Spinal Post-traumatic Deformity

An International Expert Survey Among AO Spine Knowledge Forum Members

Erin E.A. De Gendt, MD, Greg D. Schroeder, MD, PhD,† Andrei Joaquim, MD, PhD,‡ Jin Tee, MD, PhD,§ Rishi M. Kanna, MD,‖ Frank Kandziora, MD, PhD,¶ Gaurav R. Dhakal, MD,# Emiliano N. Vialle, MD, PhD,** Mohammad El-Sharkawi, MD, PhD,†† Klaus J. Schnake, MD, PhD,‡‡ Shanmuganathan Rajasekaran, MD, PhD,‖ Alex R. Vaccaro, MD, PhD,† Sander P.J. Muijs, MD, PhD,* Lorin M. Benneker, MD, PhD,§§ and F. Cumhur Oner, MD, PhD**

Study Design: Survey among spine experts.

Objective: To investigate the different views and opinions of clinically relevant spinal post-traumatic deformity (SPTD).

Summary of Background Data: There is no clear definition of clinically relevant SPTD. This leads to a wide variation in characteristics used for diagnosis and treatment indications of SPTD. To understand the current concepts of SPTD a survey was conducted among spine trauma surgeons.

Methods: Members of the AO Spine Knowledge Forum Trauma participated in an online survey. The survey was divided in 4 domains: Demographics, criteria to define SPTD, risk factors, and management. The data were collected anonymously and analyzed using descriptive statistics, absolute, and relative frequencies. Consensus on dichotomous outcomes was set to 80% of agreement.

Results: Fifteen members with extensive experience in treatment of spinal trauma participated, representing the 5 AO Spine Regions. Back pain was the only criterion for definition of SPTD with complete agreement. Consensus ($\geq 80\%$) was reached for kyphotic angulation outside normative ranges and impaired function. Eighty-seven percent and 100% agreed that a full-spine conventional radiograph was necessary in diagnosing and treating SPTD, respectively. The "missed B-type injury" was rated at most important by all but 1 participant. There was no agreement on other risk factors leading to clinically relevant SPTD. Concerning the management, all participants agreed that

Received for publication April 5, 2022; accepted June 29, 2022.

From the *Department of Orthopedics, University Medical Center Utrecht, Utrecht, The Netherlands; †Department of Orthopaedic Surgery, Rothman Institute, Thomas Jefferson University, Philadelphia, PA; ‡Department of Neurosurgery, State University of Campinas, Campinas Cidade Universitária Zeferino Vaz—Barão Geraldo, Campinas—SP, Brazil; §Departement of Neurosurgery, The Alfred Hospital, Melbourne, VIC, Australia; ‖Department of Orthopaedic and Spine Surgery, 1. Ganga Medical Centre and Hospitals Pvt Ltd, Coimbatore, IN; ¶Center for Spinal Surgery and Neurotraumatology, BG Unfallklinik Frankfurt am Main gGmbH, Frankfurt am Main, Germany; #National Trauma Center, Bir Hospital, National Academy of Medical Sciences, Mahankal Marg, Kathmandu, Nepal; **Department of Orthopaedics, Cajuru Hospital, Catholic University of Paraná, Curitiba—PR, Brazil; ††Department of Orthopaedic and Trauma Surgery, Assiut University Medical School, Assiut, Egypt; ‡‡Center for Spinal and Scoliosis Therapy, Malteser Waldkrankenhaus St. Marien, Erlangen, Germany; and §§Spine Service, Orthopedic Department Sonnenhofspital, Bern, Switzerland.

IRB-approval was not sought because of the nature of this research.

This study was supported by AO Spine through the AO Spine Knowledge Forum Trauma, a focused group of international Trauma experts. AO Spine is a clinical division of the AO Foundation which is an independent medically-guided not-for-profit organization. Study support was provided directly through the AO Spine Research Department.

