THE SCARCITY OF ORTHOPAEDIC PHYSICIAN SCIENTISTS

Joseph A Buckwalter V, M.D., Ph.D.*, Jacob M Elkins, M.D., Ph.D.

ABSTRACT

Breakthrough advances in medicine almost uniformly result from the translation of new basic scientific knowledge into clinical practice, rather than from assessment, modification or refinement of current methods of diagnosis and treatment. However, as is intuitively understood, those most responsible for scientific conception and creation –scientists – are generally not the ones applying these advances at the patient's bedside or the operating room, and vice versa. Recognition of the scarcity of clinicians with a background that prepares them to develop new basic knowledge, and to critically evaluate the underlying scientific basis of methods of diagnosis and treatment, has led to initiatives including federally funded Physician-Scientist programs, whereby young, motivated scholars begin a rigorous training, which encompasses education and mentorship within both medical and scientific fields, culminating in the conferment of both MD and PhD degrees. Graduates have demonstrated success in integrating science into their academic medical careers. However, for unknown reasons, orthopaedic surgery, more than other specialties, has struggled to recruit and retain physician-scientists, who possess a skill set evermore rare in today's increasingly complicated medical and scientific landscape. While the reasons for this shortfall have yet to be completely elucidated, one thing is clear: If orthopaedics is to make significant advances in the diagnosis and treatment of musculoskeletal diseases and injuries, recruitment of the very best and brightest physician-scientists to orthopaedics must become a priority. This commentary explores potential explanations for current low-recruitment success regarding future orthopaedic surgeon-scientists, and discusses avenues for resolution.

INTRODUCTION

Knowledge in the medical sciences is growing by an astounding rate, and orthopaedics is no exception. As observed over a decade ago, "In the last twenty-five years, basic sciences have made such dramatic progress that it is difficult for even for the most scientifically inclined orthopaedists to understand current basic research."[1,2] After a decade of intense scientific enterprise, this observation rings even truer today. Given this widening gap between research and practice – between the bench and the bedside – how can we continue to efficiently and correctly apply new medical advances to the practice of orthopaedics? While there will always be those motivated few who devote precious time away from the practice of medicine and dabble in the basic sciences until they have reached the level of proficiency comparable to a scientist, we cannot collectively depend on these few to carry the torch of translational science. Thus, we must identify and nurture from an early educational stage those individuals devoted to such a career. Perhaps the best-known national initiative to bolster medical research by development of clinician-scientists is the Medical Scientist Training Program (MSTP). Initiated in 1964 by the National Institute of General Medical Sciences (NIGMS), the MSTP was established to promote careers in biomedical research and academic medicine by supporting trainees through both medical and research training, leading to the conferment of both MD and PhD degrees. Trainees typically receive full tuition waivers and are supported by a stipend throughout their training period, which typically lasts 8 years.[3] Additionally, there are approximately 75 additional medical schools that do not have NIGMS MSTP training grants, but also offer opportunities for MD-PhD students. The typical structure of MD-PhD programs is that the first two years are devoted to a traditional pre-clinical medical curriculum. Following this period, trainees are transitioned to their research lab, and produce their dissertation under their research mentor. Following completion of their PhD dis-

Mailing Addresses:
*Joseph A. Buckwalter V, M.D., Ph.D.
E-mail address: joseph-v-buckwalter@uiowa.edu
Jacob M Elkins, M.D., Ph.D.
E-mail address: jacob-elkins@uiowa.edu
University of Iowa Hospitals and Clinics
Department of Orthopaedics and Rehabilitation
200 Hawkins Drive
01085 JPP
Iowa City, Iowa 52242
Telephone: (319) 353-7656
Fax: (319) 353-6754

