Improvement of Orthopedic Residency Programs and Diversity

Abstract

Purpose: To date, little has been published comparing the structure and requirements of orthopedic training programs across multiple countries. The goal of this study was to summarize and compare the characteristics of orthopedic training programs in the U.S.A., U.K., Canada, Australia, Germany, India, China, Saudi Arabia, Russia and Iran.

Methods: We communicated with responders using a predetermined questionnaire regarding the national orthopedic training program requirements in each respondent's home country. Specific items of interest included the following: the structure of the residency program, the time required to become an orthopedic surgeon, whether there is a log book, whether there is a final examination prior to becoming an orthopedic surgeon, the type and extent of faculty supervision, and the nature of national in-training written exams and assessment methods. Questionnaire data were augmented by reviewing each country's publicly accessible residency training documents that are available on the web and visiting the official website of the main orthopedic association of each country.

Results: The syllabi consist of three elements: applied clinical knowledge, applied clinical skills, and professional and management skills. The application of simulation techniques for both teaching and assessment are fundamental to modern surgical education. The skill of today's trainees predicts the quality of future orthopedic surgeons. The European Board of Orthopaedics and Traumatology (EBOT) exam throughout the European Union countries should function as the European board examination in orthopedics. We must standardize many educational procedures worldwide in the same way we standardized patient safety.

Conclusions: Considering the world's cultural and political diversity, the world is nearly unified in regards to orthopedics. The procedures (structure of the residency programs, duration of the residency programs, selection procedures, using a log book, continuous assessment and final examination) must be standardized worldwide, as implemented for patient safety. To achieve this goal, we must access and evaluate more information on the residency programs in different countries and their needs by questioning them regarding what they need and what we can do for them to make a difference.

Key words: Residency Programs, Educational Procedures, Cultural Competences, Women in Orthopedics, Politics

Level of evidence III

Introduction

Little is currently known regarding the similarities and differences between orthopedic and trauma training programs throughout the world. The formation of several institutions, such as the European Federation of the National Associations of Orthopaedics and Traumatology (EFORT) and The European Union of Medical Specialists (UEMS), was necessary to begin organizing and evaluating the level of orthopedic education in Europe. As another section of the UEMS, the European Board of Orthopaedics and Traumatology (EBOT) was established in 1994. Its first achievement was to organize a board examination. The EBOT fellowship examination has been designed to standardize and improve the standard of orthopedic training in Europe [1]. Unfortunately, the EBOT currently remains an optional exam.

However, the European countries are united today, and orthopedic education seems to be a driver in these countries. In 2017, Madanat et al compared the differences between the current European orthopedic and trauma residency programs for the first time. The 4 most important topics included the residency duration, the selection procedures, the utilization of log books, and whether there was a final examination. In general, residency was completed in five to six years in all included countries. Nearly all countries used a logbook. Approximately 80% of the participating countries had a final examination. The authors concluded that there are many similarities between the training programs; however, important differences continue to exist in their general requirements and final qualification [2]. Ultimately, this was the first study that collected essential information regarding the differences between orthopedic training programs across Europe [2]. In particular, in the field of orthopedics and trauma, the coordination of knowledge and practical skills is important [3]. This study indicated that a larger portion of female residents than specialists implies a future shift in gender parity. This finding is inspiring, as orthopedic surgery has the lowest percentage of female residents of any surgical specialty [4].

Orthopedics is the medical subspecialty that most closely reflects world politics and social culture. This paper will open a new frontier to understanding our globalized world, highlighting the importance of not only the level of our surgical know-how and precision but also our minds, where we can provide and serve more than at any time previously. To date, little has been published comparing the structure and requirements of orthopedic training programs across multiple countries. The goal of this study was to summarize and compare the characteristics of orthopedic training programs in the U.S.A., U.K., Canada, Australia, Germany, India, China, Saudi Arabia, Russia and Iran.

Methods

We collected all important information regarding residency programs in 10 countries on four continents. We communicated with responders using a predetermined questionnaire regarding the national orthopedic training program requirements in each respondent's home country. Specific items of interest included the following: the structure of the residency program, the time required to become an orthopedic surgeon, whether there is a log book (where the

operations performed by residents are listed), whether there is a final examination prior to becoming an orthopedic surgeon that is applied, the type and extent of faculty supervision, and the nature of national in-training written exams and assessment methods. Questionnaire data were augmented by reviewing each country's publicly accessible residency training documents that are available on the web and visiting the official website of the main orthopedic association of each country. Compared to other developed countries, Germany lagged behind. We therefore sent out an additional questionnaire via e-mail to 40 German orthopedic chiefs in German and received 15 responses.

Results

The results will be presented by country with specific comments. The information regarding the structure of the residency programs is presented in Table 1.

