Lumbar lordosis as tool to assess the level of pain in patients with low back pain after lumbar disc herniation

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ABSTRACT

Background: It is presently unknown if lumbar lordosis (LL) might be applied to monitor low back pain (LBP) in patients with lumbar disc herniation (LDH). There is presently only conflicting data that does not show a correlation of LL with LBP: Previous studies do either include chronic LBP or do not consider that each patient has an individual value of LL that cannot be compared to other patients.

Methods: Power analysis: At least 32 patients had to be enrolled in the study. Out of 84 consecutive patients with acute onset of pain (< 6 weeks) that were treated operatively from 11/2015 to 04/2017 by microscopic laminotomy for LDH, 35 were enrolled in this retrospective within – subject analysis after exclusion of patients with chronic LBP or severe disc degeneration of the lumbar spine. We recorded self - reported assessment of pain (VAS) and LL before the operation, 1 week and 6 weeks after the operation. We performed a paired – samples t - test (within – subject) to compare means of LL at admission to our institution with LL 6 weeks after surgery. Pearson's correlation was determined for LL and VAS. Significance level was set at $p < 0.05$.

Results: VAS at admission to our institution was 7.1 (0.4), VAS 6 weeks after surgery was 1.0 (0.3). LL at admission to our institution was 40.0 (2.1), LL 6 weeks after surgery was 48.0 (1.8). The difference was significant ($p < 0.0005$) with a high statistical power ($1-\beta = 0.99$). Correlation of LL and VAS was significant ($p < 0.01$, $r = -0.32$).

Conclusions: The increase of lumbar lordosis following surgery is significantly correlated to the decrease in the level of perceived pain in patients with a LDH and may be used as an additional tool to monitor the success of treatment in the investigated group of patients.

1. Introduction

Self-reported pain intensity ratings currently are the reference standard to monitor pain intensity in patients with low back pain (LBP). However, self-reported ratings are by definition subjective and influenced by multidimensional factors,^{1,2} herewith leading to higher doses and longer time of administration of pain killers, with possible subsequent side effects and risk of addiction.³ Therefore, objective and unsophisticated tools to monitor the level of pain in LBP are needed.⁴

There are reports of pain monitoring by neuro – imaging (functional MRI) but the technique is yet still to be further established and would only be available in highly specialized centers.⁴

Imaging of the lumbar spine is reported to show only a weak or no correlation with the perceived level of pain.^{1–7}

Some investigations compared the degree of lumbar lordosis (LL) of

healthy volunteers to patients with LBP. However, the results were contradictory: While Piazzola et al.⁸ and Murray et al.⁹ reported that LL was higher in patients with LBP than in healthy controls, others^{10–12} reported the opposite.

These different results may be explained by the biases in these reports:

The previous studies do not take into account that each patient has an individual value of LL that cannot be compared to other patients.¹³ Thus, a comparison of patients with LBP to healthy controls leads to a bias.

Furthermore, it is mandatory to differentiate between acute and chronic LBP:

A chronically increased LL can lead to subsequent degeneration of the facet joints,^{8,9} resulting in an increase or a different quality of the perceived LBP.

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A chronically decreased LL can influence the LBP due to hypokyphosis, loss of sagittal balance and subsequent degeneration of intervertebral discs.^{10,12}

Thus, in patients with chronic LBP it is not possible to distinguish if the LBP influenced LL, or if a chronically altered LL led to LBP.

To date, no study excluding those biases has evaluated the changes of LL due to LBP.

2. Theory

Our primary hypothesis was that LL increases when visual analogue scale (VAS) (0-10) of LBP decreases in the investigated group of patients.

3. Methods

3.1. Study design

We conducted a retrospective single-center study on prospectively collected data: We included consecutive patients treated operatively from 11/2015 to 04/2017 by microdiscectomy for a LDH. Surgery was conducted by the first author in all patients. Postoperatively non-steroidal anti-inflammatory drugs were administered for two weeks in all patients. All patients were postoperatively instructed by the same team of physiotherapists and the surgeon with the same postoperative protocol: All patients learned the same isometric exercises (back strengthening), were allowed to bear weight up to 5 kg and told to avoid trunk rotation for 6 weeks. There was no limitation for walking, no sports were permitted for 6 weeks.