sertation, trainees again transition back into the medial realm, completing the final two years of clinical education prior to graduation. Currently, there are 911 MSTP slots at an average annual cost of $41,806, at a total of 43 participating institutions.[4] So, with an annual operating budget of nearly $40 million dollars, it is a fair question to ask whether the MST program is meeting its objective of training physician-scientist. In the largest analysis to-date of MSTP graduates, Brass et al.,[3] surveyed nearly ½ of the NIH-funded MSTP graduates during a 40-year period. They found 81% of alumni were employed in academia (vs. 16% in private practice). Of those employed in academia, 82% were involved in research, and 60% had research funding. Two-thirds devoted more than 50% of their effort to research, and nearly 40% of alumni reported 75% or greater of time devoted to research. Are MSTP graduates, therefore, successful? Despite the lack of a clear tidemark in establishing "success", these data seem to support the realization of NIGMS' charge to develop clinician scientists. However, a closer look at the data uncovers some concerning trends. Despite on 16% of alumni entering private practice (which for the sake of discussion can be seen as a direct failure of the MSTP mission), some specialties are seen to enter private practice at substantially higher rates. Greater rates of private practice were seen in fields that have recently increased in popularity, such as dermatology (44%), ophthalmology (44%) and surgical specialties (27%). Additionally, it was noted that matriculation into these fields by MSTP graduates have step-wise increased over the past four decades. Why do we see an increase failure rate of the physician-scientist model in these competitive, lucrative, and surgical-heavy specialties, including orthopaedic surgery? While true that time constraints are arguably greater for the surgeon-scientist as compared to the traditional physician-scientist, from simple arithmetic analysis of the previous data suggest that nearly 50% of MD-PhDs in surgery conduct research with at least a 50% time commitment. How about the remaining 50%? Data from Ahn et al.,[5] surveying orthopaedic resident's attitudes toward research, demonstrate that nearly all orthopaedic residents surveyed assert that orthopaedic research performed by orthopaedists was important, however only 42% felt they were likely to perform research in their careers. Reasons against intent to perform research following training include debt relief, protected time, and salary support. However, these general statistics are for the general orthopaedic resident. How about the rare MD-PhD orthopaedic resident? What motivations exist for a resident who has spent nearly a decade (or more) training for a career as a clinician-scientist to proverbially throw in the towel and submit to a career of private practice? This decision is troubling in the perspective that these residents were certainly vetted – at one time or another – for their commitment to pursue research. While it is tempting to place the onus on the individual, certain amount of responsibility certainly lies within the institution charged with training and preparing residents for their careers. What, then, are the institutional behaviors responsible for failure of the Surgeon-Scientist? Perhaps fault lies in a recent shift in emphasis toward clinical research. Perhaps more directly, fault can be placed upon not attracting MD-PhD candidates?

BASIC SCIENCE VS. CLINICAL RESEARCH

Certainly, research is an important component of most current orthopaedic residencies, however is arguably more emphasized at some institutions over others. It can be argued that only a small minority of "research" conducted at these institutions by orthopaedists or orthopaedic residents falls under the label of basic or translational science. As a point of reference, consider a recent annual (2014) meeting of a major regional orthopaedic research conference representing 20 states, including several dozen orthopaedic institutions, many of which are well known research powerhouses nationally. Of 208 paper presentations and 153 poster abstracts, only 51 represented a research project that was not primary composed of surveys, database searches, chart reviews, clinical studies, etc. Of these 51, the vast majority were comprised of radiographic studies, requiring only access to radiographic images. Only a select handful represented true basic science endeavors, including cell biology/biochemistry, anatomy, or biomechanical work. Furthermore, the academic degree of the presenting or primary author reveals that a physician was not primarily performing many of these projects. Review of previous years' submissions reveals similar statistics. If you allow for assumptions – first that if substantial research is performed by a resident then it would be submitted, and second that the research pattern of these 20 states mirrors those in the remaining 30 – then extrapolation of this single reference point illustrates that residents and/or young faculty are not performing basic science research at an appreciably meaningful volume. While clinical research is of paramount importance in our chosen profession, a strong argument can legitimately be made arguing in favor of the primacy of basic science in medicine in general and orthopaedics specifically. As argued by Brand et al.,[6] "advances in clinical practice continue to arise more often from the lab rather than from the clinic". In orthopaedics, these advances include tissue engineering, biologics, gene therapy, and imaging. Unless clinicians are involved in the development of the techniques, they are less likely to be efficiently transferred to the clinic." However, when one only has experience in the clinic, then understanding of the bench-to-