United Kingdom: Since August 2007, Modernising Medical Careers (MMC) reorganized junior doctor training in the U.K. The shortest length of time required from basic medical qualification to becoming an orthopedic consultant in the U.K. system is theoretically approximately 10 years. After the successful completion of the (foundation year) FY1 and FY2 years, the trainee is required to compete for Specialty Training (ST) positions, which take approximately 8 years. The ST years are presently divided into three phases. The first phase lasts for 2 years (ST1 and ST2) and consists of 4- or 6-month rotations in surgical specialties. The goal of this program is for the Royal College of Surgeons' entrance examinations to be completed within this time-frame. Important fields for trainees include plastic surgery, neurosurgery and cardiothoracic surgery. ST and FTSTA (a training post for a fixed term of not more than 2 years) trainees are evaluated with a standardized Annual Review of Competence Progression (ARCP). This evaluation is performed on a 6- to 12-month basis by consultant trainers. The annual evaluation is the regional in-training assessment (RITA), which compares the yearly research performance and logbook records. All candidates must present their map of the previous work, their procedure-based evaluations, and their learning objectives for the expected period [5].

Australia: The orthopedic training system in Australia is markedly similar to that in the U.K. The ratio of orthopedic surgeons to the general population varies from 1 in 16,400 in Adelaide to 1 in 133,200 in South Australia. After graduating from medical school, the trainee must complete at least 3 years of work in a specialty, first as an intern and then as a resident. The first part of the Fellow of the Royal Australian College of Surgeons (FRACS) examination must be completed within this period of time. After passing this exam, the trainee is subsequently qualified to apply for an accredited training position in orthopedics. Throughout surgical training, the main focus is on the management of trauma. Once the position of registrar is attained, the candidate is able to train in a chosen program over 4 years. In the first year of training, the Orthopaedic Principles and Basic Science (OPBS) examination is administered. In the fourth year of accredited training, the final fellowship specialty examination is completed, which has a pass-rate of greater than 90%. The shortest time possible from graduation to the completion of training is therefore 7 years. As in the U.K., a bottle-neck occurs during the transition to an accredited registrar. The trainee may

have to spend 2 or more years in the orthopedic service position prior to gaining a place in the accredited registrar program [5].

Canada: The Canadian resident must complete 2 postgraduate internship years. The Orthopaedic Residency Training Program in Canada typically comprises 5 years of postgraduate clinical training and 1 year of research training. The 5 years of clinical training contain a minimum of 3 years in orthopedics and 1 year in non-specialty training. In contrast to the U.K., Canadian orthopedic residency training programs are financed by universities. The research year may be performed at any stage. There are two key examinations completed during the residency years. The first examination is a Principles of Surgery examination that is completed at the end of the second year of training. The final examination (the Comprehensive Objective Examination in Orthopaedics) is a combined written and oral exam that is completed at the end of the fifth year. Once trainees have successfully passed the fellowship examinations of the Royal College of Surgeons of Canada, they are qualified for a license to practice [5].

United States of America: The orthopedic residency program takes 5 years. Initial resident training (the PGY1 or 'internship') includes experiences in general surgery, plastic surgery, emergency medicine, the intensive care unit and anesthesia, among others. From PGY2 on, trainees are overseen by the chief (PGY5) resident. This training mainly involves practical experience in the emergency room and the operating theater. The chief resident is able to provide patient care with only slight supervision from the director. The Residents are subject to continuous in-training evaluations. Every November, the Orthopaedic In-Training Exam (OITE, compared and audited nationally) must be completed by all residents. Most residents pursue a year of research. Following the completion of an accredited residency, the candidate can complete a fellowship. Following the completion of an accredited residency, the candidate prepares for the Part 1 board examination, which is only in written form. After practicing for 22 months, they can apply for the Part 2 examination. Part 2 consists of an oral examination, and candidates must submit a log book that includes all surgical procedures performed during a defined 6-month period. Although board certification is completely voluntary, 98% of all candidates take the Part 2 examination within 5 years of completing residency. Teaching and academic appointments are pursued by 42% of orthopedic surgeons [5].

The Current Status of Assessment in England and the U.S.A.

The syllabi consist of 3 elements: applied clinical knowledge, applied clinical skills, and professionalism and management [6]. In the United Kingdom, understanding the principles of fracture management is mandatory for entering specialist training. Typically, this is through the AO Principles of Fracture Management program, which in the United Kingdom integrates some of the Intercollegiate Surgical Curriculum Program (ISCP) workplace-based assessments, including procedure-based assessments (PBAs) and case based discussions (CBDs) [7]. An orthopedic resident must learn how to develop a proper surgical plan and how to choose the surgical approach, implant and fixation method [8]. In addition to informal feedback from superiors, clinical evaluations include the In-Training Evaluation Report (ITER), procedure logs, and 360° evaluations [9-11].

