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ORIGINAL ARTICLE

Universal disease-specific outcome instruments for spine trauma: a global perspective on relevant parameters to evaluate clinical and functional outcomes of thoracic and lumbar spine trauma patients

Said Sadiqi[1] · Jorrit-Jan Verlaan[1] · A. Mechteld Lehr[1] · Marcel F. Dvorak[2] · Frank Kandziora[3] · S. Rajasekaran[4] · Klaus J. Schnake[5] · Alexander R. Vaccaro[6] · F. Cumhur Oner[1]

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Abstract
Purpose Besides a patient reported outcome measure, the AOSpine Knowledge Forum Trauma aims to develop a new concept of a surgeon reported outcome measure (SROM) for spine trauma patients. This study aims to identify parameters that spine surgeons consider relevant to evaluate clinical and functional outcomes of thoracic and lumbar spine trauma patients.
Methods An international cross-sectional web-based survey was conducted among spine surgeons from the five AOSpine International world regions. They were asked to evaluate the relevance of a compilation of 16 clinical and radiological parameters for thoracic and lumbar spine trauma patients, both for the short term (3 months–2 years) and long term (≥2 years), on a five-point scale. The responses were analyzed using descriptive statistics, frequency analysis, and Kruskal–Wallis test.
Results Out of the 279 invited members of AOSpine International and the International Spinal Cord Society, 118 (42.3 %) participated in this study. Of the 16 surveyed parameters, 5 were identified as relevant by at least 70 % of the participants. *Neurological status* was identified as most relevant. In contrast, five parameters were not deemed relevant for any spine region or time period, except for *comorbidity*. Only minor differences were observed when analyzing the responses according to each world region, spine surgeons' clinical experience, or professional background.
Conclusions Including a large and representative sample of spine trauma experts, this study identified parameters to evaluate clinical and functional outcomes of thoracic and lumbar spine trauma patients. The results form the basis for the development of a SROM for this specific patient population.

Keywords Expert survey · Clinician perspective · Clinical and radiological parameters · Outcome instrument · Spine trauma

✉ Said Sadiqi
s.sadiqi-3@umcutrecht.nl

[1] Department of Orthopaedics, University Medical Center Utrecht, HP G05.228, P.O. Box 85500, 3508 GA Utrecht, The Netherlands

[2] Department of Orthopaedics, University of British Columbia, Vancouver, BC, Canada

[3] Center for Spinal Surgery, BGU-Hospital, Frankfurt, Germany

[4] Department of Orthopaedic and Spine Surgery, Ganga Hospital, Coimbatore, India

[5] Center for Spinal Surgery, Schön Klinik Nürnberg Fürth, Fürth, Germany

[6] Department of Orthopaedics, Thomas Jefferson University, Philadelphia, PA, USA

Introduction

Controversy remains regarding the evaluation and optimal treatment of many types of spine injuries [1–4]. In the absence of an outcome instrument specifically designed and validated for spine trauma patients, it is difficult to compare different treatment options, and to develop more rational choices for treatment strategies. Therefore, the AOSpine Knowledge Forum Trauma aims to develop and validate such instruments for adult spine trauma patients that reflect both the patients' and clinicians' perspectives [5]. The patient reported part, named AOSpine Patient

Reported Outcome Spine Trauma (AOSpine PROST), has already been developed and being validated in international multicenter studies. Besides this AOSpine PROST, the Knowledge Forum decided to develop a new concept of a surgeon reported outcome measure (SROM) to reflect the perspective of the treating surgeons. Their perspective is predominantly based on clinical and radiological assessments, and may differ substantially from the patients' perspective [6, 7]. A SROM tool is needed to formalize the most relevant assessment parameters as a simple, reliable and quick to administer tool that is completed by the treating surgeons, and is able to predict the clinical outcomes of spine trauma patients. Together with the independent patient reported outcome, the SROM provides a holistic view of patients' function and health status.

