

# Analysis of a performance-based functional test in comparison with the visual analog scale for postoperative outcome assessment after lumbar spondylodesis

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## Abstract

**Study design** Prospective, non-blinded, non-randomization.

**Purpose** Pain scales are commonly used to assess the condition of spine patients, although the degree of correlation between different pain scores, and between the scores and the patients' functional status is, at best, variable. Pain usually limits physical activities, but there is a lack of a widely accepted tool for investigating pain-related physical impairment in everyday routine work. The purpose of this study was to evaluate and correlate the visual analog scale (VAS) and the “timed up and go” (TUG) test in patients after lumbar spondylodesis.

**Methods** Thirty-eight patients with degenerative lumbar disease who were treated with monosegmental or bisegmental spondylodesis were included on a consecutive and prospective basis. The VAS and TUG were assessed preoperatively and during the first 12 weeks postoperatively. Special attention was paid to the early follow-up after surgical intervention. Correlations between the two tests were assessed.

**Results** The VAS showed gradual reduction after surgery, reaching statistical significance on the sixth postoperative day, with significant changes over time from the first to

third, third to sixth postoperative days and from the sixth postoperative day to 2 weeks after surgery. In contrast, the TUG demonstrated a significant deterioration in function on the first and third postoperative days, returning to baseline levels thereafter (at postoperative days 6 and 14). Significant improvement in function in comparison with the preoperative status was established after 4 weeks and continued until the last follow-up examination. The TUG showed significant differences between all visits along the timeline. A correlation between the two tests was only observed on the first day after surgery.

**Conclusion** In summary, the TUG appeared to be significantly more sensitive for describing the course after spine surgery. The TUG represents an appropriate performance-based functional test that is not time-consuming. Assessment of both pain and functionality is, therefore, needed to evaluate patients adequately.

**Keywords** Visual analog scale · Timed up and go test · Lumbar spondylodesis · Outcome assessment · Postoperative follow-up

## Introduction

The rate and variety of spine surgery procedures is rising dramatically in comparison with other musculoskeletal surgical procedures. Rightly so, this is accompanied with an increasingly critical evaluation of these procedures and their underlying, indications by the scientific community and regulatory authorities [1]. Therefore, the use of appropriate standardized outcome instruments is of major importance to document treatment effects of surgical interventions and to point out potential advantages of new surgical techniques. There is, however, a lack of scientific

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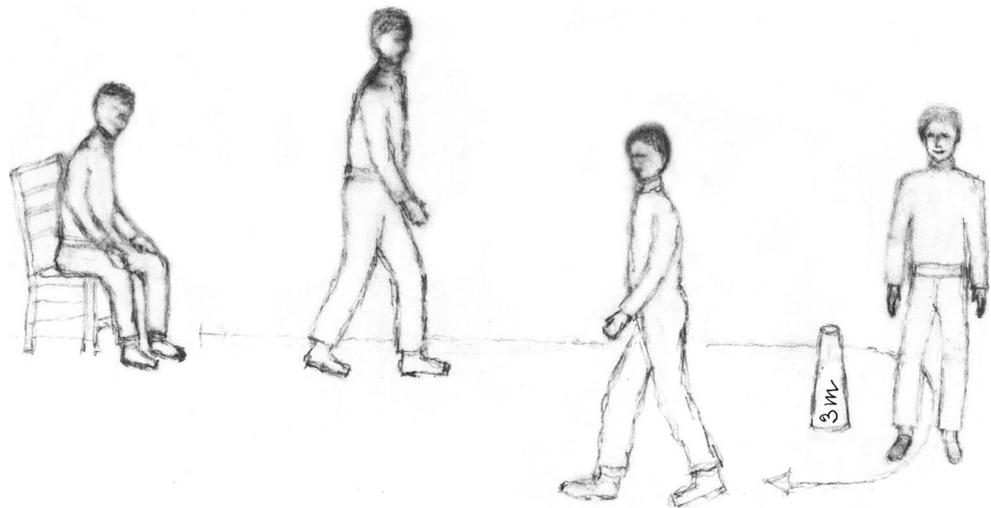
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**Fig. 1** The patient sits on a chair. The time is recorded, whilst the patient stands up on command and walks a distance of 3 m as fast as she/he can. After reaching the 3 m line, the patient turns around and returns to the chair to sit down again



consensus in the field of spinal surgery regarding the most appropriate outcome measures [2, 3]. Preoperative and postoperative evaluation of the intensity of pain and pain-related functional impairment, represent a major challenge, as it is difficult to achieve an objective characterization of the patients' mental and physical condition.

