

Global variability in orthopedic surgery training

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Abstract

Medical and orthopedic training varies throughout the world. The pathways to achieve competency in orthopedic surgery in other countries differ greatly from those in the United States. This review summarizes international educational requirements and training pathways involved in the educational development of orthopedic surgeons. Understanding the differences in training around the world offers comparative opportunities which may lead to the improvement in education, training, and competency of individuals providing orthopedic care.

Introduction

Medical and orthopedic surgery training varies throughout the world. This review examines differences in pre-medical, medical, and residency training that providers must undergo in many countries around the world prior to achieving competency as an orthopedic surgeon. The terms “orthopedic surgery”, “medical training,” “education”, and/or “residency” were used along with a selected country’s name to query the PubMed database and articles that focused on training pathways were included. Relevant governmental and organizational websites were also utilized. The training pathways of 11 countries from different parts of the world are described (Figure 1).

The Americas

Canada

Canadian students must complete three or four years of undergraduate education before applying to four-year medical school programs. Upon completion of medical school, certification in orthopedic surgery requires the successful completion of a residency approved by the Royal College of Physicians and Surgeons. Application to residency involves a competitive match process.¹

Classically, orthopedic residency in Canada has had a conventional rotation-based structure that lasts five years.² This training includes 26 months of foundational surgery training as a junior resident and 39 months of training in orthopedic surgical subspecialties. The foundational surgery section includes 6-18 months as a junior resident in orthopedic surgery along with one-month blocks of critical care, trauma, general and/or vascular surgery, and internal medicine. Senior resident orthopedic training includes a requirement for two months of training in a community orthopedic center. More recently, the Department of Orthopaedic Surgery at the University of Toronto has successfully trialed a competency-based curriculum.³ This approach allows for residents to meet defined objectives in a module-based approach with the resident moving forward to the next module after achieving technical and knowledge “competence”. Although resource intensive, this program claims to accelerate the pace of procedure skill acquisition and diminish wasted time. Given the successful results of this program, there will be changes to all orthopedic training programs within Canada with all training sites shifting to this competency-based approach.⁴

Mexico

In Mexico, the educational process begins with medical school, rather than a separate undergraduate degree. Medical school lasts for 6 to 7 years and given the universal healthcare structure, students are required to then work for one year in governmental clinics either in remote or disadvantaged communities. Subsequently, a medical school graduate must take the National Exam of Medical Residencies in order to qualify for a residency in orthopedics. Students who successfully pass the exam can join a four-year residency at any public or private institution. One can complete modules within residency or focus on general training. Advanced subspecialty training can range from three months to two years, though few programs are formalized and subspecialty recognition may not be acknowledged by other teaching hospitals or the federal education institute.⁵

South America

Brazil

Undergraduate medical education in Brazil follows the completion of secondary schooling. Both State and Federal medical schools run similar six-year curriculums beginning with two years of preliminary science and introduction to patient interactions. The third and fourth years consist of

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further specialized education introducing clinical skills and surgical specialties. The final years are considered an internship and entail supervised independence with rotations in five major areas of care; internal medicine, general surgery, pediatrics, obstetrics and gynecology (OB/GYN) and collective health.^{6,7} Education in orthopedics has been criticized as being severely underrepresented within medical school curricula.⁸ As of 2016, evaluation of medical students is carried out through the National Serial Assessment of Medical Students, a series of tests completed every two years of medical school. Successful completion of the third and final exam during year 6 is required for graduation, and exam scores are used in residency selection.⁹

Orthopedics residencies are separate from the general surgery pathway.¹⁰ At the Instituto Nacional de Traumatologia e Ortopedia (INTO), a public teaching hospital that focuses only on trauma and orthopedics in Brazil, residency programs in orthopedics last three years and focus on all subspecialties. There is also a separate residency in hand surgery lasting two years which follows orthopedic or plastic surgery residency training. Following completion of residency, the institute offers fellowship opportunities in craniomaxillofacial, spine, orthopedic oncology, knee, shoulder and elbow, foot and ankle, and hip surgery.¹¹ Required changes to residency programs in all but nine specialties, particularly with

regards to the implementation of compulsory time in Family and Community Medicine programs, are likely to have significant effects on orthopedics training in the near future.¹²