First, it should be investigated what the SROM would consist of in order to reflect the surgeons' perspective adequately. Therefore, surveys were conducted among international spine trauma experts in order to identify relevant clinical and radiological parameters. Considering the anatomical and functional differences and treatment practices of different spine regions, two separate surveys were conducted: one focusing on the thoracic and lumbar spine and another on the cervical spine. The objective of this paper is to report on the results of the first survey that aimed to identify the parameters that spine surgeons consider to be relevant when evaluating clinical and functional outcomes of patients sustaining a traumatic injury to the thoracic and lumbar spine.

Materials and methods

Study design

This study was conducted as a cross-sectional web-based survey among spine surgeons from all five AOSpine International world regions (Asia Pacific, Europe and Sub Saharan Africa, Latin America, Middle East and North Africa, and North America).

Recruitment of participants

Potential participants were recruited through AOSpine International. We aimed to include a worldwide sample of spine surgeons with substantial expertise in spine trauma care, as well as an interest in outcome assessment and classification for this specific patient population. Based on these prerequisites, members of the AOSpine Knowledge Forums Spinal Cord Injury and Trauma ($n = 10$), [5] members of the spine trauma study group of the International Spinal Cord Society (ISCoS) ($n = 10$), [8] initial responders in the preparatory expert survey of AOSpine PROST development ($n = 200$), [9] and experts involved in the international validation of the novel AOSpine Thoracolumbar Spine Injury Classification System ($n = 100$) [10] were considered potential participants. Taking into account the overlap between these groups and excluding experts without sufficient contact details, a personal email invitation with an electronic link to the survey was sent to a total of 279 experts. Eligibility criteria were defined as orthopedic-, trauma- or neurosurgeon with at least 5 years of experience in the treatment of adult spine trauma patients. Sufficient command of the English language was required to complete the survey.

Survey instrument

The survey questionnaire consisted of two parts. In the first part, participants were asked about their professional background.

The second part of the survey was subdivided into three parts. Each subpart focused on one specific anatomic spine region, defined as the thoracic spine (T1–T10), thoracolumbar junction (T11–L2), and lumbar spine (L3–L5), respectively. Each part started with a general case, representing a spinal trauma case after conservative or operative treatment ("Appendix 1"), followed by a predefined compilation of 16 clinical and radiological parameters ("Appendix 2"). These parameters were based on: (1) parameters identified in the systematic literature review of AOSpine PROST development, [11], (2) parameters used by the AOSpine Thoracolumbar Spine Injury Classification System, [12] and (3) expert interviews among three spine surgeons from a level-1 trauma center. Participants of the survey were asked to indicate the relevance of each parameter for the clinical and functional outcome of adult ($\geq$18 years) patients who suffered an acute traumatic injury to the thoracic, thoracolumbar or lumbar spine, both for the short-term (3 months–2 years) and long-term ($\geq$2 years) post-trauma on a five-point scale: 'definitely not relevant', 'probably not relevant', 'possibly relevant', 'probably relevant', and 'definitely relevant'. Relevance was further defined by the authors as the parameter being associated with-, related to-, and considered to be important for the clinical and functional outcome of spine trauma patients. The parameter *age*, described as the age of patients that, in the absence of serious medical comorbidities, could influence their outcome, was surveyed in an open question. Finally, free text fields were provided at the end of each subpart to enable the respondents to add any missing parameters or general comments.

Data collection

The survey was conducted in November and December 2014. All invited experts received a reminder after 2 and 3 weeks. An additional reminder was sent to the region with the lowest response rate. All responses were recorded and analyzed anonymously.

Statistical analysis

The characteristics of the participants and the additional open question about the age that could influence patient outcome were analyzed using descriptive statistics. For the surveyed parameters, absolute and relative frequencies of relevance were calculated, along with their 95 % confidence interval. The response options 'probably relevant' and 'definitely relevant' were analyzed to indicate the relevance of each parameter. Furthermore, various subanalyses were performed using descriptive statistics and Kruskal–Wallis test (significance level 0.05) to identify possible differences in responses between: (1) world regions, (2) degree of clinical experience (up to 10, 11–20 years or more than 20 years), (3) perspectives of orthopedic surgeons and neurosurgeons, and (4) surgeons with and without a completed spine fellowship.