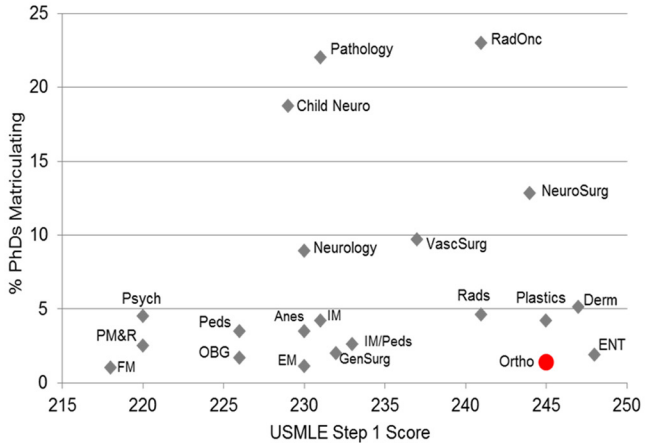

Figure 1. Percentage of PhDs matriculating into residency, ordered by average USMLE Step 1 score. For simple estimation of a specialty's competitiveness, USMLE Step 1 scores are considered as a surrogate. Orthopaedics, as illustrated with the red round marker, is near the bottom in terms of % matriculants with a PhD degree. Other specialties, including Otolaryngology (ENT), Dermatology (Derm), Plastic Surgery (Plastics), Neurologic Surgery (NeuroSurg), Radiation Oncology (RadOnc), Vascular Surgery (VascSurg), Internal Medicine (IM) and Internal Medicine-Pediatrics (IM/Peds), General Surgery (GenSurg), Neurology Anesthesia (Anes), Pediatrics (Peds), Obstetrics-Gynecology (OBG), Psychology (Psych), Physical Medicine and Rehabilitation (PM&R) all have a greater percentage of MD-PhD matriculation relative to orthopaedics. Only Family Medicine (FM) and Emergency Medicine (EM) have relatively fewer MD-PhD matriculants.

bedside paradigm is critically limited. Therefore, there is little surprise that the majority of orthopaedic surgeons view clinical research as more important than basic science.[7] Undeniably – especially in the recent era of "big data" – clinical research holds great advantage over that of basic science. Results are quick, and typically require little in terms of time or resource commitment. Projects are completed over a weekend with nothing more than a computer spreadsheet program and an email to a statistician. Rather than laboring to explore the timeless questions of "how?" and "why?" these projects march forward collecting and collating others' clinical observations. The relative increase in the ease of these studies has perpetuated the facility of publishing for the sake of publishing. However, such a pattern of publishing does little outside self-serving, and most certainly does not contribute to the body of new orthopaedic knowledge.[8]

Certainly, musculoskeletal research is alive and well, as can be easily attested by reviewing of any recent ORS annals. Moreover, a large volume musculoskeletal research is published in bioengineering or rheumatology journals often far from the view of practicing orthopaedists or orthopaedic residents in training. And although the most circulated and impactful orthopaedic journals, such as the Journal of Bone & Joint Surgery (JBJS) or Clinical Orthopaedics and Related Research (CORR) gladly welcome basic submissions, the number of basic science submissions is far lower than clinical research submissions. This trend comes at a price for orthopaedics. As cautioned during his Presidential Address to ORS in 2002,[9] Dr. Thomas Brown states that as more and more orthopaedic research is conducted by non-orthopaedists, orthopaedic exploration faces the risk of becoming more and more specialized as research "accelerates down the path of scientific virtuosity for virtuosity's sake", to the unfortunate detriment of our patients.