Dr Schroeder has received funds to travel from AO Spine and Medtronic. Dr Vaccaro has consulted or has done independent contracting for DePuy, Medtronic, Stryker Spine, Globus, Stout Medical, Gerson Lehrman Group, Guidepoint Global, Medacorp, Innovative Surgical Design, Orthobullets, Ellipse, and Vertex. He has also served on the scientific advisory board/board of directors/committees for Flagship Surgical, AO Spine, Innovative Surgical Design, and Association of Collaborative Spine Research. Dr Vaccaro has received royalty payments from Medtronic, Stryker Spine, Globus, Aesculap, Thieme, Jaypee, Elsevier, and Taylor Francis/Hodder and Stoughton. He has stock/stock option ownership interests in Replication Medica, Globus, Paradigm Spine, Stout Medical, Progressive Spinal Technologies, Advanced Spinal Intellectual Properties, Spine Medica, Computational Biodynamics, Spinology, In Vivo, Flagship Surgical, Cytonics, Bonovo Orthopaedics, Electrocore, Gamma Spine, Location Based Intelligence, FlowPharma, R.S.I., Rothman Institute and Related Properties, Innovative Surgical Design, and Avaz Surgical. In addition, Dr Vaccaro has also provided expert testimony. He has also served as deputy editor/editor of Clinical Spine Surgery. The remaining authors declare no conflict of interest.

Reprints: Erin E.A. De Gendt, MD, Department of Orthopedics, University Medical Centre Utrecht, Postbus 85500, 3508 GA Utrecht, The Netherlands, Internal mail no. G05.228 (e-mail: E.E.A.DeGendt@umcutrecht.nl).

Supplemental Digital Content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website, www.jspinaldisorders.com.

an asymptomatic patient should not undergo surgical treatment and that neurological deficit is an absolute surgical indication. For most of the participants the preferred surgical treatment of acute injury in all spine regions but the subaxial region is posterior fixation.

Conclusion: Some consensus exists among leading experts in the field of spine trauma care concerning the definition, diagnosis, risk factors, and management of SPTD. This study acts as the foundation for a Delphi study among the global spine community.

Key Words: spinal post-traumatic deformity, consensus, spine trauma, diagnosis, expert survey, Delphi study

(*Clin Spine Surg* 2023;36:E94–E100)

Spinal post-traumatic deformity (SPTD) is a complication of a traumatic injury of the spinal column. After trauma, some deformity of the spine may be present in different amount, but when and how a specific deformity in a specific region of the spine becomes "clinically relevant" SPTD is poorly understood. It is known that SPTD can lead to impairment of the quality of life and decrease in function in daily life.[1,2] Over a decade ago, a survey was held by Schoenfeld et al[3] among experienced spine trauma surgeons to reach a consensus on what constitutes a SPTD. Consensus of the definition of SPTD was a "painful kyphotic deformity after a spine trauma". However, clinically relevant SPTD was not distinguished from asymptomatic SPTD and no consensus was reached on more specific patient factors or treatment factors.[3]

In clinical practice and in research, the lack of a clear definition of SPTD causes confusion. First, as SPTD is a complication of a traumatic spine injury, one could argue that SPTD should be preventable by better management of the spine injury itself. To compare the management of the acute injuries and even predict the chance of development of SPTD you need to have a good defined outcome. This definition of SPTD is however nonexisting. Second, patients with SPTD may need high-risk surgical procedures with unpredictable outcomes. To compare the different treatments of SPTD (surgical and nonsurgical) the diagnosis of SPTD should be uniform.[4,5]

A new project of the AO Spine Knowledge Forum (KF) Trauma focusses on defining clinically relevant SPTD. In the first phase of this project, a systematic review was conducted to search the literature for a description of definition of SPTD. Literature is still inconclusive on what exactly constitutes a "clinically relevant" SPTD.[6] This review did identify relevant different domains in the literature such as patient factors (eg, pain and neurological deficits), radiologic parameters (eg, Cobb angle, sagittal balance, and Roussouly profile), Patient Reported Outcome Measurements (PROMs) and indications for surgical intervention in patients with SPTD.

We aim to investigate the expert opinion of the different domains of SPTD. This will lead to the development of a Delphi study, which will be held among the global AO Spine community to create a widely supported definition of clinically relevant SPTD.

METHODS

Study Design and Recruitment of Participants

An online survey was developed and distributed to the members of the AO Spine KF Trauma. The survey was developed based on the results of the systematic review and discussion among the experts and included all factors deemed important. The AO Spine KF Trauma is a group of 18 leading experts in the field of Spine Trauma. This group consists of orthopedic surgeons and neurosurgeons from all 5 AO Spine regions (Europe and Southern Africa, Asia Pacific, Latin America, Middle East and Northern Africa, North America).

Expert Survey

The full survey is available as supplementary data, Supplemental Digital Content 1, http://links.lww.com/CLINSPINE/A242. The survey consisted of 4 "Domains"; Domain 1: Demographics, Domain 2: Criteria to define SPTD and radiologic assessment, Domain 3: Risk factors, and Domain 4: Management.