Results

Response rate

Out of 279 experts who received the survey, 147 (52.7 %) responded to the study invitation. A total of 118 (42.3 %) participated in this study as some of the responders did not meet the inclusion criteria ($n = 8$) or only completed the background data ($n = 21$). The socio-demographic characteristics of the participants are shown in Table 1. The majority of the participants were males (97.5 %), consistent with the demographics of spine surgeons. The mean age was 46.3 years and the mean years of experience 16.3 years (range 5–42 years). The experts were from 44 different countries, representing all AOSpine International world regions. With 92.4 %, the main working field of the participants was the clinical practice.

Relevance of parameters

The relevance of each parameter for patients with traumatic thoracic, thoracolumbar, and lumbar spine injuries is shown in Tables 2, 3 and 4, respectively. *Neurological status* was identified as the most relevant parameter for all defined spine regions, as well as for the short term and long term. Although less relevant than *neurological status*, four other parameters were also identified as relevant by at least 70 % of the participants for all defined spine regions and time periods: *implant failure within 3 months*, *patient satisfaction*, *sagittal alignment (kyphosis)*, and *age*. *Patient's current level of pain* and *mobility* seemed to be relevant for the thoracolumbar and lumbar spine only. Furthermore, three parameters (*surgical site infections*, *misplacement of implants*, and *implant failure after 6 months*) were found to be relevant specifically for the short term and one parameter (*bony fusion*) for the long term, regardless of the spine region. The remaining five parameters (*comorbidity*, *coronal alignment (scoliosis)*, *vertebral body height loss*, *spinal canal encroachment on trauma CT/MRI*, and *disc height loss*) were not identified as relevant, except for *comorbidity* being relevant for the lumbar spine in the short term.

As shown in Table 5, no large differences were observed for the age that, in the absence of serious medical comorbidities, substantially may influence outcome of the defined group of patients (range of means 50.1–54.1 years).

Regional differences

Minor differences were observed when analyzing the responses according to each world region. In general, the North American participants were most likely to consider parameters as least relevant. Parameters identified as relevant by at least 70 % of the participants among all world regions are indicated in Tables 2, 3 and 4.

Concerning the thoracic spine, for the short term the largest differences in responses were observed for the parameters *vertebral body height loss* (range 6.3–72.7 %; $p < 0.001$) and *spinal canal encroachment on the trauma CT/MRI* (range 18.8–84.8 %; $p < 0.001$), being least relevant for North American participants and most relevant for Latin American participants. For the long term, besides these two parameters ($p < 0.05$), *surgical site infections* also showed large interregional differences (range 31.3–87.9 %; $p < 0.001$).

For the thoracolumbar spine, it was notable that the parameters *mobility* and *vertebral body height loss* were found much less relevant by the North American participants compared to the other world regions, both for the short term ($p \leq 0.004$), and long term ($p \leq 0.038$).

The same pattern was seen for the lumbar spine. For the short term, *misplacement of implants* was relevant for 53.3 % of the North American participants, while the relevance among the other world regions ranged from 82.8 to 90.0 % ($p = 0.069$). The largest differences among all world regions were seen for *vertebral body height loss*, both on the short term (range 13.3–79.2 %; $p < 0.001$) and long term (range 20.0–75.0 %; $p = 0.012$).

Table 1 Characteristics of surveyed experts ($n = 118$)

Male (%)	115 (97.5 %)
Age, mean ± SD (range) in years	46.3 ± 8.5 (30–68)
AOSpine world region (%)	
Asia Pacific	25 (21.2 %)
Europe/Sub Saharan Africa	34 (28.8 %)
Latin America	33 (28.0 %)
Middle East/North Africa	10 (8.5 %)
North America	16 (13.6 %)
Profession (%)	
Neurosurgeon	39 (33.1 %)
Orthopaedic surgeon	72 (61.0 %)
Trauma surgeon	6 (5.1 %)
Other	1 (0.8 %)
Spine fellowship completed (%)	91 (77.1 %)
Main working field (%)	
Clinic	109 (92.4 %)
Management	2 (1.7 %)
Education	4 (3.4 %)
Research	1 (0.8 %)
Other	2 (1.7 %)
Years of practice, mean ± SD (range) in years	16.3 ± 8.0 (5–42)

Influence of experience and professional background

Differences in response where considerably less when investigating the influence of spine surgeons' degree of experience and professional background.

