Experience of a fellowship in spinal surgery: a quantitative analysis

Wojciech Konczalik · Sherief Elsayed ·
Bronek Boszczyk

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Abstract

Objectives The objective of our paper was to ascertain the self-reported competency level of surgeons who had completed a 1-year spine fellowship versus those who had not. Our secondary objective was to determine whether there was any difference between orthopaedic and neurosurgeons.

Methods A 60 question online questionnaire was provided to AOSpine Europe members for completion online.

Results 289 members provided a response, of which 64 % were orthopaedic surgeons and 31 % neurosurgeons (5 % did not specify). Eighty (28 %) had completed a 1-year fellowship. Theoretical and practical knowledge of the management of spinal deformity was the greatest difference seen upon completing a fellowship. Multiple elective and emergent conditions were demonstrated to have a significant difference upon completion of a fellowship. There was no difference between orthopaedic surgeons and neurosurgeons.

Conclusions In order to provide an efficient and safe service covering the broad spectrum of spinal pathology, a formal spine fellowship, ideally with a formal curriculum, should be considered.

Keywords Spine · Fellowship · Training · Complications · Assessment

Introduction

Spinal surgery is a dynamically developing field of medicine. It has been a focus of extensive research that has led to numerous advances in surgical procedures. The increased volume of rapidly accumulating knowledge delineates a trend for spinal surgery becoming an established and discrete discipline distinct from general orthopaedics and neurosurgery. The importance of this discipline has dramatically evolved over the past decades [1]. It has transformed from being the domain of neurosurgeons, as a method of neural element decompression, to becoming a major aspect of neurosurgical and orthopaedic practise (spinal procedures now comprise 14 % of orthopaedic practise and 60 % of neurological practise [2]).

A reduction in training due to the instigation of the European Working Time Directive is a cause of concern amongst the medical profession. It is believed that the quality of training may be compromised, and that despite of modifications to the surgical training curriculum and the introduction of innovative teaching methods into residency programmes, future doctors may be less competent than their present day counterparts [2]. Combined with the rapid advancement of the field, the knowledge base and skills required are becoming unmanageable for an orthopaedic or neurosurgical resident to master.

Subspecialisation is a phenomenon that not only results in better services and patient outcomes due to increased physician expertise, but is also cost-effective [3]. 80 % of graduates enrol in some type of advanced surgical training programme after completion of general surgical training

W. Konczalik (✉)
University of Nottingham, Nottingham, UK
e-mail: wojtekonzalik@gmail.com

S. Elsayed · B. Boszczyk
Centre for Spinal Studies and Surgery, Queens Medical Centre,
Nottingham NG3 5DF, UK
e-mail: elsayed@professionalmedical.co.uk

B. Boszczyk
e-mail: bronek.boszczyk@nuh.nhs.uk

[4]. Spinal fellowships are becoming increasingly popular, with 54 % of neurosurgical residents at the EANS (European Association of Neurosurgical Specialities) training course in 2004 interested in further training in spinal surgery [3] for example.

The efficacy of subspecialty training provides better outcomes—we do not know whether fellowship training is directly responsible for this. Whilst it can be assumed that fellowship training meets this goal in a particular subspecialty, to our knowledge this has not been formally assessed in spinal surgery.

A fellowship allows for an increased exposure to specialised disorders, which is associated with improved surgical outcomes [5, 6]. It is also the time to acquire decision-making skills and familiarise oneself with the most recent surgical techniques and their associated complications. Fellowship programmes are not uniform, each emphasising certain disease processes perhaps at the cost of others. Regardless of the nature of the spinal fellowship, it is expected that upon completion of the programme a fellow is competent in the diagnosis and management of a wide spectrum of spinal disorders and trauma. Arguably, this lack of regulation of the curriculum of spinal training leads to variable competence amongst specialists.

The primary objective of this study was to determine whether fellowship training led to an increase in (self-assessed) competency. The secondary objective was to determine whether there was any difference in theoretical and practical competencies between those respondents who had been trained as neurosurgeons and those who had been trained as orthopaedic surgeons.

Materials and methods

An online questionnaire was devised based on a previously published fellowship assessment questionnaire [3] and distributed amongst AOSpine members in Europe via the AOSpine website. It consisted of 60 questions and enquired about previous surgical training, fellowships and their nature, and both theoretical and practical competency amongst basic and advanced spinal conditions. Details of previous surgical training included the year and type of residency training, as well as the perceived quality of training and exposure to spinal conditions. The presence of any fellowships was recorded. Competence in a total of 15 areas of spinal surgery has been covered, including both the theoretical and practical aspects.

