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REVIEW ARTICLE

Advancing spinal fellowship training: an international multi-centre educational perspective

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Abstract

Purpose The purpose of this article is to review the importance of contemporary spine surgery fellowships and educational strategies to assist with fellowship design and delivery.

Methods Spine surgery fellowship includes trainees from orthopaedic and neurosurgical backgrounds and is increasingly indicated for individuals wishing to pursue spine surgery as a career, recognizing how spinal surgery evolved significantly in scope and complexity. We combine expert opinion with a review of the literature and international experience to expound spine fellowship training.

Results Contemporary learning techniques include boot camps at the start of fellowship which may reinforce previous clinical learning and help prepare fellows for their new clinical roles. There is good evidence that surgical specialty training boot camps improve clinical skills, knowledge and trainee confidence prior to embarking upon new clinical roles with increasing levels of responsibility. Furthermore, as simulation techniques and technologies take on an increasing role in medical and surgical training, we found evidence that trainees' operative skills and knowledge can improve with simulated operations, even if just carried out briefly. Finally, we found evidence to suggest a role for establishing competence-based objectives for training in specific operative and technical procedures. Competence-based objectives are helpful for trainees and trainers to highlight gaps in a trainee's skill set that may then be addressed during training.

Conclusions Spinal fellowships may benefit from certain contemporary strategies that assist design and delivery of training in a safe environment. Interpersonal factors that promote healthy teamwork may contribute to an environment conducive to learning.

Graphic abstract

These slides can be retrieved under Electronic Supplementary Material.

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Extended author information available on the last page of the article

Keywords Spine surgery fellowship · Postgraduate education · Surgical training · Boot camps · Surgical simulation · Competency

Introduction

Spinal surgeons originate from diverse clinical backgrounds—neurosurgical and orthopaedic/trauma. As spinal surgery is not universally recognized as a specialty in its own right in most countries, surgeons' previous training experience and approach may vary and there may be differences in emphasis and methods. Indeed, there remains a demonstrable variation in the operative and non-operative management of spinal conditions between orthopaedic surgeons and neurosurgeons, each of which brings different strengths [1–3]. A recent survey demonstrated that there is a profound difference even in managing standard pathologies such as disc herniation or lumbar spinal stenosis [4]. A subspecialty fellowship in spinal surgery may harness training and educational benefits originating from a collective experience—orthopaedic and neurosurgical.

The American Accreditation Council for Graduate Medical Education (ACGME) defines fellowship as "a program that provides advanced training in progressive levels of subspecialization following completion of training in a primary specialty and, if applicable, a related sub-subspecialty. It is a structured educational activity comprising a series of clinical and/or other learning experiences designed to train physicians to enter the unsupervised practice of medicine in a subspecialty" [5].

Notwithstanding, no strict model of fellowship exists and this may be due, in part, to the relative paucity of spine surgery fellowship curricula internationally. Indeed, the educational content of a fellowship may range from a period of simple observation up to and including fellowships with international recognition, such as AO fellowships. To this end, the archetypal competence-based spine surgery fellowship curriculum set of learning objectives was developed by the Canadian Spine Society [6].

The case for spine surgery fellowships

Fellowship is increasingly desirable or even necessary in spinal surgery for a number of reasons. First, there is evidence that sub-specialization improves outcomes in spinal surgery [7]. Increased exposure to particular disorders and their specialized management has been linked clinically to better outcomes [8, 9]. Separately, improvements in department-level cost-effectiveness have been associated with fellowship-trained spine surgeons, with the assumption being that this is due to improved outcomes [10]. However, whether subspecialty training and fellowship is the cause of this effect per se has not been conclusively established.

Secondly, advances in operative techniques, such as minimally invasive surgery and intraoperative navigation, typically necessitate a dedicated period for skill acquisition for one to acquire proficiency. Surgeons who have not completed a spine surgery fellowship may not have had sufficient exposure to certain highly specialized techniques during their neurosurgical or orthopaedic training. Whereas spinal surgical procedures make up, on average, the majority of total departmental neurosurgical operating volume (nearly two-thirds by one estimate), these procedures make up a minority (around one-seventh) of the same in orthopaedic departments [11]. Additionally, differences exist in orthopaedic and neurosurgical expertise. Spinal deformity, materials science and disorders of skeletal growth may traditionally be regarded as the realm of orthopaedic spinal surgery. Conversely, intradural pathology and the management of disorders involving the craniocervical junction are typically considered areas of expertise of neurosurgeons. A case for dual-trained specialist spine surgeons has been made elsewhere [12], and fellowship-trained surgeons perform an increasing proportion of procedures within their area of subspecialty training. Fellowship training is increasingly becoming the rule rather than the exception [13].

Finally, training opportunities may have reduced due to limitation of trainee surgeons' working hours worldwide. North American residents have a limit of 80 h per week implemented by the ACGME [14, 15]. In the UK and Europe, the European Working Time Directive and, more recently, the UK Junior Doctors' Contract have imposed significant restrictions on duty hours [16–19]. Reduced quantity of time to train, noticeable in British postgraduate surgical training post-European Working Time Directive, may result in reduced quality of training [20]. An extension of training to include dedicated acquisition of spine surgery knowledge and operative as well as procedural techniques may be a solution to this problem.