Concerning the different degrees of clinical experience, some differences were observed for *sagittal alignment (kyphosis)* (range 60.0–87.0 %; $p = 0.010$) and *bony fusion* (range 46.7–79.4 %; $p = 0.010$) for the thoracic spine on the short term. Both parameters were considered least relevant by the surgeons with more than 20 years of clinical experience. For the thoracolumbar spine, even less differences were observed between the surgeons with different degrees of experience. Moreover, none of the parameters showed statistically significant differences. *Mobility* of the lumbar spine showed some differences for the short term (range 60.7–88.7 %; $p = 0.014$).

Comparing the responses of orthopedic surgeons and neurosurgeons for all spine regions, parameters were, in general, considered more relevant by orthopedic surgeons. Neurological status was most relevant for both groups of professionals.

Almost no differences were seen when comparing the responses between surgeons with and without a completed spine fellowship, except for one parameter. In the thoracic spine, *spinal canal encroachment on the trauma CT/MRI*, was substantially more relevant for surgeons without a completed spine fellowship, both for the short term (77.8 vs. 52.7 %; $p = 0.021$) and the long term (81.5 vs. 44.0 %; $p = 0.001$).

Comments

Although a large number of participants ($n = 52$; 44.1 %) provided extra comments, the majority repeated one or more of the surveyed parameters to emphasize their importance. A considerable number of comments were related to factors more relevant for the patient reported outcome such as daily activities, return to work, and urinary and bowel function. The novel variables provided in the comments section and not indicated in the questions were related to *bone quality*, including *bone density* and *osteoporosis*, which are relevant in osteoporosis and ankylotic conditions.

Discussion

To our knowledge, this is the first survey exploring the perspective of worldwide experts on parameters they find most relevant to evaluate the clinical and functional outcomes of adult patients sustaining traumatic injuries to the thoracic and lumbar spine.

A representative sample of 118 experts from all five AOSpine International world regions and with substantial experience in the clinical practice of spine trauma was surveyed in this study. This contributes to the multinational and multicultural perspective in the identification of the most relevant clinical and radiological parameters for outcome measurement.

Of the 16 surveyed parameters, 5 were identified as relevant by at least 70 % of the participants for all spine regions, both for the short term and long term. *Neurological status* was identified as most relevant parameter. This was not a surprising finding as neurological injury can be devastating with an abrupt change in patients' quality of life, as well as long-term clinical consequences. Moreover, many studies report on neurological status as a strong determinant of outcome in spine trauma patients [13–16]. Also some radiographic findings were found to be relevant for all spine regions and time periods. These parameters could be related to occult instability of the injured spine level with gradual post-traumatic deformities, which may very well influence patients' outcome and result in conversion of the treatment [17–19]. Another relevant parameter for all spine regions and time periods was *age*. As increased age may be associated with multiple comorbidities along with their influence on patients' function and health [20, 21], it was surprising that *comorbidity* was not identified as relevant. These findings were partly clarified

Table 2 The relevance of the parameters for the thoracic spine (T1–T10), on the short-term and long-term post-trauma