THE MD-PHD CANDIDATE

One of the first analyses into MD-PhDs in orthopaedics demonstrated that less than 1% of MD-PhD graduates had chosen orthopaedics for a career.[10] At the time of publication in 2001, only 12 graduates of MSTP had entered orthopaedics, and only an approximate 2% of US orthopaedic faculty held both degrees. Additional investigations re-affirm that orthopaedics is one of the least successful disciplines in terms of recruiting MD-PhD graduates.[11] But why? Perhaps a fair initial assessment would be to look at the relative importance of research in selecting orthopaedic residents. In a massive study of program directors across all specialties, of the top seven residency programs in terms of competiveness (plastics, ortho, ENT, ophtho, radiology, rad-onc and NSG), ortho ranks only behind radiology in terms of program directors' rated importance of published research.[12,13] When investigation is narrowed to only orthopaedics[14], a history of published research falls at number 14 of 26 resident-selection criteria for acceptance into orthopaedic residency, several spots below "formality at interview", "personal appearance" and "medical school reputation."[14] Perhaps even more troubling is the listing of "candidate is MD/PhD" at number 17, just one spot above "reputation of undergraduate institution" and three spots above "appearance of CV." Furthermore, in a similar analysis, orthopaedic applicants actually viewed the value of an MD-PhD less than program directors.[15] Therefore, in a field that values applicant and CV appearance as much as future clinician-scientists, is it really surprising that we are now facing a critical shortage of qualified surgeon-scientists? Equally predictable is the number of MD-PhDs currently in orthopaedic residency. Based on recent match data,[16] we find that orthopaedics ranks at the very bottom in terms of PhD matriculants for competitive specialties (Figure 1). When considering all specialties that participate in the NRMP Match, Orthopaedics ranks only behind Family Medicine and Emergency Medicine in terms of recruiting MD-PhD applicants. Interestingly, Physical Medicine and Rehabilitation (PM&R, aka Physiatry) – orthopaedics' musculoskeletal brethren – has a recruitment rate for MD-PhDs twice that of orthopaedics. Substantial gaps are also illustrated between orthopaedics and other surgical specialties, such as Plastic

Surgery (3-fold higher MD-PhD rate), Vascular Surgery (7-fold) and Neurosurgery (9-fold). With the relative similarity of orthopaedics to these specialties (as compared to anesthesia or radiation oncology, for example), it is fair to ask why these other specialties are successful in attracting MD-PhD trained residents. Perhaps MD-PhD senior medical students are applying to orthopaedics, but they are not successful in landing a residency spot. While there are no hard-and-fast numbers to support this, this is certainly a possibility. However, it is much more likely that these students simply are not applying to orthopaedics. As described by Ahn et al.,[17] while nearly 14% of MSTP students interviewed were interested in a surgical career, only 1.4% listed orthopaedics as their top choice. And while the authors applauded this level of interest and enthusiastically stated that at this rate the field may double the number of active clinician scientists within orthopaedics in just fifty years, these numbers should be regarded as unacceptably low. Recalling the "Knowledge Doubling Curve" as described by Buckminster Fuller,[18] it is estimated that the progress of medical science is currently doubling each 1.5 years. In this context, waiting 50 years to double the number of individuals willing and able to deal with such expanses of knowledge seems anything but a success.

Of course, there is always the importance of our collective environmental culture. Despite major recent technologic advances in surgery, perhaps many surgical fields have been unable to shake the stereotypes of being overly non-cerebral, as compared to traditional clinician-scientist realms such as Internal Medicine, Neurology and Pathology. And perhaps no other surgical specialty has found itself as stereotyped with the non-cerebral phenotype as orthopaedics: one needs few guesses to surmise which specialty a PubMed search for "strong as an ox" returns.[19] Additional slang references for orthopaedics[20] such as "caveman" and "knuckledragger" are pervasive in the medical environment, and unfortunately do not help dissuade the propagation of our paradoxical stereotype: despite becoming increasingly competitive while attracting the brightest and most accomplished medical students, orthopaedic residents and surgeons are regarded as (boneheadedly) stupid and slow. Despite this seeming insult, it is apparent that some in the orthopaedic community actually embrace this perception.[21,22] While a change in perception of orthopaedic surgeons is not expected to change overnight, a possible consequence may be MD-PhD applicants contemplating research careers shying away from orthopaedics and move toward pathways which appear to be more welcoming to their research pursuits.

While remaining at the level of conjecture currently, there are perhaps additional reasons for the relative scarcity of MD-PhD applicants in orthopaedics. There is perhaps resistance from various MSTP program directors at potential medical schools when applicants openly state that they want to earn a PhD and pursue a career in orthopaedics. Applicants maybe gently persuaded to pursue alternative research directions and clinical practices, which are more in line with traditional MD-PhD scholarly activity. Additionally, MD-PhD school matriculants are often exposed early in their training to a variety of research environments, a process designed to assist students identify a research area before making a commitment to a research mentor. Certainly an increased exposure to orthopaedic research at this pivotal time may serve to improve early interest in this fascinating field.