Demographics

The first domain consisted of 5 questions on the demographics of the participants: their region, years of experience, subspecialty (orthopedic or neurosurgical), and work setting (academic hospital, general hospital, and private).

Criteria to Define SPTD and Radiologic Assessment

The second domain consisted of 13 questions about the different criteria that needed to be fulfilled to define a clinically relevant SPTD (answers per factor: should be fulfilled or not fulfilled). The factors that were included for definition of SPTD were: amount of deformity, disturbance of sagittal balance (including most relevant parameter), back pain (including a Visual Analogue Scale of pain), impaired function (including Oswestry Disability Index and walking distance), secondary progression after treatment of the acute spine trauma (surgical vs. bracing), persisting instability or nonunion, disk degeneration, and the time frame of development of SPTD after trauma. The preference on the type of radiologic examinations was explored [standing local conventional radiogram (CR), dynamic CR, full-spine CR, computed tomography–scan, magnetic resonance imaging (MR)-scan and bone quality assessment] for diagnosis and treatment of SPTD. The radiologic examinations were rated on a 2-point scale: "optional" or "strongly necessary".

Risk Factors

The third domain contained 4 questions: 3 ranking questions (radiologic/morphologic, patient-related, and treatment of spine trauma) about the risk factors for development of SPTD and 1 multiple choice question on the degree of risk per spine region. The question on radiology/

TABLE 1. Criteria That Need to be Fulfilled to Define SPTD

Criteria	Fulfilled*	Not Fulfilled*
Kyphotic angulation outside normative ranges†	14	1
Degree of angulation:		
> 10 degrees	3	
> 20 degrees	5	
> 30 degrees	6	
Sagittal imbalance	10	5
Most relevant measurement		
SVA > 5 cm	6	
Pelvic rotation	4	
Back pain†	15	0
Visual Analogue Scale of pain		
> 1	0	
> 4†	12	
> 7	3	
Impaired function†	13	2
Oswestry Disability Index		
> 40%	9	
> 60%	4	
Walk distance		
Unlimited	5	
< 1 km	2	
< 100 m	6	
Secondary progression	9	6
Persisting instability or nonunion	6	9
Disc degeneration†	2	13
Development of SPTD		
Irrelevant	2	
Within 0–2 mo	3	
Within 2–6 mo	7	
Within 6–12 mo	1	
After 12 mo	2	

*Number of participants.
†Agreement ≥ 80% is reached
SPTD indicates spinal post-traumatic deformity; SVA, sagittal vertical axis.

TABLE 2. The Radiographic Assessment Necessary to Perform for Diagnosis and for Treatment of SPTD

	Strongly Necessary		Optional		No Answer	
Radiographic Assessment	Diag.	Treat.	Diag.	Treat.	Diag.	Treat.
Standing local CR*	13	11	2	3	0	1
Dynamic CR	3	7	12	7	0	1
Full-Spine CR*	13	15	2	0	0	0
CT-scan	10	10	5	4	0	1
MR-scan*	6	12	9	3	0	0
Bone quality assessment	2	6	12	9	1	1

*Agreement ≥ 80% is reached.
CR indicates conventional radiography; CT, computed tomography; Diag., diagnosis; MR, magnetic resonance imaging; SPTD, spinal post-traumatic deformity; Treat., treatment.

morphology contained 6 factors, the question on patient-related factors contained 9 factors and the question on treatment of spine trauma contained 8 factors. The ranking was from "most important" (assigned number 1) to "least important" and the number of ranks equaled the number of factors per question. The factor with the lowest mean is rated the most important. The risk per spine region (subaxial, cervicothoracic, mid-thoracic, thoracolumbar, and lumbar) was rated on a 3-point scale: low risk, moderate risk, or high risk.

Management of the Primary Injury and Indications for Surgery in SPTD

The last domain contained questions about the consequences of type of management of acute spine trauma on the development of SPTD and the indications for treatment of patients with SPTD. The first 7 questions assessed whether certain treatments of acute spine trauma have an impact on the development of SPTD. The experts were asked which treatment they preferred (bracing, posterior, anterior, or combined surgery) in a neurologically intact patient with an unstable spine injury for the different regions of the spine. To further specify on which surgical treatment (anterior or posterior alone) for acute spine trauma could increase the risk on SPTD in the different spine regions, the participants were asked to score the risk on a 3-point scale (yes, possible, or no). If yes or possibly was indicated, an additional question per spine region was opened to ask whether this risk was dependent on fracture type, bone quality, or something else. The following question of the survey assessed whether there are certain Roussouly type sagittal profiles that increase the risk of development of SPTD.[7] The answers were yes, no, or possibly for each of the different sagittal profiles according to Roussouly. The last question was about the different indications (relative or absolute) for surgical treatment of patients with SPTD. The following indications were considered: asymptomatic, pain, progressive radiologic deformity, physical dysfunction, neurological deficits, and cosmetic concerns.