Although the ITER is one of the more commonly used tools in North America, it has been shown to be ineffective at selecting between different levels of performance or in recognizing

trainees who are not suitable [12]. The value of other tools, including 360° evaluations and log books, is also uncertain [10,11,13]. The most frequently applied examination to evaluate resident knowledge in North America is the OITE, administered by the AAOS [14]. This examination is completed annually by all orthopedic residents and covers twelve categories, the largest of which is musculoskeletal trauma [14,15]. It has been suggested that the OITE could function as a yearly guide for educational superiors to determine what topics should be mastered by trainee orthopedic surgeons [16] and that it may be used to compare residents academically [15]. However, it has been shown that although the OITE performance correlates with scores on Part 1 of the American Board of Orthopaedic Surgery (ABOS) examination, it does not necessarily correlate with the resident's overall subjective clinical and surgical performance [16]. Furthermore, the OITE does not address hands-on surgical skills. In the United Kingdom, an annual online in-training exam (UKITE) is part of the training and provides an opportunity to create a "benchmark" for both trainees and training programs. The United Kingdom also has an obligatory exit examination with both a written component and an oral component that includes patients, and it is completed toward the end of training [17].

As training trends toward a competency-based framework, it is feasible that trainees will benefit from both simulation-based and clinical assessments. This combination is important because although simulation-based techniques have strengths, there are concerns regarding the "transferability of skills learned in the simulated setting to the real world" [18]. The application of simulation techniques to both teaching and assessment are fundamental to modern surgical education. They provide opportunities for risk-free practice, and their use has been shown to be helpful in evaluating, preserving and increasing the skills that have been learned, including non-technical skills [19,20].

Germany: One hundred years ago, the field of surgery was conquered worldwide by innovative German surgeons, such as Theodor Billroth (1829–1894), Ernst Ferdinand Sauerbruch (1875–1951) and Gerhard Küntscher (1900–1972). However, in 2018, there is a clear contrast between Germany and the U.S.A. or England in regard to the education of future orthopedic surgeons. In the U.S.A. and England, a dynamic education system directs innovation and fosters a new perspective in continued education, whereas in Germany, the training system is deteriorating because of a lack of change and innovation. The U.S. and English residency programs have a distinct duration, "Bundes Ärztekammer" the German Medical Association, i.e., by 17 State Medical Councils "Landesärztekammern", defines a minimum duration of training, whose key criterion is to have performed a minimum number of operative and non-operative procedures that may practically be performed in a set time window, which definitely takes longer than the minimum limit set by the Bundes Ärztekammer. Most often, the residents have their cases confirmed by their chiefs once 6 years have passed. If, in contrast, a chief solely confirms the cases that were performed by the residents, the residents must attend their program beyond 6 years. In contrast to the average U.S. resident, who performs 1,572 procedures during their 5 years of residency, the German resident performs 730 operative and non-operative procedures [21,22].

In Germany they have a probation period of 6 months, during which the education may be terminated. Administrators who are not doctors may terminate the contract. Working under employment contracts for short periods of time makes residents ordinary individuals. It is a very important issue. If the system does not adequately care about the residents, who will be tomorrow's surgeons, the lack of a guaranteed complete residency contract is a poor foundation for a good residency program and permits additional stress from the

administration, which is not a factor that nurtures one's strengths. "The German system therefore lacks a solid foundation for effective training at a particular institution" [23]. This is in contrast to most other countries, where residents work under a guaranteed contract for the full duration of their residency at a particular institution, which enables them to focus entirely on their clinical training.

In Germany, residents must frequently perform activities that are delegated in the U.S.A. to physician assistants. U.S. residency programs are examined every 3–5 years, updated and upgraded following standardized complete reviews by a national, specialty-specific, Resident Review Committee (RRC). Programs with deficits are placed on probation. If advances are not made within a certain period of time, the programs are closed. This is an important contrast to the average German residency program, which unfortunately "lacks a standardized, periodical quality assessment of residency training" [23].

Flierl [23] noted that U.S. residency programs create a highly structured, progressive and innovative educational system. The surgical caseload for U.S. residents has more than doubled, over a shorter time-period of training, compared with that in Germany. Residents also have a higher level of supervision by senior surgeons. In a questionnaire distributed by the German surgeon association, 61% of the 500 interviewed residents were unsatisfied with their superiors' teaching and education, and 33% had meetings on a regular basis with their superiors. Sixty-one percent received no financial aid to educate themselves, and 36% attended education classes during their holidays [24]. Internet-based interviews of 730 orthopedic residents by the DGOU (German Association of Orthopedics and Trauma surgeons) that ran from 10.09.2011 to 31.03.2012 noted that 80% of residents would choose orthopedics again, whereas 73% of famulus (medical student) accompanying orthopedic residents and 53% of students around their family and related individuals would not choose orthopedics as a residency program [25]. Eighty percent of orthopedic residents learn from simulation-based assessment techniques, and the majority wish to have the AO Part I and II courses, an advanced trauma life support (ATLS) class and a sonography class as an integrated part of their education [26]. For example, having a shoulder arthroscopy simulator is a good way to be prepared for shoulder arthroscopy [27].