Theoretical skills competence was graded on a 4-point scale and described as “excellent”, “good”, “basic” or “poor”. Theoretical competence was defined as an “excel-

lent” or “good” understanding the condition (see Appendix—Table 2).

Practical skill competence was also graded on a 4-point scale and described as “not able to perform the procedure”, “can perform the procedure under direct supervision”, “can perform the procedure without direct supervision” and “can deal with the complications and difficulties which may arise”. Respondents were deemed to have achieved practical skill competence if they were able to perform the procedure without direct supervision or were able to deal with complications and difficulties which may arise (see Appendix—Table 3).

Results

A complete response to the questionnaire was provided by 289 AOSpine Europe members (13 % response rate) from 32 countries. 64 % of respondents were trained as orthopaedic surgeons, and 31 % were trained as neurosurgeons (5 % did not elaborate). Eighty (28 %) had undertaken a full 12-month fellowship (see Appendix—Table 1) and 83 % of those undertaking a fellowship did so in a teaching hospital, with the remaining 17 % working in a general hospital or private practise.

A significant difference in competency levels was defined as a 20 % difference between AOSpine members who have undertaken a full fellowship versus those who have not. Our results have demonstrated that there was no significant difference in theoretical knowledge or practical skills between those who have been trained as orthopaedic surgeons versus those trained as neurosurgeons. However, significant differences were noted when the group which completed fellowship training was compared to those who have not.

With regards to theoretical knowledge, respondents from both groups were competent in the majority of areas related to spine surgery, excluding competency in spinal deformity, where a 27 % increase in competency was seen when upon completion of a fellowship. Significant differences began to emerge when assessing practical skill competency, especially in the management of emergency conditions with both groups exhibiting a similar level of competence in the surgical management of elective conditions. The only exception was the surgical management of spinal deformity, where a difference of 32 % was noted in favour of the fellowship group.

With regards to emergency surgical procedures, our results demonstrated a significant difference in the competency levels of those who had undertaken a full fellowship, versus those who had not, in the following areas: cervical spine trauma (24 %), anterior cervical stabilisation

(22 %), posterior cervical stabilisation (28 %), lumbar and thoracic trauma (28 %), anterior lumbar and thoracic stabilisation (26 %) and its complications (23 %).

A competency assessment of the fellowship group was performed in addition (Appendix—Table 2). This revealed that 10 % of AOSpine post-fellowship members cannot perform an anterior cervical stabilisation without supervision and 27.5 % were unable to perform an anterior lumbar stabilisation without direct supervision. 24 % of the group reported to be unable to perform posterior stabilisation of the cervical spine without supervision. Posterior stabilisation of the lumbar spine was a procedure that post-fellowship members felt more comfortable with; no members were unable to perform surgery and only 2.5 % required direct supervision. In the management of cervical and lumbar trauma, supervision was required by 20 and 11 % of responders, respectively. In managing complications, 45 % of surgeons who completed a spinal fellowship rated themselves as being able to deal with all post-operative complications, but only 22.5 % stated that they were able to deal with the vascular complications of anterior surgery. Overall, 59 % required supervision to manage vascular complications of anterior lumbar spinal surgery. There was a similar disparity in the management of dural complications (lacerations) in posterior surgery, where 16 % of responders were in need of supervision.

Analysis of the quality of previous training (appendix—Table 4) revealed that 66 % of respondents were competent in spinal imaging at the end of their orthopaedic/neurosurgical training. 73 % were competent in spinal surgery (both theory and practise), and 50 % were competent in the use of a microscope. Interestingly, of the whole group only 43 % were competent in the actual practise of conservative management of spinal conditions (Fig. 1).

Discussion

Subspecialisation is becoming increasingly more prevalent in medicine, resulting in more cost-effective and comprehensive patient care [3, 7]. Due to the great number of different conditions embraced by spinal surgery, orthopaedic and neurosurgical training are unable to cover all aspects of treatment leaving some trainees with deficits in the management of even the most prevalent spinal conditions [7]. A comprehensive list of spinal conditions that both residencies should be familiar with can be found in Herkowitz et al. Resident and fellowship guidelines: educational guidelines for resident training in spinal surgery [8]. Even the most respected accredited residency training programmes will not

be able to fully prepare the surgeon to be competent in the vast and complex area of spinal surgery.