Data Collection and Analysis

The survey was distributed with RedCap (REDCap Software—Version 6.5.2—© 2020 Vanderbilt University) between 23 January 2020 and 29 February 2020. Reminders were sent out weekly until the survey was completed. The response of each participant was assigned a study identification number for anonymous analysis of the collected data. The analysis was performed by a blinded researcher for the identification code of the participants.

The data of Domains 1, 2, and 4 was analyzed using descriptive statistics, absolute, and relative frequencies. Consensus for dichotomous outcomes was set at 80% agreement between participants.[8–10] The data of Domain 3 was analyzed with frequency analysis and means for the rating questions.

RESULTS

Domain 1: Demographics

The survey was distributed to 18 KF Trauma members and completed by 13 orthopedic surgeons and 2 neurosurgeons; 1 member completed the survey partially.

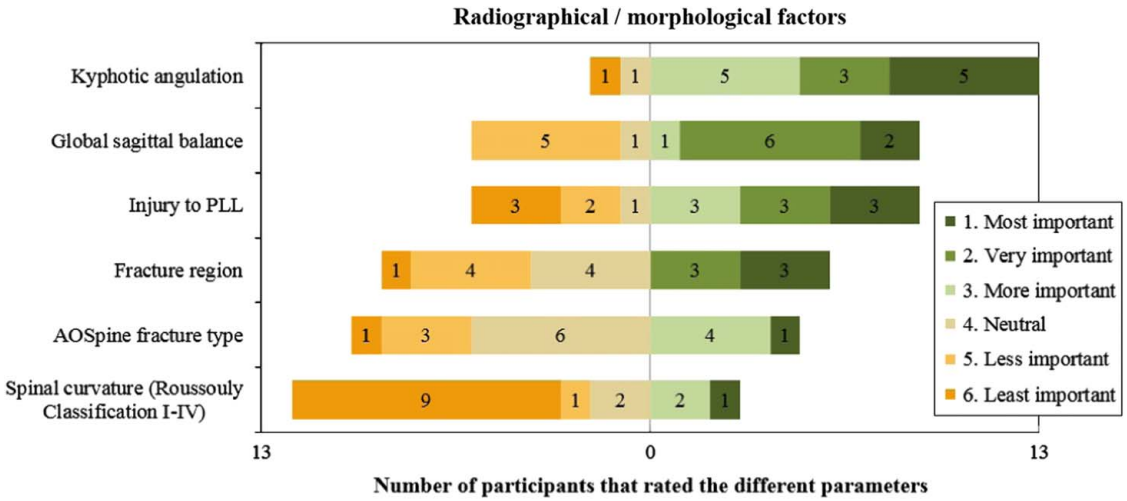

FIGURE 1. The factor at the top of the figure had the lowest mean, thus was rated as most important and the factor at the bottom had the highest mean (rated least important). (1) the 6 radiologic/morphologic factors are displayed; (2) the 9 patient-related factors are displayed; (3) the 8 treatment-related factors are displayed. PLL indicates posterieur longitudinal ligament.

Six were from Europe and Southern Africa, 3 from North America, 3 from Asia Pacific, 2 from Latin America, and 1 from the Middle East and Northern Africa. The experience of the participants ranged from 5 to 10 years to more than 20 years. Of the participants 73% worked at an Academic medical institution, 20% at a general hospital, and 7% in private practice.

Domain 2: Criteria to Define SPTD and Radiologic Assessment of SPTD

The participants reached unanimous agreement on the presence of "Back pain" as a necessary criterion to define clinically relevant SPTD and agreement that the Visual analogue scale of pain (80%) should be ≥ 4 out of 10. The items "kyphotic angulation" (93%) and "impaired function" (87%) also reached agreement. On "disc degeneration" the participants agreed that it was not a necessary criterion (87%).

Concerning the radiologic assessment for the diagnosis of SPTD standing local CR and Full-Spine CR were strongly necessary for the diagnosis of SPTD. For treatment choices of SPTD agreement was reached for the necessity for a full-spine CR and an MR-scan. The results are summarized in Tables 1 and 2.