Parameter	% of experts	(95 % CI)	(Range regions)	(Range experience)
Short term (3 months–2 years)				
Neurological status[a]	95.8	(91.5–99.2)	(90.9–100.0)	(93.3–96.3)
Implant failure within 3 months[a]	92.3	(87.3–97.4)	(81.3–97.1)	(90.0–97.1)
Surgical site infections	90.7	(85.6–95.8)	(68.8–100.0)	(88.9–94.1)
Patient satisfaction[a]	81.4	(73.8–89.0)	(75.8–92.0)	(73.3–85.3)
Implant failure after 6 months	77.1	(68.6–84.7)	(66.7–100.0)	(75.9–79.4)
Misplacement of implants	74.6	(67.8–82.2)	(43.8–90.0)	(68.5–86.7)
Sagittal alignment (kyphosis)	73.7	(66.1–80.5)	(56.3–87.9)	(60.0–87.0)
Age	71.2	(62.7–79.6)	(62.5–100.0)	(63.3–79.4)
Patient's current level of pain	68.7	(60.2–76.3)	(62.5–76.0)	(60.0–74.1)
Bony fusion	68.7	(60.2–77.1)	(37.5–78.8)	(46.7–79.4)
Comorbidity	61.1	(52.5–69.5)	(40.0–72.7)	(50.0–70.6)
Spinal canal encroachment	58.4	(49.2–67.8)	(18.8–84.8)	(55.6–64.7)
Vertebral body height loss	54.2	(44.9–62.7)	(6.3–72.7)	(40.0–61.1)
Mobility	38.1	(29.7–46.6)	(18.8–60.0)	(29.4–42.6)
Coronal alignment (scoliosis)	38.2	(30.5–47.5)	(18.8–60.0)	(26.5–48.1)
Disc height loss	32.2	(23.7–40.7)	(6.3–52.0)	(26.5–38.9)
Long term (≥2 years)				
Neurological status[a]	91.5	(85.6–95.8)	(81.8–100.0)	(90.7–93.3)
Sagittal alignment (kyphosis)[a]	85.6	(78.8–91.5)	(80.0–88.2)	(80.0–88.9)
Patient satisfaction[a]	83.9	(77.1–89.8)	(81.3–90.0)	(79.6–90.0)
Bony fusion	78.0	(70.3–85.6)	(56.3–91.2)	(76.5–80.0)
Implant failure within 3 months	72.9	(64.4–80.5)	(68.8–76.5)	(72.2–73.5)
Age	71.2	(62.7–78.8)	(60.6–80.0)	(70.0–73.5)
Implant failure after 6 months	65.2	(56.8–73.7)	(58.8–80.0)	(63.0–70.6)
Patient's current level of pain	62.7	(54.2–71.2)	(56.3–66.7)	(58.8–73.3)
Surgical site infections	61.9	(53.4–70.3)	(30.0–87.9)	(57.4–70.0)
Misplacement of implants	56.8	(47.5–65.3)	(31.3–72.0)	(51.9–66.7)
Comorbidity	54.3	(44.9–63.5)	(30.0–68.0)	(51.9–60.0)
Spinal canal encroachment	52.5	(44.1–61.9)	(18.8–72.7)	(48.1–56.7)
Coronal alignment (scoliosis)	50.8	(41.5–59.3)	(25.0-70.0)	(44.1–55.6)
Vertebral body height loss	49.2	(39.8–58.5)	(12.5–68.0)	(40.0–55.9)
Mobility	44.1	(34.7–53.4)	(18.8–50.0)	(32.4–53.3)
Disc height loss	35.6	(28.0–44.9)	(12.5–50.0)	(26.5–40.7)

Relative frequencies are shown, along with their 95 % bootstrapped confidence intervals (CI), and range among the different world regions (range-regions) and different degrees of experience (range experience)

[a] Relevant for at least 70 % of the participants in all AOSpine International world regions

by the free text comments. Some participants found age to be relevant because of the potential risk of osteoporosis in women over 50 years of age. Probably this pattern of thoughts also explains the indicated age that could influence outcomes of these patients, ranging from a mean of 50–54 years. Combining all these findings supports that *bone quality* was reported as missing parameter. Bone quality plays a key role in aspects such as whether a patient should undergo surgery and subsequently the choice of surgical treatment, but also for the potential risk of implant failure and the possibility for gradual neurological deterioration [22, 23].