Oceania

Australia

There are two undergraduate medical pathways in the Australian medical system for basic education, with students graduating secondary school and applying into either a five to six-year undergraduate program or completing an undergraduate education before pursuing a masters level degree. Though the latter grants a degree as a doctor of medicine (MD) and is becoming more common, both degrees are equivalent and allow students to apply into prevocational training programs.¹³ These prevocational programs, remnant of British influence, consist of a compulsory intern year.¹⁴ This training includes 10 weeks of medicine, 8 weeks of emergency medical care, 10 weeks of surgery, and 19 weeks of electives. Prospective surgeons, now registrars after finishing internship, apply into competitive Surgical Education and Training (SET) programs at specialist medical colleges accredited by the Australian Medical Council. Specialty training can begin as early as the second year post-graduation, though there is no specific time of entry, and further prevocational training is common to ensure competitiveness for a limited number of vocational posts.¹⁵

Orthopedics is one of nine surgical specialty SET programs. Applications are made through the Australian Orthopaedics Association and applicants undergo semi-structured interviews and critical evaluation. Orthopedics training generally takes 5 years, with potential to complete training in 4 years. Orthopedics registrars complete standardized courses required of all SET participants, including Australian and New Zealand Surgical Skills Education and Training, Critical Literature Evaluation and Research, and Early Management of Severe Trauma. Research projects are required components of SET and specific requirements vary per program. Orthopedics registrars will take both the Clinical Examination and Generic Surgical Science Examination taken by all SET participants, as well as the Orthopedic Principles and Basic Science Examination.¹⁶

Following successful completion of these examinations and required courses, a final Fellowship Examination consisting of written and clinical components is completed for recognition as a specialist. Certified

specialists can begin work in private practice, hold consultant positions at hospitals, or undertake further sub-specialty training either in Australia or abroad.

Europe

Overview

In Europe, the number of medical graduates that pursue specialty training can vary from year to year. In the majority of countries, the number of applicants to orthopedic surgery training programs is often greater than the number of training positions available.¹⁷ More than half of the programs in Europe select their trainees based on results of an interview or an interview and merit, though others rely on national exams or a formal application alone. A majority of residency programs are 6 years and a minority are 5 years in duration. There is no standardization of programs as countries have minimum case requirements ranging from 150 to 1800 and final exams ranging in difficulty and format.¹⁸ The Federation of Orthopaedic Trainees in Europe (FORTE) has been attempting to standardize these training pathways within the 27-member countries. There is no mandatory European-wide licensing examination, though graduates of European residency programs have the option of taking the two-part European Board of Orthopaedics and Traumatology (EBOT) fellowship examination. After training, many graduating orthopedic residents seek employment in other countries within Europe given financial and working environment considerations.¹⁹

United Kingdom

Following completion of an A-level degree, students enter into medical school. Prospective students are evaluated based on academic and extracurricular experience via their application, which includes work history and a personal statement. Scores on three possible tests, the UK Clinical Aptitude Test, the BioMedical Admissions Test, and the Graduate Medical Admissions Test, can also be factored in, depending on the university.²⁰

Education and evaluation models differ between medical schools, with grades reflecting a combination of learning and clinical skills and length of study varying between 4-6 years. During medical school, students complete the Situational Judgement Test, an exam designed to test clinical decision making. Students' scores on the SJT are combined with their medical school performance, educational achievements, additional degrees, and publications, all of which are converted to numerical values to give medical students a score out of 100. With this score as their acceptance criteria, students apply to foundation schools.²¹

The Foundation Programme, which lasts for two years after completion of medical school, is a salaried program required for certification to be a practicing physician. Year one (F1) is designed as a transition from student to physician, and a steady increase in responsibility concludes with registration granted by the General Medical Council. Year 2 (F2) focuses on medical skills and clinical decision making.²²

At this point, interested physicians can choose to specialize. They can also apply



Figure 1. World map highlighting reviewed countries.

for a Locum Appointment for Training, a short-term position focused on specific training that can potentially count as credit towards specialization training. The requirements of postgraduate medical training are coordinated by the General Medical Council, with differing programs working either as “run-through” training, in which there is automatic progression as requirements are met, or “uncoupled” training that requires completion of core training before application again into high specialties.²³

Trauma and Orthopaedic Surgery (T&O) is an uncoupled field that requires two years of Core Surgical Training (CST) to be completed first, a program with a competitive application of its own in the National Selection process. Following completion of a set list of procedures and experiences in CST, surgeons must complete the Membership Examination of the Surgical Royal Colleges of Great Britain and Ireland (MRCs) to finish core training and apply into T&O. Applications are again completed through the National Selection process. A minimum of 10 months of trauma and orthopedic surgery experience during CST is ideal for selection as it reflects evidence of commitment, and courses on fracture management, basic surgical skills, Care of the Critically Ill Surgical Patient (CCrISP), and casting techniques are also encouraged. T&O applicants must have participated in an audit and show clear understanding and potential for research, with actual research accolades and risk management skills encouraged. The application concludes with an interview process to select qualified surgeons.²²