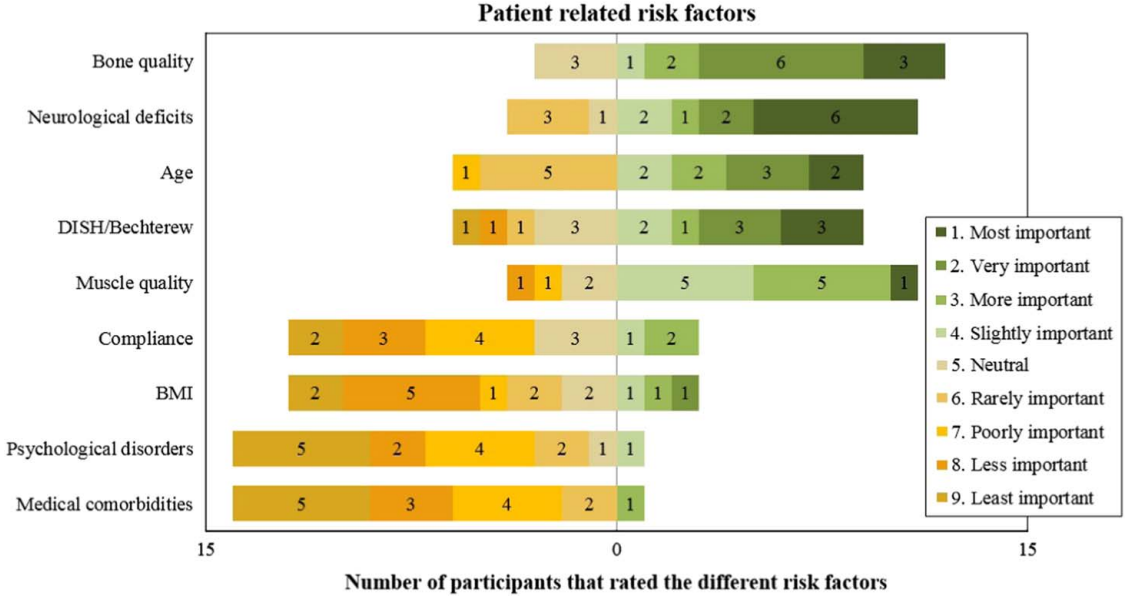

FIGURE 2. The factor at the top of the figure had the lowest mean, thus was rated as most important and the factor at the bottom had the highest mean (rated least important). (1) the 6 radiologic/morphologic factors are displayed; (2) the 9 patient-related factors are displayed; (3) the 8 treatment-related factors are displayed. BMI indicates body mass index.

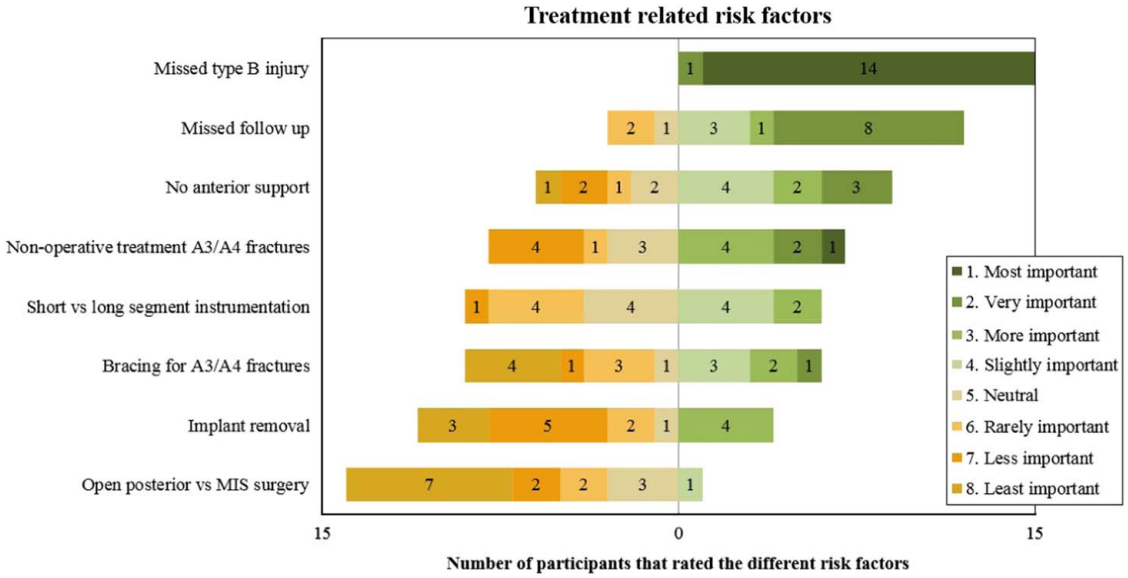

FIGURE 3. The factor at the top of the figure had the lowest mean, thus was rated as most important and the factor at the bottom had the highest mean (rated least important). (1) the 6 radiologic/morphologic factors are displayed; (2) the 9 patient-related factors are displayed; (3) the 8 treatment-related factors are displayed. MIS indicates minimally invasive surgery.