To obtain direct input, we distributed an electronic questionnaire to 40 chiefs of orthopedics and trauma in Germany and, in some cases, included a personal interview to shed additional light on what could be improved to have the same level of residency education in Germany as is available in Canada or the U.S.A. All chiefs recognized the need for a change. They must try to set up a way for residents to evaluate their programs and make these results publicly available. In this way, only good organized surgical programs will be able to offer doctors a residency position in the future, and clinics that do not provide a high-quality, resident-oriented program must be closed for the purpose of resident's education. Training should only be performed at accredited training institutes. Most chiefs agree that the German log book cannot be fulfilled within 6 years. Thus, the log book requirement should be shortened to include all possible options suggested, or the hospital chiefs should make their surgical case data public so that all log books could be checked for accuracy. We also strongly highlight the importance of having residents not work under an ordinary working contract; instead, a full-time contract at a well-organized hospital for the full duration of the residency is recommended. Trainees must be regularly evaluated during each rotation. Resident evaluation is the responsibility of the attending physician, who records the level achieved by the trainee according to a specific scale provided on the resident evaluation form. Residents should be provided with the opportunity to evaluate faculty members. The Ärztekammer must directly regulate and monitor residency programs.

Unfortunately, in Germany, there are currently approximately 17 Ärztekammer, which regulate the Länder (States) separately. We are positive that the use of a central monitoring system, such as the RRC, will permit both the better monitoring of orthopedic residency programs and their improvement. Programs with deficits must be placed on probation. Training should be performed solely at accredited training institutes.
We emphasize that in Germany, there must be a bonus program for clinics that take care of their residents by means of teaching through a DRG-System (coding the cost system), i.e., the clinic must be paid for having a good residency program.

Saudi Arabia: The Saudi Commission for Health Specialties (SCFHS) is the authorized administrative organization that accredits local training institutions and controls the qualification of residents and doctors in Saudi Arabia. It directly manages post-graduate local training in various medical fields. Orthopedic surgery training is the responsibility of the Saudi Orthopedic Residency Program, which is, in turn, supervised by the SCFHS. The Saudi Orthopedic Residency Program has divisions in the major Saudi cities, and training is only performed at accredited training institutes. The minimum orthopedic training duration is five years, and trainees are frequently assessed during each rotation. Resident evaluations are the responsibility of the attending physician who records the level achieved by the trainee, which is based on a specific scale on the resident evaluation form. The resident evaluation form tests 4 main training domains: knowledge, clinical skills, operative skills, and personality and ethics. Residents must pass a mandatory examination at the end of each training year to be permitted to advance to the next level of training. After the fifth training year is completed, the trainee becomes board qualified. Candidates who pass the theoretical and clinical sections of the final exam are qualified by the Saudi Board of Orthopedic Surgery (SBOrth).

The Saudi Orthopedic Residency Program steps toward leadership in the Middle East [28].
In 2014, Al-Ahaideb et al. compared the orthopedic residency training program in Saudi Arabia with a selected Canadian residency program. The study indicated that the Canadian and Saudi samples had comparable male-to-female ratios, and both sets of participants had an even experience distribution. Together, the Saudi and Canadian responses confirmed that textbooks were their main source of specialty information, followed by peer-reviewed scholarly articles and, finally, scientific discussion among staff. However, Canadian-trained residents tended to read scholarly articles more frequently (46.7%) than their Saudi-trained colleagues (10.5%) (P=0.002). Canadian and Saudi trainees experienced their greatest surgical exposure in the trauma field. The assignment of a specific mentor for trauma rounds was highly rated by most trainees, rather than increasing their frequency or duration. Residents in Canada and Saudi Arabia reported less surgical training in upper extremity and arthroplasty surgery, respectively. In the Saudi program, residents were not provided with the opportunity to assess faculty members. Furthermore, Saudi board-eligible trainees had less self-confidence in the performance of standard orthopedic operations without supervision, which suggests that their surgical exposure was insufficient. The authors concluded that the surgical logbook should be reformulated in a way that confirms that each resident had sufficient surgical training in basic orthopedic procedures [29,30].

Russia: In Russia, the density of orthopedic surgeons is approximately 9.2 per 100,000 citizens; approximately 1% are females, and they work mostly at outpatient clinics. Officially, residency programs in Russia require only 2 years of training; however, most residents pursue postgraduate study for 3 years, which includes research. Candidate selection varies between

hospitals and is based on an interview. Each resident maintains a daily diary, recording all operations and manipulations wherein he/she is involved. At the end of each week, the chief resident verifies and approves the log entries. Residency training programs are structured according to the ordinance program software, which delivers 120 credit units of training materials over 2 years. Following the completion of residency programs according to the curriculum established by this software, the graduates gain proficiency in universal and professional competencies. Following the completion of training, an orthopedic specialist should master the following topics:

a) Anatomy and function of the musculoskeletal system in normal and various pathologic states, the algorithm used for patient examination, the major pathological symptoms and consequences of injuries and diseases, and the primary treatment and rehabilitation measures for these injuries and diseases.
b) Ability to organize specialized medical care for patients, obtain and analyze clinical and laboratory data, and diagnose and perform basic medical procedures.
c) Comprehensive examination and primary care methodology, primary methods of conservative and surgical treatments, ability to appropriately perform anti-shock measures and identify life-threatening disorders, and ability to apply relevant rehabilitation measures.