New registrars join T&O rotations with Specialty Training 3 (ST3) designation, reflecting their two previous years of surgical training. They continue to follow the Intercollegiate Surgical Curriculum Programme and maintain all records of training in an electronic logbook. Registrars are assigned supervisors, who are partially responsible for grading their performance along with yearly feedback assessments and examinations.²⁴ Generally during ST7, registrars take and pass the Fellowship of the Royal Colleges of Surgeons Trauma and Orthopaedics Exam, a rigorous two-part examination reflecting mastery of the specialty. The Certificate of Completion of Training (CCT) is given in ST8, allowing qualified surgeons to be registered as licensed specialists by the General Medical Council and certified to practice in the UK. Subspecialty fellowship training is typically gained during ST7 and ST8.¹

Germany

In Germany, medical school begins at the university level. The federal Central Office for Allocation of Places in Higher

Education organizes the competitive application process for medical schools. The students' abitur score, similar to a GPA in the United States, is the primary criteria for admission, with a score on the German Aptitude Test for Medical Studies considered highly as well.²⁵

Following medical education guidelines established by the Regulation of the Licensing of Doctors (AppOÄ), medical schools in Germany have implemented similar standardized tracks, with experimental curriculum models employed at some universities. Medical education is generally six years with the first two focusing on basic science. The first four semesters culminate in the first state examination, which consists of multiple choice and oral evaluations, can be repeated twice, and must be completed for entrance into clinical studies. Students then undertake three years of clinical science learning, which includes mandatory clerkships in internal medicine, general surgery, general practice, pediatrics, and OB/GYN. Four one-month clerkships are also completed, including a clerkship in a family doctor's office and ambulatory care clinic with one often held abroad. This concludes with the second state examination referred to as the Hammerexamen, the “monster exam,” that covers all medical topics. Following clinical sciences, students complete one practical year in which they take on significantly more clinical responsibility, comprised of three 16-week terms in internal medicine, surgery, and an elective subject. The third state examination, an oral exam covering practical year subjects, is then taken. Completion of the licensing exam grants the professional title of Physician (Arzt/Ärztin), while acquisition of the academic title of “Dr. med” requires successful completion of a dissertation, which approximately 70% of all graduates do.²⁶ Specialization to become a certified orthopedic surgeon is a non-university degree and is therefore not run by academic universities. At a minimum, training surgeons will obtain specialist certification in 6 years, but the timeline is not very strict. In general, residents will complete 2 years of common trunk rotations, 1 year of general related rotations, and 3 years of specialized orthopedics rotations. Requirements are not based on time spent training but are instead based on competency.²⁷ Work contracts are not ensured at specific institutions, and residents can be required to move between locations to maintain a job. Residencies do not adhere to standardized guidelines and can suffer from poor organization. Surgeries are rarely performed by junior consultants and trainees.^{28,29} Following accreditation, surgeons are able to apply into more specialized fellowship programs which last two to three years.

Spain

In Spain, students apply for selective medical school positions after completing secondary school. A weighted numerical value factoring in college grade average, general exam scores, and specific scientific exam scores determines edibility for different universities' medical programs.³⁰ Education at the medical school level lasts for six years, beginning with two years of basic sciences followed by a year of specialized medical subjects. The final three years focus primarily on clinical education, with an internship beginning in the third year and lasting the remainder of medical school. Introduction to orthopedics begins with rotations in the fourth year. While medical schools have moved towards more standardized programs directed by the European Union, there is still substantial differences in curriculum design and student evaluation between schools. Following completion of medical school, students are recognized as doctors, but must complete residency to practice medicine.³¹ Application into residency programs is based almost entirely on the Examen Medico Interno Residente (MIR), a national multiple-choice exam taken following completion of the medical degree and prior to choosing a specialty. Prior to student applications, the number of accredited residency posts available in all specialties is reviewed and finalized by the Ministry of Health, a value which has been lower than the amount of medical school acceptances since 2010. Students with the highest exam scores on the MIR are given preference in choosing their specialty and location.³²