Domain 3: Risk Factors for Development of SPTD

Figure 1 shows the radiographic/ morphologic factors, no factor reached a consensus. Overall, the "kyphotic angulation" was rated as the most important factor (mean 2.4; ranking interval 1–6) and the "Spinal Curvature" as the least important (mean 4.9; ranking interval 1–6).

Figure 2 shows the different patient-related risk factors, no consensus was reached. "Bone quality" (mean 2.7; ranking interval 1–5) and "Neurological deficit" (mean 2.9; range 1–6) were rated most important and "Medical comorbidities" as least important (mean 7.5; ranking interval 3–9).

Figure 3 shows the ranking of the treatment-related risk factors. The factor "missed type B-injury" (mean 1.1; ranking interval 1–2) was ranked by 14 out of the 15 participants as most important factor.

When comparing the risk probability of the various spine regions to develop SPTD, thoracolumbar spine was ranked as high risk by 80% (Fig. 4).

Domain 4: Management of the Primary Injury and Indications for Surgery in SPTD

Table 3 shows the results which treatment of an acute spine fracture might prevent SPTD. Agreement (80%) was reached that rigid bracing and longer duration of the bracing of an acute spine injury do not prevent SPTD. Eighty-seven percent agreed that minimally invasive surgery for acute spine injury does not prevent SPTD more than open surgery.

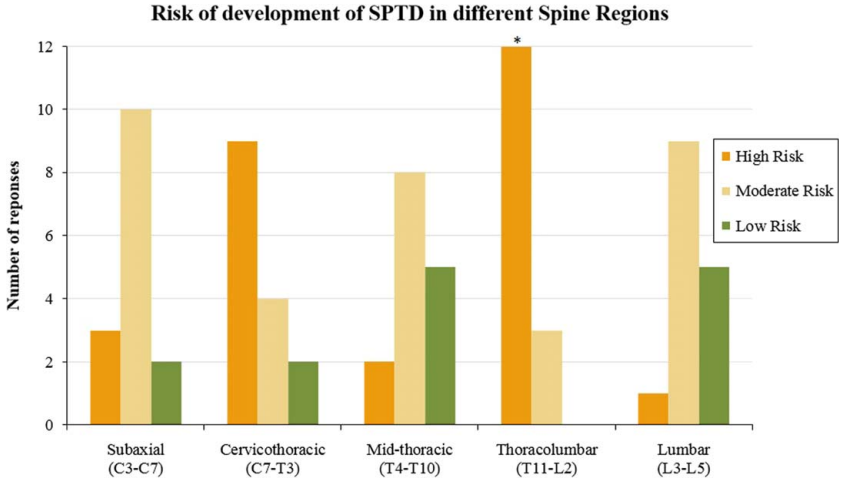

FIGURE 4. Risk of development of spinal post-traumatic deformity (SPTD) in the different spine regions. This figure shows the assessment of risk on development of SPTD by the participants, clustered by the various regions of the spine. Risk of SPTD can be classified either low, moderate, or high for each spine region.

TABLE 3. Which Treatment of An Acute Spine Injury Might Prevent SPTD

Type of Treatment	Yes	No
Does rigid bracing prevent SPTD?*	3	12
Is there an impact of duration of brace in prevention of SPTD?*	3	12
Are there regions that benefit from bracing?	6	9
Which regions benefit from bracing?		
C3–C7	2	
C7–T3	1	
T4–T10	3	
T11–L2	4	
L3–L5	3	
Does MIS predispose to SPTD more than open surgery?	5	10
Does MIS prevent SPTD more than open surgery?*	2	13
Is the use of monoaxial screws important in acute management?	11	4

*Agreement ≥80% is reached.

MIS indicates minimally invasive surgery; SPTD, spinal post-traumatic deformity.

Monoaxial screws concerning the sagittal profile, no agreement that certain Roussouly types could promote the development of SPTD was reached.