Orthopaedics has difficulty recruiting research-focused residents. However, the importance of this small demographic within our training organization cannot be overstated. Surgeon-scientists are important in that the driving scientific questions for which they are equipped to address arise from the bedside and the operating room which they receive constant exposure. This unique perspective is clearly different from research-only trained scientists, or clinicians who lack the necessary tools to formulate inquisition in line with the scientific process. And, unfortunately, we appear to be moving in the wrong direction. In a large survey of members of the Orthopaedic Research Society (ORS) and American Academy of Orthopaedic Surgeons (AAOS), Brand et al.,[23] identified that only 3.6% of AAOS members were also members of ORS. Additionally, this study identified that the overwhelming majority of orthopaedists are not the PI on most NIH grants for which they have collaborated on. Furthermore, over a 10-year period, only 64 orthopaedic surgeons were identified whom were PIs on NIH grants exceeding $100,000, and that there was a downward trend for NIH funding for the specialty. When assessed for reasons, demands of clinical services – and not funding – was the rationale for decreased participation of research by orthopaedic surgeons. In a fascinating follow-up,[6] these 64 surgeon-scientists were probed for factors associated with their research success. Among many enlightening elements, perhaps the strongest influence was early exposure to research. Of these successful surgeon-scientists, the vast majority had begun research prior to residency, and only 10% after. Additionally, 44% had specialized dedicated research training, most for greater than one year. Thus, the expectation (or hope) that many of these bright, accomplished (but research-naïve) newly recruited residents will one day be at the vanguard of orthopaedic research is not founded in precedent. Perhaps a better strategy would be to actively recruit those with dedicated research experience and drive into orthopaedics.

While certainly a good start, merely recruiting more MD-PhD candidates (or others similarly equipped for a

research career) might not be the panacea for solving our problem of the scarcity of surgeon-scientists. As previously discussed, over a quarter of the MD-PhD graduates who have entered a surgical field have entered private practice. And while the exact percentage is unknown, given the correlation between field competitiveness and rate of entering private practice[3], it is likely that an even higher rate of private practice is expected for MD-PhDs in orthopaedics. And, of course, non PhD-trained MDs leave the realm of academic practice at equally alarming numbers. Attrition rates for academic physicians are high and are increasing, with nearly 30% of American full-time MD faculty either planning or considering leaving academic medicine.[24,25] Attrition rates for surgical faculty are even higher.[26] So, moving forward, our challenge will be to recruit – and retain – young physician-scientists.

NURTURING RESEARCH INTEREST

The alarm regarding the scarceness of the orthopaedic surgeon-scientist has been raised many times. Thoughtful analysis,[11,27-31] has identified numerous obstacles regarding successful integration of research into an orthopaedic career. These include infrastructure, economic constraints, clinical burden, etc. However, a common theme amongst these is the existence of a nurturing environment for potential surgeon-scientists in training. Not only does formal research training increase scholarly activity,[32] it provides an opportunity for the development of strong mentor-mentee bonds, which have been described as being perhaps the most important step in fostering research interest for those in training.[28,29]

CONCLUSION

"How can surgeons and scientists advance the integration of science into orthopaedic practice and thereby improve treatment? The three requisites are (1) scientists with an understanding of clinical problems; (2) surgeons with an understanding of science; and (3) critical scientific evaluation of the results of clinical practice."[1,2] This is the entire foundation behind the development of MST and MD-PhD programs. And while the absolute numbers of MD-PhD graduates have actually increased in recent years, the numbers of orthopaedic surgeon-scientists have been in steady decline for decades, and there is no indication recovery for this 'endangered species'. Many factors have been identified as obstacles toward developing a research career within orthopaedic surgery; however these usually describe a strategy to foster research in residents and young faculty who likely had little interest in scientific pursuits prior to matriculating into the field. Instead, an entire demographic of young, research trained and mostly advanced degree-holding applicants with great potential are largely ignored. Perhaps one of the greatest opportunities to expand the ranks of surgeon-scientists is to recruit them, rather than relying on training them. Until we as a field learn to value a commitment to research more than board scores and undergraduate/medical school reputation, orthopaedics may continue to watch potential physician-scientists move on to something more welcoming.

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