Qualified applicants who choose to pursue orthopedics and are accepted into a residency program begin a five-year specialization process. The structure varies between programs, but training generally begins with at least one year of general surgery before moving through different subspecialties of orthopaedics.³³ Training includes mandatory rotations in anesthesia, plastic surgery, and vascular surgery, as well as a rotation in pediatrics. Research is optional, with some programs placing higher value on resident research. There is no required number of surgeries for residents to perform and no mandatory exams during training, with assessment done continuously as well as with annual logbook review and department evaluation.³⁴

Africa

Kenya

With a push towards standardization and with structural input from European

and American medical regulatory bodies, East African nations like Kenya have seen surges of growth in both their medical and orthopedic training programs. Requirements for admission into Kenyan Bachelor of Medicine, Bachelor of Surgery (MBChB) programs are similar to those seen in European medical systems, including a strong Certificate of Secondary Education performance and proficiency in English.³⁵ As of 2018, nine universities in Kenya are accredited by the Kenya Medical Practitioners and Dentists Board to offer MBChB programs, tripling from three programs in 2010.

Though teaching programs and methodologies are constantly developing, the universities follow a similar structure. Undergraduate medical education consists of five years, with the first two years covering general scientific subjects such as anatomy, biochemistry, microbiology, and pharmacology. Years three to five focus on different specialties, including internal medicine, radiology, surgery, ophthalmology, and forensic medicine. At the University of Nairobi, orthopedic surgery is taught as part of years three and five.³⁶ Grading varies between universities, though written, oral, practical, and clinical examinations are all implemented.

Following certified completion of an undergraduate medical education, students undertake an internship year consisting of three-month rotations in medicine, surgery (including 6 weeks of orthopedics and trauma), pediatrics, and OB/GYN. During this time, physicians take on significant responsibility, and gain exposure to potential subspecialties. Registration as a practicing physician through the Medical Practitioners and Dentists Board is completed at the conclusion of the internship year.

Postgraduate education in a chosen specialty is completed through master's degrees at supporting universities. To combat the deficit of orthopedic surgeons in Kenya, The University of Nairobi and Moi University have recently developed Masters of Medicine (M.Med) in Orthopedics degrees. The degree takes a minimum of three years, and consists of course work, clinical practice, and a research project. Grading is done with a combination of written papers, oral presentations, two major examinations, and continuous clinical assessment, which includes seminars and clinical encounters recorded in a logbook. Courses begin with a general surgery focus, including surgical anatomy and surgical pathology, before progressing to general orthopedics and orthopedic subspecialties by the third year. A research dissertation is compulsory.³⁷

Asia

China

Due to ongoing reform in the Chinese medical education system, changes in how students train to become orthopedic surgeons are currently underway.³⁸ Obtaining a Chinese medical degree can be accomplished through a significantly wider array of pathways than is seen in Western counterparts; all pathways generally begin with completion of the National Higher Education Entrance Examination at the conclusion of senior year of high school. At the university level, the most common pathway is a 5-year medical school curriculum, though there also exists a more intensive 8-year track, with greater focus on research and clinical applications, that will grant a Doctorate of Clinical Medicine degree.³⁹ The first half of the five-year pathway focuses on general education and basic science, followed by 1.5 years of clinical rotations in major medical specialties. In the final year, medical students complete four-month rotations in internal medicine and surgery (which includes orthopedic surgery), single month rotations in OB/GYN and pediatrics, and a flexible two-month rotation. Completion awards one of a variety of bachelors in medicine degrees.⁴⁰

Graduates undertake a postgraduate year of clinical work concluding in the National Medical Licensing Exam, consisting of both written and clinical skills components. Successful completion allows for physicians to pursue specialization. No standardized training protocol exists for orthopedics residents, and requirements vary substantially between hospitals.⁴¹ Generally, licensed physicians interested pursuing orthopedic surgery will complete 5 years of a clinical residency, beginning with three years of surgical education followed by two years of orthopedic rotations. No standardized list of procedures or compulsory exams exist, with programs following general guidelines intended to promote a wide range of experiences. Advanced academic degrees can also be obtained in conjunction with residency programs, generally requiring additional research years and publication in English language journals.⁴²

India

At the conclusion of secondary education, students interested in medicine take the National Eligibility-cum-Entrance Test (NEET), a controversial exam that provides the sole admissions criteria for acceptance into most medical college programs. High fees associated with attendance at private schools often deters many students.⁴³

There is variability between Indian medical colleges, but many follow a similar

4.5-year Bachelor of Medicine and Bachelor of Surgery (MBBS) program outlined by the Medical Council of India. Year one focuses on basic scientific foundations such as anatomy and physiology, before transitioning to more clinical subjects such as community medicine, pathology, and microbiology in the subsequent three semesters. During this "para-clinical" phase, students begin gathering clinical experience in wards. In the final two years, students are educated on a wide range of medical and surgical specialties, such as psychiatry, dermatology, ophthalmology, and orthopaedics.⁴⁴ Research is not a primary component of the medical education, and is often disregarded completely due to the intensity of coursework.⁴⁵ Ongoing revisions to this curriculum are intended to address the immense amount of specialty material covered during the 4.5 years, which has been viewed as excessive and better covered once physicians chose to specialize.