In Table 4 the preferred treatment per spine region in a neurologically intact patient with an acute unstable spine injury is shown. Agreement was reached (≥80%) that the preferred treatment of all spine regions except the subaxial cervical spine region is posterior fixation of the acute injury.

A majority of the participants agreed that there was no increased risk on SPTD when using the posterior approach alone for acute spine injury in the CTh region (80%) and the mid-Th region (93%), 20% and 7% said it was a possible risk, respectively. Fracture type was chosen most often by the participants as dependent factor.

Figure 5 shows an overview of different indications for surgical management of patients suffering from SPTD. All experts agreed that an asymptomatic patient should not undergo surgical treatment. Also unanimous agreement was reached that patients with a neurological deficit have an absolute surgical indication.

DISCUSSION

This survey among leading spine trauma experts, was performed to look for possible agreement on diagnosis, risk factors, and management of SPTD. Many criteria and factors were subjected to the experts' opinion in this survey. In total 15 questions from this survey reached an agreement of 80% or more. However, there remains a great degree of disagreement about other possibly relevant items.

The "painful" in the definition of Schoenfeld and colleagues is consistent with our survey. We found a unanimous agreement that "Back pain" needs to be fulfilled in a patient to define SPTD. This is consistent with the findings from the survey of Schoenfeld et al[3] a decade ago. In the literature over the years, back pain was mentioned often in combination or as a surgical indication in patients with SPTD.[11]

Our survey found a unanimous agreement on "Neurological deficits" being an absolute indication for surgical indication in patients with SPTD. The question remains whether patients with a known neurological deficit fall in this category as well, or only whether they have increasing neurology. There was full consensus that asymptomatic patients with SPTD have no indication for surgical intervention. This confirms the survey of Schoenfeld et al[3] which stated that there could be patients with an asymptomatic SPTD, but whether this is clinically relevant is unclear.

General agreement was found that a standing "full spine CR" is required to support surgeons in diagnosis and treatment decision making. The main reason for this type of CR is to look at the sagittal balance of the patient.[1,4,5] The severity of the sagittal imbalance might point the surgeon to a different type of treatment.[1,12] Interestingly, dependency on sagittal balance to define SPTD was endorsed by only 67% of the experts, which did not exceeded the 80% consensus limit. It could be argued that SPTD can exist with a balanced spine and an imbalanced spine.

As a novelty the experts were asked to rate risk factors for the development of symptomatic SPTD from most important (corresponds to number 1) to least important (corresponds to the amount of factors per question) as is seen in Figures 1–3. Some convergence among the participants on certain items was observed. For example, the "kyphotic angulation" item was found most important by 5 experts but least important by 1 expert; and the "spinal curvature", was found most important by 1 expert and least important by 9 experts. However, there is a wide variation in most of the items leading to a lack of clear consensus. They do give an indication on the overall importance per factor.

The disagreement between participants on the majority of the factors is not unexpected. This can be due to current diversity in the definition as found by De Gendt et al[6] in their recent systematic review of the

TABLE 4. What is The Preferred Treatment Per Spine Region for An Acute Unstable Spine Injury in a Neurologically Intact Patient

Spine Region	Bracing	Posterior Surgery	Anterior Surgery	Combined Surgery
Subaxial (C3–C7)	1	4	9	4
Cervicothoracic (C7–T3)	1	14*	1	2
Mid-thoracic (T4–T10)	1	15*	0	0
Thoracolumbar (T11–L2)	1	12*	0	4
Lumbar (L3–L5)	1	14*	0	1

*Agreement ≥80% is reached.

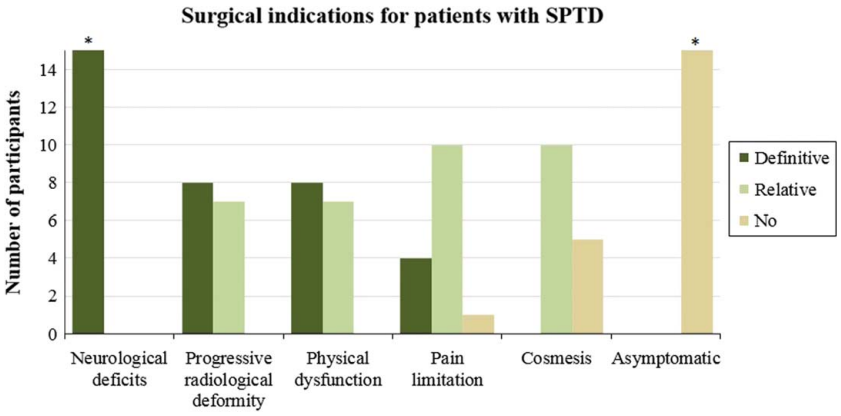

FIGURE 5. Surgical indications for patients with spinal post-traumatic deformity (SPTD). This figure shows different indications of patients with SPTD to qualify for surgical treatment. Participants rated each symptom on being definitive, relative, or no indication for surgical treatment. An asterisk (*) indicated consensus, as more than 80% of participants had the same rating.