Evaluation tools have been created to monitor academic performance and intermediate certification that include mandatory course requirements and surgical procedures and hospital-based research that varies between programs. Residents undergo intermediate certification that is held twice during the training period. Final certification is a summative evaluation of a mandatory, 3-part, final examination, which comprises a written test, oral interviews, and evaluation of practical skills using simulations.

Degree programs that include research enable doctors to expedite the process for achieving the next level of expertise. Orthopedic surgeons of the highest category must possess knowledge regarding all modern technologies, including endoscopy, osteosynthesis, and endoprosthetic devices. In the future, it is necessary to increase the residency duration to 5 years with expanded simulation-based training and improved education in foreign languages. Many orthopedists working in Russia belong to countries of the former Union of Soviet Socialist Republics (Belarus, Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan, and Ukraine); doctors from Africa and the Middle East have also pursued specialized education in Russia.

Developing countries: More than 80% of the world's population and an enormous reservoir of orthopedic pathologies are present in developing countries. More than 80% of all deaths in these nations are the result of road traffic accidents, and more than 90% of those that involve children occur in developing countries [31].

In Malawi, only four orthopedic surgeons care for a population of 12 million individuals. Most of the 25 district hospitals have only one Senior House Officer physician and no specialists. Developing countries have three options available for training orthopedic surgeons. A country may attempt to conduct all training within its own borders. For larger countries with established medical structures, such as Nigeria and Uganda, this is reasonable. They have well-run postgraduate programs in orthopedic surgery. In smaller countries with less advanced services and very few qualified trainers, the extent of their training is limited. The second option is to address this problem through a regional rather than national approach.

The third option is to send trainees to more developed countries for all of their instruction. Historically, this approach was the only option for many developing countries. Although this training is typically of a high standard, there are several disadvantages to this solution: the

pathology in more developed countries is different, and some trainees who complete all of their postgraduate training in developed countries do not return home. There are benefits to spending a short period in a developed country, typically at the end of national or regional training. This should be for one year with a focus on a particular field, such as joint replacement or spine surgery. When possible, these visits should be organized as a formal exchange between trainees from developed and developing countries [32].

India: The first 4 and a half years of medical school are dedicated to basic medical training. Once completed, students earn a Bachelor of Medicine and Bachelor of Surgery (MBBS) degree. Following the completion of basic medical training, students enter a 1-year Obligatory Rotating Residential Internship (CRRI). This program is similar to a rotating or transitional internship. Following the successful completion of the CRRI, medical students receive medical college diplomas. To apply for residency specialty training, MBBS graduates must pass a national and/or state-level "postgraduate entrance exam", a written exam that is the deciding factor for placement in postgraduate training. According to the Medical Council of India, there are 225 MS(Orth) training programs available to resident physicians. There is a 3-year residency program, after which a doctor earns the right to proclaim himself/herself to be an orthopedic surgeon. After graduating from medical college, an entrance examination is administered, and students are subsequently allotted seats in colleges based on these results [33-40].

This 3-year program is an academic and clinical education program. The residency program is always attached to a teaching hospital. These may be funded privately or by the government. In the first year, the resident is introduced to inpatient work, history taking, clinical examinations, differential diagnoses and the basics of how to prepare a patient for treatment, whether surgical or conservative. He/she is attached to a unit that has specific trauma call days, outpatient clinics and operative theater days. They work under the constant supervision of their senior residents and a consultant. The consultant is in charge of their training and supervises the dissertation work of the resident. The residents also take undergraduate level classes. Over the course of the next two years, the residents learn to operate under strict supervision. Basic training in India involves the treatment of trauma and fractures. Specialized clinics or sub-specialties are present in only a few hospitals. Following the completion of the three-year residency, the resident must clear a theoretical and practical examination, after which he/she will receive a post-graduate degree (M.S., Masters in Surgery-Orthopedics, or a D.N.D., Diplomate of the National Board in Orthopaedics).

There is a shorter 2-year program referred to as the Diploma in Orthopaedics, where no dissertation is presented. Following the completion of residency, a young orthopedic surgeon has an opportunity to join a 3-year senior residency program in a government-funded or private hospital. They are always attached to a senior consultant.