It is advised, therefore, that those intending to specialise in spinal surgery should pursue additional training with a sufficient caseload to ensure adequate exposure to spinal pathology, which is the most important predictor of both the surgeons' subjective confidence and improved patient outcomes [2, 5, 9, 10].

The majority of AOSpine members who responded to the questionnaire came from an orthopaedic background. This is surprising given the fact that spinal surgery is a more popular career choice amongst neurosurgically trained surgeons [2, 11, 12]. It is difficult to establish whether this finding is a result of a disparity in the response rate between orthopaedic surgeons and neurosurgeons or whether it is due to the high prevalence of orthopaedic surgeons in the AOSpine organisation; however, similar trends have been observed in previous studies [2, 13].

Despite differences in training and variable exposure to spinal ailments, the results of our survey indicated that self-assessed competency of orthopaedic and neurosurgical trainees in their theoretical and practical aspects of the spinal training was similar. These findings are not consistent with outcomes of similar research in the field. Previous studies have shown that neurosurgical residents are more competent at performing spine-related procedures than their orthopaedic colleagues [2, 12]. This is largely due to the amount of training devoted to spine-related disease, which is a major constituent of the neurosurgical training agenda.

Significant differences in time and exposure to spine training differentiated the neurosurgical and orthopaedic residencies (37 and 16 % of total residency time devoted to spine, respectively) [2]. Orthopaedic training focuses on the entirety of the musculoskeletal system, including bone physiology, musculoskeletal malignancy and rehabilitation. The exposure to spinal conditions is restricted, as it is assumed that orthopaedic residents wishing to further pursue the specialty of spinal surgery will enrol in further subspecialty training [12]. There is a possibility that our results have been subjected to responder bias, or results were influenced by the fact that the study was performed on groups, which were specifically interested in spine surgery. Orthopaedic trainees may have had significant exposure to spinal disease for a prolonged period of time following their residency, allowing them to achieve a similar level of competence in this subspecialty to neurosurgeons.

Training in European residency spinal programmes has clear strengths, especially in the field of spinal surgery, where a majority of trainees become competent at

Figs. 1–7 Comparison of competence in performing spinal procedures in AOSpine members who completed a spinal fellowship versus those who have not. *Poor* not able to perform the procedure, *Basic* able to perform the procedure under direct senior supervision, *Good* able to perform the procedure without supervision, *Excellent* able to deal with all complications and difficulties which may arise

managing elective procedures. Regardless of the speciality, weakness was displayed in the conservative management of spinal conditions, where only 43 % of respondents felt confident in the area.

In a previous study, it was shown that a significant proportion of senior orthopaedic/neurosurgical residents are actively interested in pursuing further education in spinal surgery [3]. This trend can be seen in multiple surgical specialties, where upon completing specialist training, surgeons embark on further subspecialty training [4]. In the field of orthopaedics, over 60 % of surgeons enrol in some form of fellowship after the completion of specialty training [7]. Further education allows for improvement in areas that were not covered in depth in residency training,

making the individual not only more employable in the future [7], but allowing for the development of good relationships with a mentor that can last even after the completion of the fellowship.

The results of our study indicate that a fellowship in spinal surgery can significantly improve competence in a number of surgical procedures. A significant (>20 %) difference between those who have completed a fellowship versus those who have not has been noted in the practical aspects of treatment in the following areas of spinal surgery: spinal deformity, cervical spine trauma, cervical stabilisation, lumbar and thoracic trauma and anterior surgery and its complications. This indicates that the fellowship period allows for significant exposure of

Figs. 1–7 continued

the fellow to these conditions, allowing for greater proficiency in their management. These findings are in keeping with the belief that experience is positively correlated to improved surgical outcomes [2, 5, 9, 10]. The influence of the spine fellowship on the management of intradural tumour surgery cannot be properly assessed due to a small sample size not representing competence of the AOSpine group as a whole in these types of procedures.