literature on SPTD. Another reason could be the lack of clarification between a diagnosis and treatment decision in this questionnaire. We decided to set agreement on 80% after review of the available literature on the Delphi process as this was designed as a preparatory survey.[8–10]

There are limitations to this study. First, only the experts from the AO Spine KF Trauma were asked for their opinion. This creates a bias because other spine surgeons were excluded from this survey. The main reason for this was that this study is a part of multiple preparatory studies before we perform a Delphi study among the whole spine community. Second, the small number of participants in this study. A single participant may substantially skew the obtained results. As this study is exploratory all different aspects mentioned will be used in the Delphi study to follow the preparatory study. Third, there are many ways the questions of a survey determine the outcomes. We will add more open questions and open fields in the upcoming preparatory studies to follow. The last limitation of the study is that only 1 scenario was provided to answer the questions of the survey. In retrospect another or more scenarios could have been provided highlighting different aspects of development of SPTD, however, that would have made the survey even longer with a chance of less respondents.

This survey showed that there is some consensus among experts in spine trauma on different domains of SPTD. We confirmed the definition stated by Schoenfeld et al[3] over a decade ago, but we suggest that additions to this definition are necessary to provide a clear and clinically relevant definition of SPTD. The additions deemed necessary for diagnosis of SPTD were: kyphotic angulation exceeding normal values, back pain with a Visual Analogue Scale of pain >4, and impaired function. The radiologic workup in diagnosis and/or treatment should contain a standing local CR, a full-spine CR, and a MR-scan. These considerations and the previous systematic review are the foundation to conduct a Delphi Study among spine surgeons globally through the AO Spine community.[6]

REFERENCES

1. Buchowski JM, Kuhns CA, Bridwell KH, et al. Surgical management of posttraumatic thoracolumbar kyphosis. *Spine J*. 2008;8:666–677.
2. Vaccaro AR, Silber JS. Post-traumatic spinal deformity. *Spine (Phila Pa 1976)*. 2001;26:S111–S118.
3. Schoenfeld AJ, Wood KB, Fisher CF, et al. Posttraumatic kyphosis: current state of diagnosis and treatment: results of a multinational survey of spine trauma surgeons. *J Spinal Disord Tech*. 2010;23:e1–e8.
4. Munting E. Surgical treatment of post-traumatic kyphosis in the thoracolumbar spine: Indications and technical aspects. *Eur Spine J*. 2010;19(suppl 1):69–73.
5. Hempfing A, Zenner J, Ferraris L, et al. Wiederherstellung der sagittalen Balance bei der Versorgung thorakaler und lumbaler Wirbelkorperfrakturen. *Orthopade*. 2011;40:690–702.
6. De Gendt EEA, Vercoulen T, Guo W, et al. The current status of Spinal Posttraumatic Deformity: a systematic review. *Global Spine J*. 2021;11:1266–1280.
7. Roussouly P, Gollogly S, Berthonnaud E, et al. Classification of the normal variation in the sagittal alignment of the human lumbar spine and pelvis in the standing position. *Spine (Phila Pa 1976)*. 2005;30:346–353.
8. Hasson F, Keeney S, McKenna H. Research guidelines for the Delphi survey technique. *J Adv Nurs*. 2000;32:1008–1015.
9. Keeney S, Hasson F, McKenna H. Consulting the oracle: ten lessons from using the Delphi technique in nursing research. *J Adv Nurs*. 2006;53:205–212.
10. Hung H-L, Altschuld JW, Lee Y-F. Methodological and conceptual issues confronting a cross-country Delphi study of educational program evaluation. *Eval Program Plann*. 2008;31:191–198.
11. Gertzbein SD, Harris MB. Wedge osteotomy for the correction of post-traumatic kyphosis: a new technique and a report of three cases. *Spine (Phila Pa 1976)*. 1992;17:374–375.
12. Jacob M, Buchowski Keith H, Bridwell LGL. Management of posttraumatic kyphosis after thoracolumbar injuries. *Semin Spine Surg*. 2010;22:92–102.