In general, the various subanalyses revealed only minor differences between world regions, degree of experience and professional background. However, it was notable that for some parameters, most of which were not identified as relevant by at least 70 % of the participants, the responses of the North American participants deviated from the responses of the other world regions. An obvious explanation for this finding is lacking, but it may be possible that

Table 3 The relevance of the parameters for the thoracolumbar junction (T11–L2), on the short-term and long-term post-trauma

Parameter	% of experts	(95 % CI)	(Range regions)	(Range experience)
Short term (3 months–2 years)				
Neurological status[a]	94.5	(89.9–98.2)	(87.5–100.0)	(92.9–96.4)
Implant failure within 3 months[a]	92.7	(87.2–97.2)	(73.3–100.0)	(92.5–92.9)
Patient satisfaction[a]	88.0	(81.7–93.6)	(80.6–100.0)	(82.1–92.9)
Surgical site infections	86.3	(79.8–92.7)	(60.0–100.0)	(83.0–89.3)
Implant failure after 6 months	85.3	(78.0–91.7)	(66.7–91.7)	(83.0–89.3)
Misplacement of implants	79.8	(71.6–87.2)	(53.3–100.0)	(71.4–85.7)
Age[a]	78.9	(70.6–86.2)	(75.0–90.0)	(67.9–85.7)
Sagittal alignment (kyphosis)	75.2	(67.0–83.5)	(53.3–93.5)	(60.7–83.0)
Patient's current level of pain	70.7	(62.4–78.9)	(53.3–90.0)	(64.3–73.6)
Bony fusion	68.8	(60.6–77.1)	(40.0–80.0)	(64.3–71.7)
Comorbidity	67.9	(58.7–77.1)	(58.6–79.2)	(60.7–78.6)
Mobility	64.3	(55.0–72.5)	(20.0–75.0)	(57.1–67.9)
Spinal canal encroachment	60.6	(51.4–69.7)	(33.3–87.1)	(50.0–66.0)
Vertebral body height loss	56.9	(47.7–66.1)	(13.3–77.4)	(46.4–66.0)
Coronal alignment (scoliosis)	53.2	(44.0–62.4)	(41.4–70.0)	(39.3–60.4)
Disc height loss	39.5	(31.2–47.7)	(6.7–54.2)	(35.7–43.4)
Long term (≥2 years)				
Neurological status[a]	92.7	(88.1–97.2)	(87.1–100.0)	(85.7–96.4)
Patient satisfaction[a]	87.1	(80.7–93.6)	(80.0–100.0)	(84.9–89.3)
Sagittal alignment (kyphosis)[a]	86.2	(78.9–91.7)	(66.7–90.3)	(82.1–90.6)
Bony fusion	77.1	(68.8–84.4)	(60.0–83.3)	(67.9–85.7)
Implant failure within 3 months	77.0	(68.8–85.3)	(53.3–82.8)	(75.0–79.2)
Age[a]	75.2	(67.0–83.5)	(66.7–82.8)	(64.3–82.1)
Patient's current level of pain	73.4	(64.2–81.7)	(53.3–83.3)	(71.4–78.6)
Mobility	72.5	(63.3–80.7)	(40.0–90.0)	(69.8–75.0)
Implant failure after 6 months	68.8	(60.6–77.1)	(53.3–79.2)	(64.2–75.0)
Surgical site infections	65.2	(56.0–74.3)	(33.3–77.4)	(60.4–78.6)
Coronal alignment (scoliosis)	63.3	(53.2–72.5)	(46.7–80.0)	(50.0–67.9)
Comorbidity	63.3	(54.1–72.5)	(58.1–75.0)	(62.3–64.3)
Misplacement of implants	62.4	(53.2–70.6)	(40.0–70.8)	(50.9–75.0)
Vertebral body height loss	56.0	(13.3–80.0)	(13.3–80.0)	(50.0–58.5)
Spinal canal encroachment	46.8	(26.7–64.5)	(26.7–64.5)	(42.9–53.6)
Disc height loss	44.9	(13.3–70.0)	(13.3–70.0)	(41.5–50.0)

Relative frequencies are shown, along with their 95 % bootstrapped confidence intervals (CI), and range among the different world regions (range-regions) and different degrees of experience (range experience)

[a] Relevant for at least 70 % of the participants in all AOSpine International world regions

only few parameters are used by the North American participants to evaluate the treatment outcomes. Interestingly, a recently conducted study showed no regional differences when looking at the perceived severity of thoracolumbar spine trauma [24]. The minimal differences in our study regarding experience and professional background may be explained by the inclusion of spine surgeons with a substantial amount of experience in spine trauma care.