In all patients location and quality of pain matched the morphologic pathology that was found in the patient's MRI. Before surgery, 1 week after surgery and 6 weeks after surgery all patients received standard standing radiographs (ap and lateral view) of the lumbar spine and assessed their pain by the visual analogue scale (VAS) (0-10). LL was determined from L1 to S1.

Patients with LBP for more than 12 weeks before surgery, prior spinal surgery, severe disc degeneration (grade 3 or 4 according to the classification of Pfirrmann¹⁴) of more than one intervertebral disc in the preoperative MRI, scoliosis on the performed standard radiographs, an age of less than 18 or more than 65 years and which were non ambulatory or were not able to perform self-assessment of the level of pain by VAS were excluded.

The radiographic measurements were conducted using a certified radiographic image viewer (Sectra Workstation IDS7, Linköping, Sweden). The built-in angle and distance measurement features were used for the analysis.

3.2. Statistical methods

Statistical analysis was carried out with SPSS 25.0 (© IBM Armonk, NY, USA). The demographics were summarized by mean and standard error of mean. Normal distribution was tested using the Kolmogorov-Smirnov-Test.

Since LL showed normal distribution, we performed a paired – samples t - test (within – subject) to compare means of LL at admission to our institution with LL 6 weeks after surgery.

Pearson's correlation was determined for LL and VAS. Significance level was set at $p < 0.05$.

Power analysis was performed with G – Power¹⁵.

Based on previous investigations^{1,8–12} an effect size of 0.5 was calculated. Prehoc calculation of needed sample size was performed (effect size 0.5, α 0.05, power > 0.9 , type of test). At least 32 patients had to be enrolled in the study to achieve a high statistical power ($1-\beta > 0.90$). Posthoc calculation of effect size and statistical power were performed to confirm the calculation.

The study was conducted according to the revised declaration of

Table 1

Lumbar Lordosis and VAS before and after surgery.

Data	Age	1. LL	1.VAS	2. LL	2. VAS	3. LL	3. LL – 1. LL	3. VAS
Mean	52,37	40,03	7,15	47,07	1,76	47,87	7,98	,97
Standard error of mean	2,395	2,10	,40	1,76	,25	1,65	1,60	,29

1. LL = Lumbar Lordosis at admission to our institution, 2. LL = Lumbar Lordosis 1 week after surgery, 3. LL = Lumbar Lordosis 6 weeks after surgery, 1. VAS = self reported pain level by visual analogue scale (0-10) at admission to our institution, 2. VAS = self reported pain level by visual analogue scale (0-10) 1 week after surgery, 3. VAS = self reported pain level by visual analogue scale (0-10) 6 weeks after surgery.

Helsinki.

The Ethics Committee of the Medical Faculty granted ethical approval for this retrospective trial. The registration number was 2017044257.

We did not receive any funding for this study, the authors state that there is no conflict of interest.

4. Results

We identified 84 consecutive patients that matched our inclusion criteria. After applying the exclusion criteria we enrolled 35 patients in our investigation (Table 1).

19 patients (54.3%) had a LDH at L4/5, 13 patients (37.1%) in L5/S1 and 3 patients (8.6%) in L2/3 or L3/4. None of the patients showed lumbosacral transitional vertebra or other spinopelvic deformities.

The mean VAS at admission to our institution was 7.1 (0.4), the mean VAS 1 week after surgery was 1.8 (0.2) and the mean VAS 6 weeks after surgery was 1.0 (0.3).

The LL at admission to our institution was 40.0° (2.1°), the LL 6 weeks after surgery was 48.0° (1.8°) (Fig. 1). The difference was significant ($p < 0.0005$) with a high statistical power: $1-\beta = 0.99$;

Fig. 1. Male patient of 49 years with lumbar disc herniation L5/S1. A: Sagittal radiography of the lumbar spine at admission to our institution. Lumbar Lordosis (LL) 31°. B: Sagittal radiography of the lumbar spine 1 week after surgery. Lumbar Lordosis (LL) 46°. C: Sagittal radiography of the lumbar spine 6 week after surgery. Lumbar Lordosis (LL) 52°.

confidence interval -11.2 to -4.7 ; $T = -5.0$ ¹⁵.

Only four patients did not show any change in LL ($< 2^\circ$ difference).

The increase in LL and the decrease of the VAS following surgery showed a significant correlation ($p < 0.01$, $r = -0.32$).