The fellowship group had significantly increased self-perceived competency levels in both the theoretical and practical aspects of spinal deformity when compared with surgeons with no-fellowship training. This finding reflects upon the neurosurgical and orthopaedic residency curricula, which fail to provide the trainees with sufficient exposure to this field of spinal pathology to ensure competency. This is likely to be a consequence of the complexity of the surgical management of spinal deformity, which requires specialised tertiary centres that can individually tailor surgical procedures to each patient [14, 15]. Access to such facilities may not be readily available for a significant proportion of neurosurgical and orthopaedic residents, thus limiting their experience in this field of spinal surgery. We believe that a clearly defined curriculum of a fellowship, with the fellow playing a central role in the management of spinal disorders, should be formulated by a named programme director. It has been suggested previously that a spinal fellowship should incorporate at least 250 cases per year for each fellow [16], and have a wide spectrum of spinal disorders ranging from degenerative disease, deformities

and trauma to paediatrics and reconstruction. There should be multidisciplinary input from both orthopaedic and neurosurgical specialists, allowing for the fellow to gain differing perspectives with regards to surgical decision-making in addition to the technical skills necessary for delivering high quality care. The facility must provide the fellow with access to a sufficient number of inpatient and outpatient cases to be able to gain the necessary expertise in the care of spinal patients. The staff should allow for the fellowship to be an educational experience with a strong academic component and refrain from the service-orientated approach. For these reasons, spinal fellowships should be ideally undertaken in large tertiary centres with a high case-per-day ratio and significant experience in managing complex spinal conditions.

Based on the results of the study there is a considerable variation in the competency of post-fellowship spinal surgeons in the management of frequently encountered spinal conditions mainly because of a lack of uniformity in the surgical curriculum, with many fellowships being preceptorships due to inadequate regulation of their content [17].

In our study, 10 % of those who undertook a fellowship cannot perform anterior cervical stabilisation without supervision, which would be deemed unsatisfactory of a spinal surgeon expected to deal with emergent cases. The reason behind this is hard to evaluate, due to the lack of previous research in this area. 24 % of post-fellowship AOSpine members do not feel confident in performing posterior cervical stabilisation without supervision. 27.5 %

cannot independently perform anterior lumbar stabilisation; however, 97.5 % are competent at performing posterior lumbar stabilisation. Due to most vertebral lesions affecting the anterior spine [18], it is a logical assumption that one would therefore expect an anterior approach to be in the repertoire of a competent spinal surgeon. However, due to the difficulty of access (need to pass through various anatomical regions), it is rarely performed without the help of appropriate specialists. In addition, fixation methods using this approach are not as good as stabilising vertebral structures as the posterior approach [18]. For these reasons, the anterior approach is less commonly utilised, resulting in reduced competence amongst respondents.

The management of spinal trauma is also an issue, with 20 and 11 % of responders being unable to manage cervical and lumbar trauma, respectively. This is a recognised deficit in spinal surgery training as a whole, with 34–48 % of senior trainees being incompetent in managing such cases [3]. Despite the fellowship having a positive impact on competence in this area, there is still a significant minority who cannot effectively manage these commonly encountered conditions that have a worldwide incidence of 2.5–57.8 per million per annum [19]. This probably results from the variation in fellowship programmes, with some favouring elective procedures at the cost of exposure to emergency cases [7, 16].

Disparity can also be seen in the management of complications arising from spinal surgery, with 59 % requiring supervision when managing vascular complications of anterior lumbar spinal surgery, and 16 % when managing dural complications of posterior surgery. It is a rare complication occurring in only 4 % of lumbar spine procedures [18]. Due to its rarity, respondents are in all likelihood not offered many occasions to familiarise themselves with the treatment of these complications. Since this study only highlights the types of deficiencies, there is a need to further investigate the underlying reasons for all the deficits in the management of these common conditions.

Candidates willing to enrol in fellowships have no official guidelines to evaluate the efficacy of these programmes other than verbal recommendations and/or faculty recognition [8]. We believe that this situation necessitates serious discussion amongst clinical educators and professional organisations and societies to develop innovative training models to accommodate for the increasing knowledge base and reduced training time due to European Working Time Directives. It has been suggested that a complete reappraisal of the educational system, focusing on competency-based training, is the best solution [20]. A thorough evaluation of the fellows' skills in respect of spinal disease management should be per-

formed at regular intervals throughout the fellowship, and the results communicated to trainees [8]. A minimum of one assessment performed every 6 months is recommended [21, 22]. Performance should be assessed by considering a large volume of separate occurrences, where the fellow has employed skills, knowledge and clinical judgement relevant to the field of spinal surgery. The fellow should also have an opportunity to provide feedback concerning the fellowship itself, discussing it with the programme director. This study is only a catalyst for further discussion, which should concentrate on establishing a standardised core curriculum and objectives in spinal fellowship training. Programmes should ensure adequate exposure to and training in all aspects of spinal surgery. They should be accredited by a central governing body composed of specialists in the area of spinal surgery.