In a government hospital, there is always a shortage of doctors and beds; however, the clinical experience is so vast because of the inflow of patients that in this three-year period, he/she will likely be exposed to nearly all orthopedic conditions. They will also have honed their surgical skills. This vast clinical experience comes at a cost, as the resident's duty hours are very tiring, sometimes stretching to 36 hours at a time. In a private hospital, it is rare that a resident is allowed to operate because the treating consultant is responsible for the surgery and cannot afford slipups. Residents who do not opt to join a hospital for their senior residency start their private practice or join a government hospital to begin their career.

Fellowship programs have started over the past few years and range from 3 months to 1 year in duration. These fellowships are offered in all sub-specialties of orthopedics. Three years after completing medical school, one can become an orthopedic surgeon. There are 70 female orthopedic surgeons in India. Women are involved in most orthopedic specialties, such as general orthopedics, hand surgery, arthroscopy, pediatric orthopedics and spine surgery. Improvements for the next generation of Indian residents would be to lengthen the orthopedic residency to a minimum of 6 years, with the last two years dedicated to the sub-specialty training of their choice. The last year should be a sub-specialty year; however, trauma on-call duties should also continue. This will ensure that the entry of the surgeon into practice makes his/her skills more robust. With most hospitals accredited by the National Accreditation Board for Hospitals and Healthcare Providers (NABH), patient safety practices are diligently followed and are a prerogative of both healthcare employers and providers. Furthermore, non-Indian doctors from neighboring countries, such as Nepal and Bangladesh, are enrolled in residency programs following inter-governmental agreements. They are supposed to travel back to their respective countries to practice following the completion of their training. Cooperation with the Western world will help Indian residents broaden their horizons and bring the best practice guidelines to the forefront of patient care.

Iran: The orthopedic surgeon density (number of surgeons per 100.000 population) in Iran is approximately 5 per 100.000. The selection of candidates is based solely on the outcome of the national exam, which is a multiple-choice questionnaire. This exam is held one time each year by the ministry of health; thus, it is a central selection system. Residents select their desired residency program based on their interests and their exam score. The duration of an orthopedic surgery residency program is 4 years. The program typically covers all aspects of orthopedic surgery, and residents have the option to rotate through different specialty services. They must also perform research activities and contribute to the education of interns and students. The residents participate in all activities (ward, outpatient clinic, operating room, emergency room and on-call services), educate students and perform research. There is also a log book, which will soon be transferred from paper to an electronic log. A rotation through sub-specialties, such as hand surgery, foot surgery, sports, joint replacement, rehabilitation, and pediatrics, is required.

There is a final exam (oral, written and an objective structured clinical examination, OSCE). All residency programs originally required an oral OSCE and 360° resident evaluation. If the residents obtained high scores, they became eligible to participate in an annual promotion exam. If they received an appropriate score on this test, they could advance to the next year of residency. In Iran, it requires a minimum of 4 years to become an orthopedic surgeon. The board exam also consists of a 150-question multiple-choice written exam and an oral OSCE exam. Once these tests are passed, the resident may be board-certified. Orthopedics has the lowest percentage of female residents compared to other sub-specialties. Although it is a male-dominated specialty, the number of female orthopedists is increasing, and they are very successful. Female orthopedists are most commonly involved in hand surgery or pediatrics. The most important improvement for the next generation of residents in Iran must involve the improvement of the selection criteria for their residency programs. The length of their residency should also increase to 5 years. In Iran, patient safety is important to daily practices. It is mandatory for every hospital to observe patient safety protocols, and it is monitored by the ministry of health. Non-Iranian doctors from Sudan and India are also enrolled in Iranian residency programs.

China: China is the second largest economy in the world and advanced from a gross domestic product in 1980 of < U.S. $200 billion to U.S. $5 trillion in 2010 [41].

Depending on the local geography, orthopedic specialist training in China is very diverse. An orthopedic candidate may have completed five years of basic medical school education, which increases to seven years with a postgraduate MPhil or eight years with a postgraduate PhD.

Graduate studies are clinically orientated and primarily occur at the hospital, with different degrees of emphasis on laboratory work. Teaching is often didactic in mainland China, whereas interactive discussions and tutorials are less common.

Three years of basic surgical training with rotations through different surgical and related specialties are required. This is followed by two years of general orthopedic training (the 'three-plus-two' training system).

To date (2011), there is no orthopedic sub-specialty training in China, with the exception in hospitals such as the Beijing Jishuitan Hospital. The orthopedic profession in China acknowledges the need to develop a training system that considers the diversities of a large country.

There are approximately 50.000 doctors who practice orthopedic surgery in China [42]. The standardization of residency training programs has been a topic of national conversation in China for decades, and the Chinese Medical Association under the commission of the Ministry of Health released mandatory residency training standards in 2012 [43]. The training standards were divided into four sections for each specialty: training objectives, rotation length requirements, training content, and reference material. At the end of 2014, 8.500 residency programs had been established in 559 hospitals, enrolling 55.000 resident physicians [44]. In 2015, the Chinese government applied a plan for the nationwide commencement of 3-year standardized residency training programs [45].