The most common pain and functional scales used in the literature are the visual analog scale (VAS) and the Oswestry Disability Index (ODI), followed by many other multidimensional scales and tests [4]. These tests depend on patients' responsiveness and an effort to convert patients' subjectively perceived pain and reported physical abilities into objective values. The "timed up and go" (TUG) test represents a performance-based functional test that objectively documents and quantifies the physical ability of walking. The patient sits on a chair with armrests. The time is recorded, whilst the patient stands up on command and walks a distance of 3 m (meters) as fast as she/he can. After reaching the 3 m line, the patient turns around and returns to the chair to sit down again (Fig. 1). This test is not time-consuming and ideal for outpatient use. It was first used to assess the functional mobility of frail elderly patients [5]. Later on, the TUG test was said to be a predictive value of physical function measurements for all-cause mortality in older men [6].

Ultimately, the improvement of performance and functionality are major goals of surgical treatment. Moreover, it is particularly important in surgery to be able to assess the patient's postoperative improvement accurately, so that any necessary new diagnostic and therapeutic steps can be taken in case of clinical deterioration. The purpose of this study was to evaluate and correlate the VAS in comparison with the TUG test, to establish both methods for describing pain and pain-related physical impairment resulting from

degenerative lumbar disease and surgical treatment. Special attention was paid to the early follow-up to detect any changes in pain intensity and functional impairment. This study cannot address the general relationship between these two tests and degenerative lumbar disease. It is intended to evaluate the postsurgical progress of patients suffering from degenerative lumbar disorders with a performance-based functional test (TUG) and a common pain assessment tool (VAS).

## Materials and methods

Thirty-eight patients with degenerative lumbar disease who were treated with monosegmental or bisegmental transpedicular spondylodesis combined with transforaminal lumbar interbody fusion (TLIF) were recruited consecutively and evaluated prospectively (Table 1). Surgery was performed after conservative options had failed for more than 3 months. The aim of this protocol was to include patients who received decompressive and instrumented monosegmental or bisegmental spondylodesis, including an intervertebral cage. The accepted indications for the study were degenerative lumbar disease from L1 to S1, confirmed by magnetic resonance imaging or computed tomography—such as degenerative or lytic spondylolysis and/or central canal stenosis, lateral recess stenosis, and foraminal stenosis causing radiculopathy or neurogenic intermittent claudication. The participants' mean age was 59 ( $\pm 9$ ) years, with a female to male sex ratio of 28–10. All of the patients were informed about the aim of the study, as well as the risks and benefits in case of inclusion, and signed informed consent was obtained. The visit plan consisted of a preoperative baseline assessment. Special attention was paid to the early follow-up including clinical

**Table 1** Demographic data of the participants

Demographic data	Female	Male	Overall
Patients	28 (74 %)	10 (26 %)	38 (100 %)
Age (mean value)	60a ( $\pm 9a$ )	56a ( $\pm 11a$ )	59a ( $\pm 9a$ )
Smoking	17 (45 %)	6 (16 %)	23 (61 %)
Operated level L4/L5	16 (42 %)	7 (18 %)	23 (61 %)
Operated level L5/S1	9 (24 %)	3 (8 %)	12 (32 %)
Operated levels L3/L4/L5	1 (3 %)	0	1 (3 %)
Operated levels L4/L5/S1	2 (5 %)	0	2 (5 %)
Pre_OP-VAS (mean value)	52.1 mm ( $\pm 24.5$ mm)	44.2 mm ( $\pm 24.5$ mm)	50 mm ( $\pm 24.4$ mm)
Pre_OP-TuG (mean value)	13.5 s ( $\pm 5.1$ s)	11.3 s ( $\pm 3.6$ s)	12.9 s ( $\pm 4.8$ s)

evaluations on the first, third, and sixth postoperative days. Additional clinical evaluations were carried out on the second, fourth, and twelfth postoperative week. All patients received postoperative analgesics according to a standardized protocol.

The parameters assessed focused on the VAS and TUG. The TUG is a clinical test that assesses the extent of the patient's mobility and is mainly used by physiotherapists. Patients sit in a standard armchair, with their back leaning against the chair. They can use any assistive walking device to stand up, walk a distance of 3 m, turn around, and walk back to the chair to sit down [7]. The investigator times the test (in seconds) [5]. Patients are instructed to walk at a comfortable, painless and safe speed. The test ends when the patient's buttocks are seated on the chair again. Patients who were unable to complete the TUG at the different time points, were not included in the evaluation for that time point. The VAS is a psychometric scale that is used for unidimensional pain assessment; patients describe the subjective intensity of pain by rating it on a 100-mm line, as reviewed by Hjermstad et al. [4]. The mean VAS of back- and leg pain (overall pain) of the patients was used for statistical analysis (Fig. 3a, b).