Several limitations of the study require consideration when interpreting this data. The low response rate was due to the size of the AOSpine organisation, which comprises of over six thousand members making an active follow-up of non-responders unfeasible. The low response rate may have introduced an element of non-response bias; however, we do believe that a sample size of 289 responders is sufficient for achieving the objectives of the study. Surgeons were made to assess their own "competence", which can be translated as a subjective measure of confidence of the individual in performing procedures and understanding concepts related to spinal surgery. As such, it omits the measurement of true aspects of "competence" such as professionalism, bedside manner, objective skill level acquisition etc. Despite the possibility of personal bias, it is reasonable to assume that AOSpine members have developed a basic capacity for honest introspective self-reflection throughout the course of their training.

One may argue that a selection bias is present when comparing the fellowship and the no-fellowship groups. The respondents who chose to undergo a spinal surgery fellowship may have had more motivation and/or baseline competency when compared with AOSpine members who began their clinical practise immediately after residency, thus overestimating the impact of a fellowship in improving theoretical and practical competence in various areas of spinal surgery.

Some of the questions may have been misinterpreted by the participants of the study, and it is difficult to assess the degree of this phenomenon. Data regarding the age of the surgeon and surgical experience were not collected. No enquiries were made regarding the country in which the spinal surgery fellowship was undertaken or the year in which it was completed. Such data would have allowed for the evaluation of spinal surgery fellowship programmes in different countries, as well as for assessing the

transformation of spinal surgery fellowship curricula over the years. However, due to the size of the study population, we believe that such comparisons would not bear statistical significance. Other than the respondents' own perception of exposure to spinal disorders, there has been no quantitative assessment of such exposure, such as patient notes, theatre lists etc.

Conclusions

In order to provide an efficient, routine and emergency service a spinal surgeon should be competent at performing procedures aimed at stabilising acute spinal instability and conditions which threaten neurological structures. A formal fellowship curriculum for spinal training should reasonably ensure such competencies.

There is a significant difference in the self-assessed competency levels of those who had undertaken a full fellowship, versus those who had not, in the following surgical skills: spinal deformity, cervical spine trauma, cervical stabilisation, lumbar and thoracic trauma, anterior and posterior surgery and its complications.

Study data suggest that even after the completion of a formal spinal fellowship, spinal surgeons do not feel that they have achieved competence in managing the vast array of conditions embraced by spinal surgery, which indicates that support from more experienced colleagues is necessary in the initial period following completion of training.

The study did not reveal any significant difference in theoretical knowledge or practical skills between orthopaedic surgeons and neurosurgeons in the field of spine surgery among AOSpine members.

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Conflict of interest None.

Appendix

See Fig. 2.

See Tables 1, 2, 3, 4.

Spine Subspecialty Questionnaire

Please only mark one appropriate answer to each question

1. In which country are you completing your residency training?

2. What is your year of residency training?

1	2	3	4	5	6	completed
1 year post training	2 years post training				3 or more years post training	

3. In what type of institution are you completing your residency training?

1	2	3	4
University or teaching hospital	general hospital	private practice	other

4. What type of spine surgery sub specialisation does your institution have?

1	2	3
Sub specialised department	dedicated sub specialised surgeon	no sub specialisation

5. Have you had specific spinal surgery training (e.g. fellowship) in addition to your general (residency) training?

1	2	3	4
Full (12 months) fellowship	short (< 6 months) fellowship	informal rotation	none

6. How many spinal procedures are performed yearly in your department?

1	2	3
0-100	100-1000	>1000

7. What percentage of the procedures performed yearly by your department are spinal procedures?

1	2	3	4
>80%	80-50%	50-20%	<20%

8. How many spinal procedures will you have performed by the end of residency?

1	2	3	4
<100	100-300	300-500	>500

9. In your institution, which speciality treats the following spine conditions:

Spinal cord injury

1	2	3	4
Neurosurgery	orthopaedic surgery	interdisciplinary approach	not treated

Cervical spine injury (decompression and stabilisation)

1	2	3	4
Neurosurgery	orthopaedic surgery	interdisciplinary approach	not treated

Thoracic and lumbar spine injury (decompression and stabilisation)

1	2	3	4
Neurosurgery	orthopaedic surgery	interdisciplinary approach	not treated

Spinal deformity

1	2	3	4
Neurosurgery	orthopaedic surgery	interdisciplinary approach	not treated

Spinal tumours (extradural)

1	2	3	4
Neurosurgery	orthopaedic surgery	interdisciplinary approach	not treated

Spinal stenosis and disc herniation

1	2	3	4
Neurosurgery	orthopaedic surgery	interdisciplinary approach	not treated

Spine arthroplasty procedures (non-fusion procedures such as disc prosthesis etc.)