The government has mandated that by 2020, a physician applying for clinical work must have completed one of these new residency programs. These changes impact the health of one-fifth of the world's population.

Unfortunately, these standards have not created quality programs. Although residents at this particular teaching hospital have the essential elements of a program in place, they also describe many areas where additional development is required. Recently published Chinese literature suggests that residency training has a long way to go before it is accurately "standardized".

Cultural Competence in Orthopedics

Competency in orthopedic surgery depends on managing complicated cases with minimum complications. A patient and his treatment include both medical and psychological competency. In today's globalized world, we interact with other cultures and thereby unconsciously unify diversity. Resident selection is a multifactorial procedure that significantly differs from the recruitment processes that other professions enjoy. The proportion of international medical graduates (IMGs) that practice in the U.S.A. is significant. Approximately one-quarter of practicing U.S. physicians are IMGs, up from 15 percent in 1967 and 6.3 percent in 1959. In 2004, twenty-eight percent of the residency cohort was represented by IMGs, with more in specific specialties, such as psychiatry and nephrology [46]. The literature widely documents racist experiences by patients and the differential treatment and healthcare disparities built on race [47,48]. Medicine is overshadowed by

infamous experiments, such as the Tuskegee and Guatemala experiments, and routine studies confirm the insufficient treatment of minority patients [49-51].
Unfortunately, the consciousness regarding racial and ethnic disparities in musculoskeletal care is low. However, although most evidence of racial and ethnic disparities is linked to cardiovascular care, discrepancies have also been identified in musculoskeletal care.

Minorities have been shown to have lower rates of total joint arthroplasty, more complications following joint replacements, higher readmission rates after orthopedic procedures, lower screening and treatment rates for osteoporosis, and increased morbidity and mortality following hip fractures [52-55].

In 2016, Adelani and O'Connor performed a study in which three hundred five members of the American Orthopaedic Association completed a survey to evaluate their knowledge of racial/ethnic disparities and their insights regarding the underlying causes. Twelve percent of the respondents believed that patients often receive different care based on their race/ethnicity in general, nine percent believed that differences exist in orthopedic care, three percent believed that differences exist within their hospitals/clinics, and one percent reported differences in their own practices. Despite these findings, sixty-eight percent admit that there is clear evidence of disparities in orthopedic care. Fifty-one percent believe that a lack of insurance significantly contributes to these disparities. Moreover, thirty-five percent of the respondents concluded that diversification of the orthopedic workforce would be a "very effective" strategy for addressing disparities, twenty-five percent believed that research would be "very effective", and twenty-four percent believed that surgeon education would be "very effective". They noted that the awareness of orthopedic surgeons regarding the racial/ethnic disparities in musculoskeletal care is low. Moreover, respondents were more likely to admit to disparities in the practices of other physicians than in their own. Increased diversity, research, and education may improve the awareness of this problem [56]. "Prejudice and discrimination are profoundly harmful to individuals and society as a whole." [57]. As we move to a more multicultural society, it is the hope of the authors that these infrequent racist encounters will continue to diminish and that medical schools and residency programs will train physicians and include more IMGs who are understanding and culturally competent [58].

Women in Orthopedics

Ruth Jackson, the first female orthopedic surgeon, opened her practice in Texas in 1932 after graduating from the University of Iowa. In 1937, she completed and passed the board exam to become the first female board-certified orthopedic surgeon [59].

After the passage of the 1972 Education Amendments to the Civil Rights Act in the U.S.A., the number of female graduates from medical school began to increase at a steady rate [60].

Similar movements have followed in Western countries. Although half of medical school graduates are currently women, they represent only 13% of all orthopedic surgery residents and 4% of the members of the AAOS [61]. Orthopedics is therefore the most gender imbalanced area of medicine. This imbalance suggests the existence of barriers to the entry and advancement of women in this field.

The Perry Initiative is a nonprofit organization that is focused on recruiting and retaining women in orthopedics. Since 2009, the organization, managed by practicing women engineers and surgeons, has conducted out-of-school programs for women in high school, college, and medical school. In 2012, the Perry Initiative launched the Medical Student Outreach Program (MSOP), which focuses on first- and second-year female medical students nationwide. The

MSOP consists of a hands-on curriculum and lectures led predominantly by female residents and attending surgeons. In 2016, the MSOP performed a study and concluded that the Perry Initiative's MSOP positively inspired women to choose orthopedic surgery as a profession. The match rate for program alumnae was twice (28-31%) the percentage of females in current orthopedic residency classes. Given these positive outcomes, the MSOP may serve as a model in both its curricular content and logistic framework for other diversity enterprises in the field. The MSOP provides medical students with the option to network with female role models in orthopedics and increase their hands-on exposure to orthopedic surgical techniques [62]. The lack of female faculty and mentorship in training programs has been cited as a potential reason for the smaller number of female medical students who enter this specialty [63].