IBM SPSS Statistics for Windows, version 21.0 (IBM Corporation, Armonk, New York) was used for statistical analysis. Descriptive statistics and the Wilcoxon signed rank test were performed. Correlations between the VAS and TUG tests were analyzed using Spearman's rho test. The level of significance was set at  $P < 0.05$ . Statistical evaluations were carried out for the following conditions:

- The preoperative assessment was set as the index value and was compared with each postoperative visit.
- The previous visit attended was set as the index value and was compared with the subsequent investigation. Perioperative examinations were thus compared with each other chronologically (e.g., preoperative visit to postoperative day 1, postoperative day 1 with postoperative day 3, etc.). This served to represent the results

along the timeline, indicating any improvement or deterioration during the postoperative course.

- The tests were correlated with each other for the defined preoperative and postoperative visits.

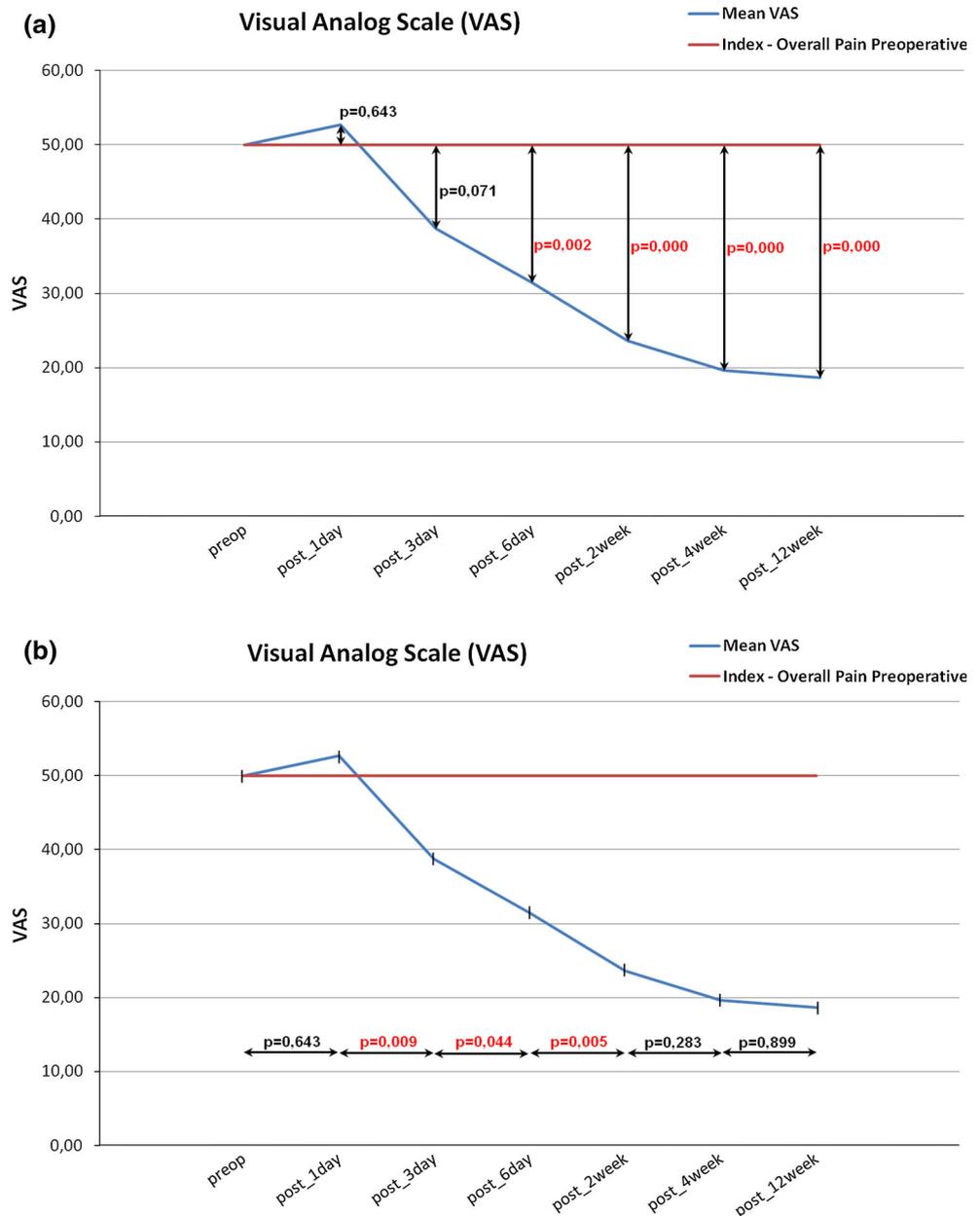
## Results

The patients' postoperative course after treatment with lumbar spondylodesis was assessed using both the VAS and TUG tests. Three stages were observed with the "timed up and go" test. Firstly, the TUG demonstrated changes in the patients' condition during the postoperative follow-up period more sensitively than the VAS and showed a significant deterioration on the first (mean  $24 \pm 10$  s) and third (mean  $18 \pm 7$  s) postoperative days in comparison with the preoperative findings (mean  $13 \pm 5$  s) (Fig. 2a). This reflects normal postoperative wound and leg pain, which restricts mobility even more than preoperatively. Secondly, following this significant deterioration, the assessments on the sixth postoperative day and 2 weeks after surgery showed that the patients' initial functional state had been restored, with no significant differences in functionality (Fig. 2a). This stage during the postoperative period may be referred to as the recovery level after the lumbar intervention performed.