1	2	3	4
Neurosurgery	orthopaedic surgery	interdisciplinary approach	not treated

10. How do you rate the quality of training on spinal imaging (MRI, CT, functional x-ray) you received during your residency?

1	2	3	4
Excellent	good	basic	poor

Fig. 2 Copy of the questionnaire which was available on the AOSpine website

11. How do you rate the quality of training in conservative spinal treatment you received during your residency (pain management, nerve blocks, facet blocks etc.)?

Theoretical skills:

1	2	3	4
Excellent	good	basic	poor

Practical skills:

1	2	3	4
Excellent	good	basic	poor

12. How do you rate the quality of training in spinal surgery you received during your residency ?

Theoretical training:

1	2	3	4
Excellent	good	basic	poor

Practical training:

1	2	3	4
Excellent	good	basic	poor

13. Are you competent in treatment of cervical disc herniation and cervical spinal stenosis (anterior technique)?

Theoretical skills:

1	2	3	4
Excellent	good	basic	poor

Practical skills:

- 4 **Not able** to perform the procedure
- 3 Can perform the procedure under **direct supervision**
- 2 Can perform the procedure **without direct supervision**
- 1 Can **deal with complications** and difficulties, which may arise

14. Are you competent in treatment of lumbar disc herniation and stenosis (laminotomy technique)?

Theoretical skills:

1	2	3	4
Excellent	good	basic	poor

Practical skills:

- 4 **Not able** to perform the procedure
- 3 Can perform the procedure under **direct supervision**
- 2 Can perform the procedure **without direct supervision**
- 1 Can **deal with complications** and difficulties, which may arise

15. Are you competent in extradural tumour surgery (e.g. metastatic spinal canal compromise)?

Theoretical skills:

1	2	3	4
Excellent	good	basic	poor

Practical skills:

- 4 **Not able** to perform the procedure
- 3 Can perform the procedure under **direct supervision**
- 2 Can perform the procedure **without direct supervision**
- 1 Can **deal with complications** and difficulties, which may arise

Fig. 2 continued

16. Are you competent in intradural tumour surgery (e.g. spinal meningeoma)?

Theoretical skills:

1	2	3	4
Excellent	good	basic	poor

*Practical skills:*4 **Not able** to perform the procedure3 Can perform the procedure under **direct supervision**2 Can perform the procedure **without direct supervision**1 Can **deal with complications** and difficulties, which may arise

17. Are you competent in surgery for dysraphic conditions (e.g. myelomeningocele, tethered cord)?

Theoretical skills:

1	2	3	4
Excellent	good	basic	poor

*Practical skills:*4 **Not able** to perform the procedure3 Can perform the procedure under **direct supervision**2 Can perform the procedure **without direct supervision**1 Can **deal with complications** and difficulties, which may arise

18. Are you competent in spinal deformity techniques (e.g. idiopathic scoliosis)?

Theoretical skills:

1	2	3	4
Excellent	good	basic	poor

*Practical skills:*4 **Not able** to perform the procedure3 Can perform the procedure under **direct supervision**2 Can perform the procedure **without direct supervision**1 Can **deal with complications** and difficulties, which may arise

19. Are you competent in emergency management of cervical spinal trauma?

Theoretical skills:

1	2	3	4
Excellent	good	basic	poor

*Practical skills:*4 **Not able** to perform the procedure3 Can perform the procedure under **direct supervision**2 Can perform the procedure **without direct supervision**1 Can **deal with complications** and difficulties, which may arise20. Are you competent in anterior cervical stabilisation techniques?*Theoretical skills:*

