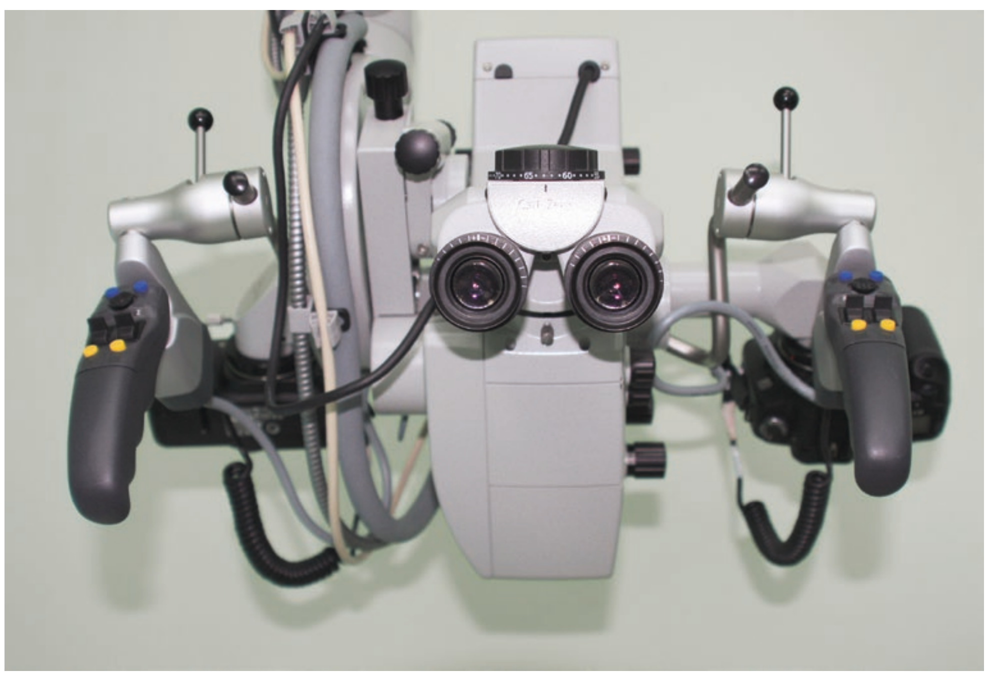

Fig. 1.2 The microscope with stereoscopic photo system