Following sufficient completion of core medical training, students enter into a 1-year Compulsory Rotating Residential Internship focusing on the implementation of clinical skills. Rotations include 2 months in each of community medicine, general medicine, surgery, and OB/GYN, 1 month of pediatrics and orthopedics, and brief time with ENT, ophthalmology, and casualty. Assessment is a combination of log book completion and physician grading, and while rotations are generally done at the student's enrolled institution, away rotations are not uncommon.

The most common pathway towards specialization in orthopedics is the acquisition of a Master of Surgery (MS) degree through university-affiliated institutions. Entrance examination scores are the primary determinants for admission, and there are few positions available.⁴⁶ The postgraduate curriculum for orthopedics specialization is standardized by the Medical Council of India. Surgeons are required to demonstrate proficiency in performing a wide range of orthopedic procedures throughout the three years, though the exact structure or specific volume of surgeries are not universally mandated. Evaluation is a combination of formative assessment by teaching physicians and summative assessments at the conclusion of the training, including a final exam, a postgraduate research thesis, theory papers, a clinical examination, and an oral examination. After acquisition of the MS degree, surgeons are licensed specialists capable of practicing as independent orthopedic surgeons. Further training in the form of a senior residency can be completed after MS education, which entails a full faculty position requiring another competitive round of interviews to obtain. Senior resi-

dencies are less standardized, generally last three years depending on the institution, and give the surgeon greater freedom in managing their own clinic. To help meet demand, Diploma in Orthopedic Surgery programs have been developed by the Medical Council of India, providing an alternative 2-year program in basic training with the option for further development. Similarly, Diplomate of National Board in Orthopedics programs have also risen in popularity, functioning as a comparable 3-year program through non-university hospitals likewise recognized by the Medical Council of India. Advanced fellowship training often lasts 2 years and is limited in enrollment.⁴⁷

Thailand

With completion of secondary school, students are able to apply into medical schools. A majority of Thai medical schools share standardized admission criteria, which includes a written aptitude test, an evaluation of the student's record, personality test, an interview, and a physical examination. The standard track is a six-year program consisting of three preclinical years followed by three clinical years, though alternative tracks such as MD/PhD programs are both available and popular. Clinical years consist of rotations in major clinical fields, with a majority of time spent in medicine (28 weeks) and Surgery & Orthopedics (20-25 weeks).⁴⁸ Successful completion of clinical rotations awards the medical student an MD degree. New doctors who qualify with clean legal and mental health records must complete the three-part National Medical License Examination of Thailand conducted by the Center for Medical Competency Assessment and Accreditation in order to be fully licensed. This exam consists of a basic medical science multiple choice component, a clinical science multiple choice component, and a test of clinical skills. Licensure is granted by the Medical Council of Thailand (MCT).⁴⁹

Following licensure, medical school graduates work a required three years for the Thai government as primary care physicians, starting under senior mentors in rural hospitals. This program, coordinated by the Ministry of Public Health, was implemented in 1972 to encourage expansion of rural health, and can be waived for a fee.⁵⁰ Physicians are then able to continue practicing rural medicine, transition to a private practice, or go on to specialize. Specialist applicants rank residency programs based on interest through the MCT and are ideally paired to the top program that accepted them in the first round of applications. The second round then matches otherwise unmatched residents to remaining pro-

grams.⁵¹ Orthopedics residencies are four-year programs, beginning with one year of general surgical training. Residents are expected to obtain a range of orthopedic experience, with a predominant focus on trauma, practice in a rural area for one year, and complete a minimum of one research project. The Royal College of Orthopaedic Surgeons oversees residency requirements, as well as final board examinations.⁵²

Conclusions

There is a litany of training pathways for orthopedic surgeons across the globe. Most begin with undergraduate medical education and have components of basic science and clinical exposure. Licensing examinations are varied and many countries have state-regulated requirements for the treatment of underserved populations as a part of or following training. Sub-specialization is not as common outside of the United States and other Western countries.

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