The VAS showed a significant improvement in the pain level for the first time on the sixth postoperative day (mean  $31 \pm 23$  mm) in comparison with the preoperative baseline visit (mean  $50 \pm 24$  mm) (Fig. 3a). At the subsequent visits, the VAS continued to show significant improvement, reflecting successful treatment.

The third stage with the "timed up and go" test showed significant improvements in postoperative weeks 4 (mean  $10 \pm 3$  s) and 12 (mean  $10 \pm 3$  s) (Fig. 2a). The time measured showed almost complete recuperation after the intervention, with a significantly reduced TUG time in comparison with the preoperative status (mean  $13 \pm 5$  s).

**Fig. 2 a** The red line indicates the preoperative baseline, while the blue line represents postoperative changes at the defined follow-up visits. Three stages of the “timed up and go” (TUG) test were observed. Significant deterioration was observed at the first and third postoperative days. No statistical significance was seen at the sixth day or 2 weeks after surgery. Significant differences from the baseline values were observed at 4 and 12 weeks after surgery. **b** The results for the TUG test at the previous visit attended were set as the index value and compared with the subsequent investigation, so that the perioperative examinations were compared with each other chronologically (arrows). This represents the results along the timeline. The TUG appeared to be more sensitive and appropriate than the visual analog scale (VAS) during the short-term postoperative follow-up period, with improvement appearing in the patients’ functional ability to walk at every point along the timeline except between the fourth and twelfth weeks