Nonetheless, perceived inadequacy of training during residency is only a small motivation for pursuing subspecialty fellowship and is by far superseded by personal interest, academic aspirations and a desire to increase one's employability [21]. Subsequently, surgeons pursuing subspecialty fellowships may have higher salaries and attract a larger private practice [22]. However, this may not apply universally to all healthcare systems and financial incentives are not typically a motivation for pursuit of a particular surgical discipline [23]. Additionally, spinal surgery is notorious for attracting litigation secondary to chronic pain and neurological deficits

being profoundly disabling symptoms [24, 25]. In one study, common root causes for litigation included unsatisfactory outcomes, missed/incorrect diagnosis, nerve damage and wrong site/wrong procedure cases [25]. Subspecialist spine surgery training prior to embarking on a career as an independent provider may variously prevent, confer protection from and/or provide skills to successfully defend oneself against litigation.

Another advantage of spine surgery fellowships includes developing one's vision of their future practice. Observations and experience gained during fellowship may help shape management of a fellow's future practice. Non-technical skills including leadership, teamwork, communication and interpersonal skills are being increasingly recognized as essential attributes of postgraduate surgical training [26, 27]. A healthy bond between mentor and mentee, including discussion and reflective practice, may facilitate this, in our opinion.

It is also known that teaching and research are intimately linked. Thus, an added advantage of pursuing a spine surgery fellowship is the accessibility of research mentorship. Institutions hosting fellowships are usually tertiary centres or centres of excellence, typically maintain large patient databases and are usually engaged in or supporting spine research. Research mentorship is associated with benefits to mentor, mentee and institution [28, 29]. From the point of view of the mentee, it can be seen as a way of "giving back" to their mentor in addition to focusing their interest in their future career.

Not surprisingly, mentors who train spine surgery fellows are more likely to be the most academically productive [30]. Clearly, causality cannot be assumed and academic productivity is hard to quantify. Nonetheless, there is general consensus that mentoring spine surgery fellows is likely to be mutually beneficial to mentor and mentee, both clinically and academically.

Mentorship often continues well beyond fellowship—including but not limited to clinical advice (e.g. in difficult/complex cases), practice management, ongoing educational endeavours and collaborations. Over and above clinical and academic gains, a fellowship confers the possibility of a mentorship for life.

The case against spine surgery fellowships

Given that fellowships are typically run by tertiary hospitals and specialist centres, they may include teaching on advanced spinal techniques and rare pathologies which may not necessarily apply to a fellow's future career. This is particularly relevant in the UK where the practice of spine surgery has been increasingly regulated by advisory inputs to the National Health Service including the National Institute for Health and Clinical Excellence (NICE) and the Get It Right First Time (GIRFT) initiative. Certain specialized procedures may therefore be restricted to particular centres under the guise of quality improvement and cost reduction such that surgeons may train to perform procedures during their fellowships that they may never perform as an independent consultant [31].

Furthermore, one may argue that a preceptorship, as opposed to a fellowship, may train a new consultant or attending surgeon more thoroughly in the particular job role they are to undertake in that particular department. Arguably, one need not gain expertise in techniques they are unlikely to use in the future. It could also be said that fellowship, like all specialty training, may detract surgeons from performing other core procedures of their specialty, such as orthopaedic trauma or cranial cases. To counter this, surgeons entering fellowship must ensure that their other global surgical skills remain current and that they keep up to date with ongoing professional development activities from their parent surgical specialties if they intend to continue using them during their career.

To this end, some neurosurgery residency programmes offer embedded fellowships during residency training. This trend has been observed in North America [32]. Although a similar provision in UK Specialist Training in Neurosurgery exists whereby a resident demonstrating above average competencies and progression may apply for their final year of registrar training to be a fellowship, there are insufficient data to report experience thus far.

In the UK, the General Medical Council are moving presently away from superspecialization to generalization. Subspecialties may be viewed as reducing available workforce for posts in the National Health Service. Consequently, an argument against fellowships is moving individuals to specialization with consequent reduction in those with general skills and a consequent reduction in workforce for a healthcare system.

Techniques

We have provided an overview of why, in our opinion, fellowship training in spine surgery is indicated. Next, we address the question of what strategies could be employed to maximize educational and training opportunities in spine surgery fellowship while maintaining optimal patient care and patient safety.