We do recognize several limitations of the current study. First, the survey was sent to a selected panel of experts. It is possible that including other experts might lead to different results. However, we believe that the participants represent a sample of spine surgeons with knowledge of and interest in outcome assessment in this specific patient population. Second, the definition of the short-term and long-term post-trauma was somewhat arbitrarily defined by the initiators of this project. However, the participants did not comment

Table 4 The relevance of the parameters for the lumbar spine (L3–L5), on the short-term and long-term post-trauma

Parameter	% of experts	(95 % CI)	(Range regions)	(Range experience)
Short term (3 months–2 years)				
Neurological status[a]	89.9	(84.4–95.4)	(82.8–100.0)	(85.7–92.9)
Implant failure within 3 months[a]	88.1	(81.7–93.6)	(86.2–90.3)	(84.9–92.9)
Surgical site infections	85.3	(78.0–91.7)	(66.7–100.0)	(81.1–89.3)
Sagittal alignment (kyphosis)[a]	84.4	(78.0–90.8)	(73.3–90.3)	(71.4–92.5)
Patient satisfaction[a]	82.5	(75.2–89.9)	(86.7–90.0)	(78.6–92.9)
Misplacement of implants	80.7	(73.4–88.1)	(53.3–90.0)	(78.6–85.7)
Implant failure after 6 months[a]	78.9	(71.6–86.2)	(77.4–86.7)	(75.0–81.1)
Mobility	78.9	(71.6–86.2)	(46.7–87.5)	(60.7–88.7)
Age[a]	78.0	(70.6–86.2)	(72.4–90.0)	(67.9–83.0)
Patient's current level of pain	75.2	(67.0–82.6)	(60.0–90.0)	(64.3–79.2)
Comorbidity	70.6	(61.5–78.9)	(66.7–80.0)	(64.3–73.6)
Bony fusion	64.2	(54.1–72.5)	(40.0–79.2)	(57.1–71.4)
Coronal alignment (scoliosis)	60.6	(51.4–69.7)	(26.7–70.8)	(46.4–69.8)
Vertebral body height loss	56.0	(46.8–64.2)	(13.3–79.2)	(39.3–62.3)
Spinal canal encroachment	52.3	(43.1–61.5)	(26.7–64.5)	(42.9–60.7)
Disc height loss	47.7	(39.4–57.8)	(13.3–70.8)	(42.9–52.8)
Long term (≥2 years)				
Neurological status[a]	90.8	(85.3–95.4)	(80.0–100.0)	(86.8–100.0)
Patient satisfaction[a]	85.3	(78.9–91.7)	(80.0–91.7)	(81.1–92.9)
Mobility	84.4	(78.0–90.8)	(66.7–93.1)	(75.0–89.3)
Sagittal alignment (kyphosis)[a]	81.7	(74.3–88.1)	(60.0–91.7)	(79.2–85.7)
Bony fusion	80.8	(73.4–87.2)	(66.7–86.2)	(78.6–85.7)
Age[a]	77.0	(68.8–84.4)	(72.4–90.0)	(71.4–79.2)
Patient's current level of pain	76.2	(67.9–83.5)	(60.0–91.7)	(67.9–85.7)
Implant failure within 3 months	75.3	(67.9–83.5)	(53.3–87.5)	(71.4–77.4)
Implant failure after 6 months	68.8	(59.6–77.1)	(60.0–79.2)	(67.9–71.4)
Surgical site infections	67.0	(57.8–75.2)	(33.3–87.1)	(58.5–82.1)
Misplacement of implants	65.1	(55.1–73.4)	(40.0–75.0)	(62.3–71.4)
Coronal alignment (scoliosis)	61.5	(51.4–70.6)	(46.7–75.0)	(53.6–67.9)
Comorbidity	59.6	(50.5–67.9)	(48.4–75.0)	(54.7–67.9)
Vertebral body height loss	56.0	(46.8–64.2)	(20.0–75.0)	(46.4–64.3)
Disc height loss	51.4	(42.2–60.6)	(13.3–66.7)	(50.0–52.8)
Spinal canal encroachment	41.3	(32.1–50.5)	(13.3–54.2)	(39.3–46.4)