1	2	3	4
Excellent	good	basic	poor

Fig. 2 continued

Practical skills:			
4 Not able to perform the procedure			
3 Can perform the procedure under direct supervision			
2 Can perform the procedure without direct supervision			
1 Can deal with complications and difficulties, which may arise			
21. Are you competent in <u>posterior</u> cervical stabilisation techniques?			
Theoretical skills:			
1	2	3	4
Excellent	good	basic	poor
Practical skills (stabilisation C3 to C7):			
4 Not able to perform the procedure			
3 Can perform the procedure under direct supervision			
2 Can perform the procedure without direct supervision			
1 Can deal with complications and difficulties which may arise			
22. Are you competent in craniocervical stabilisation techniques?			
Theoretical skills:			
1	2	3	4
Excellent	good	basic	poor
Practical skills (stabilisation C0 to C2):			
4 Not able to perform the procedure			
3 Can perform the procedure under direct supervision			
2 Can perform the procedure without direct supervision			
1 Can deal with complications and difficulties, which may arise			
23. Are you competent in emergency management of thoracic and lumbar spinal trauma?			
Theoretical skills:			
1	2	3	4
Excellent	good	basic	poor
Practical skills:			
4 Not able to perform the procedure			
3 Can perform the procedure under direct supervision			
2 Can perform the procedure without direct supervision			
1 Can deal with complications and difficulties, which may arise			
24. Are you competent in <u>posterior</u> thoracic and lumbar stabilisation techniques?			
Theoretical skills:			
1	2	3	4
Excellent	good	basic	poor
Practical skills:			
4 Not able to perform the procedure			
3 Can perform the procedure under direct supervision			
2 Can perform the procedure without direct supervision			
1 Can deal with complications and difficulties, which may arise			

Fig. 2 continued

25. Are you competent in dealing with dural lacerations in posterior spine surgery?*Theoretical skills:*

1	2	3	4
Excellent	good	basic	poor

Practical skills:

- 4 **Not able** to perform the procedure
- 3 Can perform the procedure under **direct supervision**
- 2 Can perform the procedure **without direct supervision**
- 1 Can **deal with complications** and difficulties, which may arise

26. Are you competent in anterior thoracic and lumbar stabilisation techniques?*Theoretical skills:*

1	2	3	4
Excellent	good	basic	poor

Practical skills:

- 4 **Not able** to perform the procedure
- 3 Can perform the procedure under **direct supervision**
- 2 Can perform the procedure **without direct supervision**
- 1 Can **deal with complications** and difficulties, which may arise

27. Are you competent in dealing with vascular complications in anterior thoracic and lumbar spine surgery?*Theoretical skills:*

1	2	3	4
Excellent	good	basic	poor

Practical skills:

- 4 **Not able** to perform the procedure
- 3 Can perform the procedure under **direct supervision**
- 2 Can perform the procedure **without direct supervision**
- 1 Can **deal with complications** and difficulties, which may arise

28. Do you think there is a need for optional (post-residency) spine subspecialty training?

1	2	3
Yes	maybe	no

29. Do you think stabilisation techniques should be part of your general speciality training or subspecialty spine training?

1	2
Subspecialty only	general training

30. Do you think anterior thoracic and lumbar approaches should be part of your general speciality training or subspecialty spine training?

1	2
Subspecialty only	general training

31. How do you rate your training in the use of a surgical microscope?

1	2	3	4
Excellent	good	basic	poor

Fig. 2 continued

32. Do you think a subspecialty period of one year (after completion of the current 5–6 year national speciality training program) should be considered in order to provide a certification of competence in a given subspecialty?

1 2 3
Yes maybe no

33. Would you personally be interested in a subspecialty spine fellowship training program (minimum 1 year)?

1 2 3
Yes maybe no

34. Do you think a combined (neurosurgery and orthopaedic) spine fellowship should be offered?

1 2 3
Yes maybe no

35. Do you think the supranational neurosurgical and orthopaedic organisations (such as EANS and EFORT) should develop spine subspecialty training programs and fellowships?

1 2 3
Yes maybe no

36. Are you a neurosurgeon (or neurosurgical resident) or an orthopaedic surgeon (or orthopaedic resident)?

1 2 3
Neurosurgeon both orthopaedic surgeon

Please place any comments here:

Thank you for your participation!