Boot camps

A boot camp at the outset of spinal fellowship may be indicated to ensure all incoming trainees have similar knowledge and operative skills at the commencement of fellowship. Interestingly, a small randomized study of surgical interns

receiving intensive boot camp style induction training or standard training found that boot camp training significantly improved surgical performance on objective structured assessments of technical skills [33]. A boot camp lasting 2 days was first piloted in the Pacific region for first year neurosurgery residents with a view to imparting cognitive and practical skills in intensive hands-on sessions [34]. Since then, there has been an unprecedented degree of participation with 94% of North American first year neurosurgery residents attending boot camps with 100% of resident and faculty respondents positively reviewing the courses [35]. There is evidence that intensive surgical skills courses significantly improve surgical skills at the beginning of residency [36]. Furthermore, there is good evidence that skills learned during orthopaedic and neurosurgical boot camps are retained when objectively tested in the future [37, 38]. A student-led approach whereby students explore and practice skills under instructor supervision was found to be more productive than an instructor-led approach where a senior surgeon demonstrated and instructed trainees [39].

Simulation

Similarly, there is increasing emphasis on simulation in training across the spectrum of medical and surgical specialties. Of primary importance, simulation confers learning in a safe environment with no risk to patient safety [40]. Time spent learning critical or technically challenging steps can also be maximized using simulation. There is good evidence that simulation can develop and improve technical, clinical, communication and management skills [41] and psychometric testing has demonstrated that trainees are keen about and receptive to simulation training [42]. Nonetheless, uptake of simulation in spine surgery training has not been as ubiquitous compared to other surgical specialties, including cranial neurosurgical subspecialties [43].

Traditionally simulation in spine surgery has involved cadaveric workshops and animal dissections. Animal dissection is problematic in that anatomical detail may not bear significant resemblance to human spines (e.g. anatomical fidelity, size and biomechanical differences with quadrupedal animals compared to bipedal humans). There are also important ethical issues to consider. Nonetheless, a large survey of neurosurgical residency programmes in the USA reported a major role for animal dissection in postgraduate neurosurgical education [44].

Cadaveric dissection workshops, on the other hand, remain an extremely useful opportunity to train [45]. In our experience, trainees reported increased confidence with surgical techniques following a 2-day course involving short introductory lectures and hands-on cadaveric practice supervised by experienced spine surgeons. Fresh frozen cadaveric material is considerably superior to traditionally prepared cadavers, although they are more expensive and entail logistical issues with transport and storage. A relative disadvantage of cadaveric dissection is the lack of specific pathology; however, most cadavers have some element of degenerative spondylotic changes.

Other disadvantages of simulation using human and animal tissue include relatively higher costs and lack of reusability. To address these concerns, synthetic tissue which is portable, reusable and without ethical problems may be an alternative [43]. Specific pathologies, such as deformity, scoliosis and degenerative spine pathologies [43], paediatric lumbar spine pathologies including neural tube defects and tethered cord [46] and intraoperative dural tear models [47] can also be modelled accurately. Using synthetic models, teaching of surgical approaches such as minimally invasive lumbar surgery [48], posterior cervical surgery including laminectomy and foraminotomy [49] and anterior cervical discectomy and fusion, using a simulator developed by the Congress of Neurological Surgeons [50], have been successfully implemented. The advent of three-dimensional printing may allow for more accurate depiction of specific pathology, including an individual patient's particular pathology before they undergo surgery.

Virtual reality (VR) simulation offers considerable promise in terms of simulating pathologies and approaches [51]. VR simulation is, in our opinion, likely to be especially helpful in training for x-ray-guided and percutaneous procedures, such as pedicle screw insertion and vertebroplasty, and there exist accurate VR simulators to acquire these skills [52]. Tactile feedback ("haptics") is an attractive possibility, allowing for a more realistic simulation of surgery, and this continues to evolve [43]. Mixed reality—associating virtual and realistic simulation—has undergone early validation and raised further prospects [53].

Unfortunately, objective evidence for effectiveness in achieving competence and good surgical outcomes from cadaveric workshops is lacking [45]. Nonetheless, there is unequivocal evidence that trainees and trainers hold them in high regard and feel they help to improve operative skills [54]. As a result, integration of simulation into spinal fellowship education has been advocated [55–57]. Further study into optimizing the scope and role of cadaveric workshops is required although there is a trend towards artificial models. In newer technological advances, there are opportunity and optimism for the further development of spinal surgery simulation.

Perspective and conclusion

We have outlined our perspectives on the importance of and requirement for spine surgery fellowship training. In brief review, there are differences in competencies that incoming

fellows from different surgical backgrounds need to develop. Newer methods of training will make fellowship training in spinal surgery safer and more efficient. As iatrogenic spinal injuries are often irreversible and are associated with significant morbidity and medicolegal problems, these advances will be welcome.

As a subspecialty, we are most likely to benefit from a combined training approach, amalgamating neurosurgical and orthopaedic elements. The Spinal Training Interface Group of the UK Spinal Societies Board presents a forward-looking blueprint [58].

Moreover, newer methods of training reflect a gradual moving away from traditional didactic Halstedian models of surgical training and learning [59, 60]. A relatively newer emphasis on soft skills, such as communication and interpersonal skills, is becoming commonplace in all postgraduate surgical training, including spine surgery. There is good scientific evidence that civility in surgery improves outcomes [61]. Having a healthy bond with one's mentor is likely to establish a culture conducive to productivity and a successful spine surgery training experience.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest relating to this review article.

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