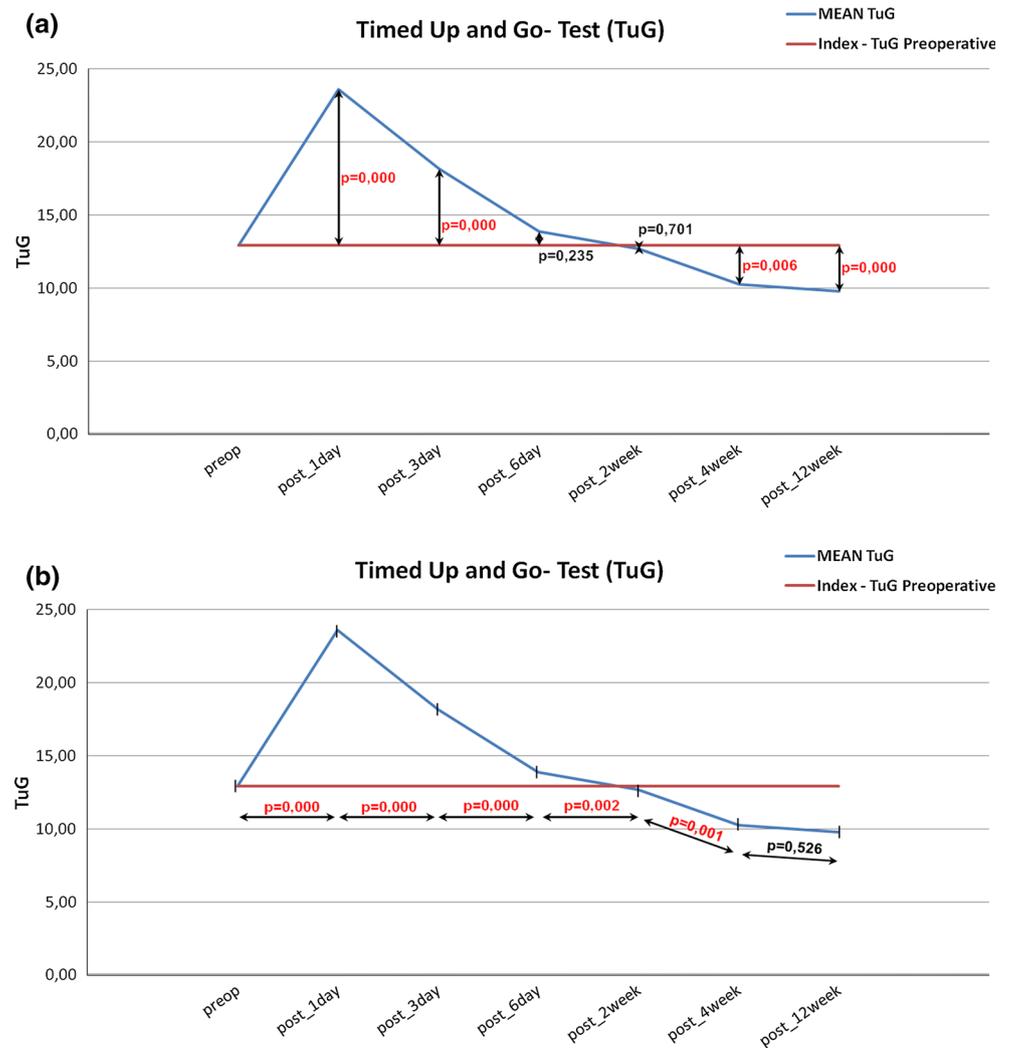
The perioperative examinations were then compared with each other chronologically (Figs. 2b, 3b). In this assessment, the VAS showed significant improvement only between the first (mean 53 ± 26 mm) and third (mean 39 ± 28 mm) postoperative days, between the third and sixth postoperative days (mean 31 ± 23 mm) and between the sixth postoperative day and second postoperative week (mean 24 ± 17 mm) (Fig. 3b). In this evaluation, the TUG again appeared to be much more sensitive with regard to improvement in the patients’ physical condition and ability to walk at every point in the timeline (Fig. 2b), with the exception of the last visit between week 4 (mean 10 ± 3 s) and week 12 (mean 10 ± 3 s) postoperatively.

On the assumption that pain leads to dysfunction and vice versa, the TUG results were also correlated with the VAS findings. Interestingly, a significant correlation was only observed on the first, postoperative day ( $P < 0.05$ ).

### Discussion

It continues to be difficult to assess patients’ physical condition and the extent of pain in an objective and quantitative fashion. The most commonly used pain scales are the visual analog scale (VAS) and numerical rating scale (NRS), along with many other multidimensional

**Fig. 3 a** The red line indicates the preoperative baseline, while the blue line represents postoperative changes at the defined follow-up visits. The visual analog scale (VAS) shows a significant improvement in pain on the sixth postoperative day, and the changes continue to be significant up to the last follow-up visit. **b.** The results on the VAS at the previous visit attended were set as the index value and compared with the subsequent investigation, so that the perioperative examinations were compared with each other chronologically (*arrows*). This represents the results along the timeline. A significant change in the VAS from visit to visit was only observed between the first and third postoperative days, between the third and sixth postoperative days and between the sixth postoperative day and the second postoperative week



scales and tests [4, 8]. All of these instruments are used in an effort to convert the subjective nature of the pain experienced by patients into objective quantities in order to measure the success of surgical treatment, to allow adjustment of pain medication postoperatively, to make it possible to recognize any deterioration after surgery, and to recruit patients into clinical trials [9, 10]. Additionally for the evaluation of minimally invasive methods, which actually do not show long-term benefits compared to conventional methods [11, 12], the TUG could be a useful tool to identify treatment benefits especially in the early postoperative period.