Relative frequencies are shown, along with their 95 % bootstrapped confidence intervals (CI), and range among the different world regions (range regions) and different degrees of experience (range experience)

[a] Relevant for at least 70 % of the participants in all AOSpine International world regions

Table 5 The age that, in the absence of serious medical comorbidities, substantially may influence the outcome of patients with traumatic thoracic and lumbar spine injuries, on the short-term and long-term post-trauma

Parameter	T spine	TL spine	L spine
Age, mean ± SD (range) in years			
Short term (3 months–2 years)	51.7 ± 16.7 (18–85)	50.1 ± 16.3 (18–85)	50.9 ± 15.8 (18–85)
Long term (≥2 years)	54.1 ± 14.0 (18–80)	52.5 ± 14.8 (18–80)	53.8 ± 14.6 (18–80)
Age, median in years			
Short term (3 months–2 years)	55.0	50.0	50.0
Long term (≥2 years)	60.0	55.0	60.0

T thoracic spine (T1–T10), *TL* thoracolumbar spine (T11–L2), *L* lumbar spine (L3–L5)

on this categorization. Finally, the selection of relevant parameters was based on the arbitrary response cut-off point of at least 70 %, representing a large majority of the participants.

In conclusion, including a representative sample of highly experienced spine surgeons from around the world, this study identified clinical and radiological parameters relevant to evaluate clinical and functional outcomes of patients sustaining traumatic injuries to the thoracic and lumbar spine. Together with the results of another expert survey focusing on the identification of relevant parameters for cervical spine trauma patients, this study forms the basis for the development of a SROM for adult spine trauma patients. After further validation, this tool should be useful to the spine surgeons for the purposes of guiding patient care and future research.

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Compliance with ethical standards

Conflict of interest AOSpine is a clinical division of the AO Foundation—an independent medically guided nonprofit organization. The AOSpine Knowledge Forums are pathology focused working groups acting on behalf of AOSpine in their domain of scientific expertise. Each forum consists of a steering committee of up to 10 international spine experts who meet on a regular basis to discuss research, assess the best evidence for current practices, and formulate clinical trials to advance spine care worldwide. Study support is provided directly through AOSpine's Research department.

Appendix 1

See Table 6.

Table 6 The general case as provided at the start of each subpart

"You see a patient with a traumatic *[T/TL/L]* fracture in the period of 6 weeks to 3 months after discharge at the outpatient department. This patient had a traumatic injury and has been treated either nonsurgically (brace, cast or functional) or surgically (with any kind of technique; posterior, anterior, circumferential with or without less invasive techniques)"

T thoracic spine (T1–T10), *TL* thoracolumbar spine (T11–L2), *L* lumbar spine (L3–L5)

Appendix 2

See Table 7.

Table 7 The surveyed clinical and radiological parameters ($n = 16$)

Age
Bony fusion as seen and assessed on radiographs taken in the clinic today
Comorbidity not associated with the index trauma, i.e., diabetes or heart disease
[T/TL/L] coronal alignment (scoliosis) on radiographs taken in the clinic today
Disc height loss on radiographs taken in the clinic today
Implant failure after 6 months (in case surgical fixation was chosen as treatment option)
Implant failure within 3 months (in case surgical fixation was chosen as treatment option)
Misplacement of implants (in case surgical fixation was chosen as treatment option)
Mobility of the *[T/TL/L]* spine
Neurological status
Patient satisfaction with the treatment
Patient's current level of pain
[T/TL/L] sagittal alignment (kyphosis) on radiographs taken in the clinic today
Spinal canal encroachment on the trauma CT or MRI
Surgical site infections (in case surgical fixation was chosen as treatment option)
Vertebral body height loss on radiographs taken in the clinic today

T thoracic spine (T1–T10), *TL* thoracolumbar spine (T11–L2), *L* lumbar spine (L3–L5)

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