We must strive to significantly improve the rate of female and minority admissions to the orthopedic profession. Our goals are to advance the patient and physician relationship and eliminate the disparities in healthcare, regardless of gender, race or religion.

We must foster the launch of an atmosphere of goodwill and collegiality toward women and minorities in the orthopedic profession and make this known to the world of medicine [64].

Orthopedics and Politics

According to the Working Group on Research of the Causes of War (Arbeitsgeminschaft Kriegsursachenforschung) of the University of Hamburg, >90% of wars have occurred in developing countries since 1945, with 32 wars and armed conflicts recorded in 2010 [65].
These facts should be considered when planning for improvements in global health and the achievement of worldwide health equity. Within the context of war in developing countries, military surgeons are among the few who can provide medical support and humanitarian aid, along with educating local doctors. The participation of military doctors in efforts to improve global health is highly needed and appreciated. The concept of a military surgeon includes the goal of being a competent surgeon, along with support for all human beings, regardless of their heritage. These doctors treat soldiers who are wounded in action or have non–hostility-related injuries, civilian personnel of the United Nations and non-governmental organizations, and civilians from the local population, as part of humanitarian aid. Preferably, military surgeons not only have the competency to conform to medical standards within the country but are also capable of performing emergency field surgery. The "Duoplus" model for training surgical officers in Germany includes specialization in general surgery in addition to a second specialization, in visceral or orthopedic/trauma surgery, and includes training in other medical skills outside the field of general surgery. In accordance with the definition approved by the German Committee of Military Medicine on May 14, 2004, the Duoplus model considers deployment-specific injuries and medical disorders, is based on real-life situations, reflects new developments in the civilian hospital environment, and conforms to current specifications for official professional training regulations [66].
Where there is no war, for developing countries, orthopedics is dependent on instruments. These instruments should be imported from developed countries, and politics may influence this process. Easy travel to other countries and having experts travel from other countries are important for sharing knowledge and skills. Permission to travel is affected by political situations. Scientific exchange with developing countries is imperative to improving surgical education.
Developed countries are also under the influence of political decisions. For example, how many hospitals can be built, how many should be closed or how many organizations and which types of organizations should be in charge of resident education? What is the financial

support from the government? How will this funding be distributed? Which hospitals will be funded, and which will not?

Research articles published on ways to improve residency programs will serve as proof for politicians, who require facts from experts in the field, researchers and clinicians.

Discussion and Conclusion

Orthopedic surgery is an interesting and diverse field that will continue to develop, with increased sub-specialization and enhanced research at the molecular level and an increased emphasis placed on outcomes and healthcare costs.

Our goal should be to improve the level of orthopedic training worldwide. Future studies should seek to gain further details regarding these training programs and include data from more countries. It is well established that "global health is a field that has grown dramatically in scope and popularity. Once focused on infectious diseases, global health today is the study, research, and practice of improving and achieving worldwide equity in health" [67].

As trauma kills more individuals worldwide than HIV/AIDS, malaria, and tuberculosis combined and disproportionately affects low- and middle-income countries, as well as the young population, we should put more effort into standardizing the educational content and minimizing the variability among residency training programs worldwide [68-73].

The development of global orthopedic care will necessitate financial aid, involvement, research, education, support and innovation. We inspire orthopedic surgeons to distinguish the critical importance of practicing, teaching, and conducting research with the goal of addressing disease burden and access to quality orthopedic care worldwide.

The relative variability among residency training programs worldwide has been primarily a result of the lack of the standardization of educational content [74].

The primary aims of orthopedic training programs are to produce competent orthopedic surgeons who are knowledgeable, able to care for patients in a professional manner, technically skillful, good communicators, and highly competent educators. Guidelines are published and applied in many countries to achieve these objectives.

In summary, we highly recommend addressing the following points in the global orthopedic residency program agenda:

1. The skill of today's trainees reflects the quality of future orthopedic surgeons.
2. We must standardize many educational procedures, i.e., assessment tests, in the same way we standardized patient safety worldwide.
3. Global health today is the study, research, and practice of improving and achieving worldwide health equity.
4. Future studies should aim to include information from more countries. We should aim to improve and harmonize orthopedic training worldwide. As European residency programs vary but a European orthopedic surgeon can work anywhere in Europe, we suggest that the EBOT exam serve as a potential final assessment of the competency of orthopedic surgeons in all European countries.
5. Hands-on cadaver and simulation labs should be accessible to residents.
6 The status of the orthopedic residencies (i.e., care) in all countries must be assessed to better understand the existing disparities and their root causes to better develop solutions.

7. Collaboration and coordination should be nurtured at every level of orthopedic care delivery, between healthcare practitioners of different backgrounds, organizations with different approaches, and countries with different economies and challenges.
8. Innovation is key, and we must foster creativity, meticulously test new ideas, and invest in new innovations with the potential for global applications such that, in the future, we can provide an equal level of orthopedic know-how and care worldwide [75].

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