The unidimensional and questionnaire-based character of the VAS is associated with many confounding factors and does not provide an adequate objective impression of the intensity of the patients' pain [4]. It is often used in the VAS-100 mm version for pain assessment. Low compliance rates have been reported in some evaluations in association with the patients' age, the degree of trauma, and other

impairments [4]. To reduce the subjectivity of pain tests, it may be helpful to combine such scales with functional tests in order to provide a more valid characterization of the patients' condition, particularly during the postoperative period, but there is still a lack of data to confirm this. Although pain often limits physical activities, a combined instrument is not yet available for investigating pain and pain-related physical impairment during the postoperative course.

The "timed up and go" (TUG) test is a performance-based functional assessment of the extent of a patient's dysfunctionality [13–17]. A number of other appropriate rating tests are available for evaluating a patient's functional state. The most commonly used scales are the Oswestry Disability Index (ODI), the Roland–Morris scale, and the Barthel Index [18–22]. Although these assessments are in frequent and widespread use, they involve limitations due to their inherently subjective nature and show variations depending on the patients' differing educational

status, cultural expectations, and degree of motivation [23]. In contrast to these multidimensional disability tests, the TUG evaluates an individual's functional state in a performance-based way without using questionnaires. In an observational study, DeBuyser et al. assessed and compared the predictive value of physical function measurements for all-cause mortality in older men. Several functional tests were included. The TUG was found to be the best predictor for mortality in older men and was also predictive in individuals with cardiovascular disease [6]. The test not only measures basic mobility after stroke, but is also a sensitive and specific assessment method in community-dwelling adults who are at risk of falling, and it appears to be predictive for patients' ability to walk safely on their own [5, 13, 24]. The TUG is not well known in the field of spinal treatment, although most patients in this area suffer compromised walking due to functional disability. If a second postoperative deterioration occurs, a suitable functional test that is not time-consuming may be helpful for interpreting the clinical signs more effectively so that further diagnostic or interventional steps can be considered.

On the assumption that pain leads to dysfunction and vice versa, both the VAS and TUG tests should theoretically indicate any significant postoperative deterioration that occurs. The TUG was, therefore, compared with the VAS in this study, but significant correlations were only noted on the first postoperative day. The assumption that pain leads to dysfunctionality and vice versa is, thus, not confirmed by these two tests. No similar comparisons of performance-based functional tests and common pain scales, focusing on the postoperative follow-up after spinal surgery, have been reported in the literature to date. In the present investigation, the TUG test was found to be more sensitive than the VAS (Figs. 2b, 3b). The postoperative fluctuation in TUG values around the preoperative baseline value, with significant initial deterioration followed by a recovery process and ending with significant postoperative improvement, most likely reflects the normal course among patients who undergo lumbar spondylodesis (Fig. 2a).

These results are also comparable with the minimal clinically important change (MCIC) in the TUG recently described by Wright et al. The study included patients undergoing hip osteoarthritis and showed an MCIC of 1.2 s [25]. All of the statistically significant results with the TUG in the present evaluation showed differences in the mean values above the MCIC described by Wright et al. When the results with the VAS are compared with the MCIC or minimal important change (MIC) values for lumbar back pain described in the literature, a 30 % change from baseline may be considered clinically meaningful and was observed in a study by Ostelo et al. [26]. This 30 % improvement was only noted on the sixth

postoperative day, and it coincided with a significant improvement in the VAS at the same time point [26]. However, the timeline analysis in the present study does not support the findings reported by Ostelo et al. The TUG showed a statistically significant timeline change at all postoperative visits, except between 4 and 12 weeks postoperatively (Fig. 2b). The VAS was, thus, found to be significant only between the first and third and the third and sixth postoperative days, as well as between the sixth postoperative day and the second postoperative week (Fig. 3b). No improvement in the patients' pain situation on each of the remaining days was therefore detected—indicating the limited sensitivity of pain scales for assessing postoperative changes (Fig. 3).

## Conclusion

This is the first study that has analyzed the “timed up and go” test and the visual analog scale in the postoperative course after spinal interventions. The TUG is a valid and sensitive performance-based functional test, which indicates a significant change already on the first postoperative day. In contrast, the VAS—a subjective and questionnaire-based pain scale—indicates significant changes only 2 weeks after surgery. The TUG appears to be more sensitive and appropriate for assessing postoperative changes and is suggested for use in conjunction with pain scales in everyday routine work. The use of this test in long-term outcome to assess both functionality and pain should be conducted.

**Acknowledgments** None of the authors has any conflicts of interest in connection with the study.

**Compliance with ethical standards**

**Conflict of interest** None.

**Ethical approval** Date of approval: April 13th, 2012; ethical approval ID: UN4624; session number 310/4.6.

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