5. Discussion

This is the first study evaluating the correlation of degree of lumbar lordosis to the VAS of LBP in patients with an acute onset of LBP caused by lumbar disc herniation (LDH).

We investigated patients in whom the generator of LBP was verified (a LDH) and who did not suffer from chronic LBP to minimize possible biases. Patients with a verified source of pain were relieved from their pain, which lead to a decrease of VAS of LBP. By performing a within patient analysis we excluded the possible bias of comparing patients with different types of LL.¹³ We could show that LL increased significantly by 8° in the mean and the VAS decreased by 6 points in the mean after surgery. LL may therefore be applied as an independent and unsophisticated additional tool to monitor pain in patients with acute LBP due to LDH.

Deformities or degeneration of the face joints might influence LL. However, by excluding patients with scoliosis we also excluded patients with severe facet joint tropism. By excluding patients with severe disc degeneration of more than one intervertebral disc we also excluded patients with degeneration of more than one facet joint and since none of the patients showed lumbosacral transitional vertebra there were no patients with facet joint deformity in these segments.

The strict inclusion criteria, recruiting only patients with a MRI verified LDH and acute LBP, as well as the standardized single surgeon surgical therapy and POP management are strengths of the present study.

A limitation of our results is that LL was only evaluated in patients with LDH and without severe degenerative changes in the intervertebral discs: Conclusion to other pathologies causing acute LBP is not possible. The reason for the change of LL after successful treatment of a LDH might be the removal of the sequestered part of the intervertebral disc. Foraminal height and width of spinal canal are increased by flexion of the lumbar spine and might be a natural reaction to a LDH, which is no longer needed if the herniation is removed. Further investigations should be performed to reveal if other spinal diseases, especially spinal canal stenosis with subsequent LBP, can also be monitored by analyzing LL. Since disc degeneration reduces the ability of the lumbar spine to perform flexion and extension, only patients without severe disc degeneration should be investigated.

VAS is a subjective parameter, and the lower reliability of the parameter is the main reason why we conducted this investigation. However, in our investigation we relieved patients of a confirmed pain generator. The mean VAS before surgery was 7.1, mean VAS 6 weeks after surgery was 1.0. A difference of 1 or 2 points would hardly be reliable, but the difference of VAS before and after surgery in this investigation seems to be reliable and valid to confirm that the pain level after the surgery was lower than before the surgery and was therefore applied in this investigation.

Four patients showed no change in LL ($< 2^\circ$ difference) despite of an improvement of VAS to zero in all 4 patients: One patient who improved from a VAS of 10.0 before surgery to a VAS of 0.0 6 weeks after surgery showed a decrease of LL after the surgery by 14.7° . The review of his images showed that the patient, who did not report any back pain before the LDH, had a thoracic Scheuermann's disease. This disease is often accompanied by an increased LL to compensate for an increased thoracic kyphosis and may present a confounding factor in monitoring pain by LL.

Another patient who improved from a VAS of 9.0 before surgery to a VAS of 2.0 six weeks after surgery showed a decrease of LL after the surgery by 5.4° . The review of the images showed that the patient had an asymmetric transitional vertebra S1. This "normal variant" may

have influenced LL. The other patients' data showed no abnormalities, in both patients VAS improved from 8.0 preoperative to 0 six weeks postoperative.

6. Conclusion

The increase of lumbar lordosis following surgery is significantly correlated to the decrease in the level of perceived low back pain in patients with acute pain by a lumbar disc herniation and may be used as an additional tool to monitor the level of pain and success of treatment of LDH.

Authorship statement

Markus Rafael Konieczny: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing - original draft; Writing, Sina Schroer: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Visualization; Writing - original draft; Writing, Christoph Schleich: Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Software; Validation; Visualization; Writing, Max Prost: Data curation; Investigation; Methodology; Project administration; Supervision; Validation; Writing, Martin Hufeland: Data curation; Investigation; Methodology; Project administration; Supervision; Validation; Writing, Hannes Kubo: Data curation; Investigation; Methodology; Project administration; Supervision; Validation; Writing, Rüdiger Krauspe: Conceptualization; Methodology; Project administration; Resources; Software; Supervision; Validation; Writing,

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Authors' contributions

All authors were major contributors concerning the management of the patients, review of the articles and manuscript preparation. All authors read and approved the final manuscript.

Ethics committee

The study was approved by the local ethics committee.

Declaration of competing interest

The authors declare that they have no conflict of interests.

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