Fig. 2 continued

Table 1 Assessment of the fellowship experience amongst AOSpine members

Duration of fellowship	Full (12 months) fellowship	Short fellowship (<6 months)	Informal rotation	None	No recorded response
Number	80	47	78	73	11

Table 2 Assessment of competence of theoretical aspects of spinal surgery in AOSpine members who completed spinal fellowship training (*full*) versus those who did not (*none*)

	Excellent		Good					Basic		Poor	
	Full	None	Full	None	Full (%)	None (%)	(%)	Full	None	Full	None
Elective											
Cervical disc herniation and cervical stenosis	41	62	22	87	79	71	−7	7	31	0	18
Lumbar disc herniation and stenosis	53	88	18	81	89	81	−8	1	21	0	5
Extradural tumour surgery	41	54	17	83	73	66	−7	8	36	5	23
Intradural tumour surgery	13	37	15	36	35	35	0	15	53	22	67
Surgery for dysraphic conditions	3	15	18	64	26	38	12	24	51	26	66
Spinal deformity	26	30	28	55	68	41	−27	10	75	8	38
Emergency											
Cervical spine trauma	43	70	23	82	83	73	−10	5	31	1	9
Anterior cervical stabilisation	49	85	18	66	84	72	−12	2	36	3	8
Posterior cervical stabilisation	44	55	17	76	76	63	−14	11	49	0	12
Cranio-cervical stabilisation	24	45	29	69	66	55	−12	13	51	4	28
Lumbar and thoracic trauma	49	76	19	85	85	77	−8	3	32	0	4
Posterior thoracic and lumbar stabilisation	55	91	14	84	86	84	−3	1	18	0	3
Anterior lumbar and thoracic stabilisation.	37	53	25	75	78	61	−16	19	54	1	16
Complications											
Posterior dural tears	49	63	19	94	85	75	−10	6	29		8
Vascular complications of anterior thoracic and lumbar stabilisation	16	22	29	65	56	42	−15	18	72	9	38

Competence defined as “excellent” or “good” understanding of the condition

Table 3 Assessment of competence of practical aspects of spinal surgery in AOSpine members who completed spinal fellowship training (*full*) versus those who did not (*none*)

	Can deal with complications		Perform without supervision							Perform with supervision		Not able to perform	
	Full	None	Full	None	Full (%)	None (%)	(%)	Full	None	Full	None	Full	None
Elective													
Cervical disc herniation and cervical stenosis	44	82	17	40	61	122	76	58	−18	7	37	3	38
Lumbar disc herniation and stenosis	57	113	12	32	69	145	86	69	−17	2	36	0	16
Extradural tumour surgery	44	70	9	43	53	113	66	54	−12	13	43	3	35
Intradural tumour surgery	12	43	10	18	22	61	28	29	2	17	28	29	100
Surgery for dysraphic conditions	7	24	13	22	20	46	25	22	−3	12	45	38	105
Spinal deformity	32	34	14	20	46	54	58	26	−32	16	63	11	75
Emergency													
Cervical spine trauma	45	79	21	44	66	123	83	59	−24	7	44	1	30
Anterior cervical stabilisation	46	87	18	34	64	121	80	58	−22	5	44	3	29
Posterior cervical stabilisation	43	59	18	42	61	101	76	48	−28	10	53	1	38
Cranio-cervical stabilisation	26	42	22	43	48	85	60	41	−19	18	48	5	61
Lumbar and thoracic trauma	52	85	16	34	68	119	85	57	−28	4	52	0	23
Posterior thoracic and lumbar stabilisation	57	102	12	48	69	150	86	72	−14	2	29	0	17
Anterior lumbar and thoracic stabilisation.	33	51	20	34	53	85	66	41	−26	13	50	4	60
Complications													
Posterior dural tears	45	94	19	47	64	141	80	67	−13	5	38		15
Vascular complications of anterior thoracic and lumbar stabilisation	18	17	19	32	37	49	46	23	−23	25	61	11	85

Competence defined as being able to perform the procedure without direct supervision (*good*), or being able to perform the procedure without direct supervision and being able to deal with complications and difficulties, which may arise (*excellent*)

Table 4 Analysis of the quality of training and its association with competence, defined as an “excellent” or “good” comprehension of given topics

Quality of training	Excellent	Good	Basic	Poor	No response	Number competent	Percentage competent (%)
Conservative management (theory)	32	127	80	37	13	159	55
Conservative management (practise)	33	92	92	56	16	125	43
Spinal imaging	77	115	65	16	16	192	66
Use of microscope	83	62	68	56	20	145	50
Spinal surgery (theory)	68	142	52	9	18	210	73
Spinal surgery (practise)	81	129	52	14	13	210	73

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