Driving reaction time before and after surgery for lumbar disc herniation in patients with radiculopathy

Martin Thaler · Ricarda Lechner ·
Bernhard Foedinger · Christian Haid ·
Pujan Kavakebi · Klaus Galiano · Alois Obwegeser

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Abstract

Purpose Although patients scheduled to undergo lumbar disc surgery often ask when they are allowed to drive a motor vehicle again, there are no published recommendations on this subject.

Methods We conducted a prospective study in 46 consecutive patients (mean age 48.9 years) to determine driving reaction time (DRT) before and after surgery in patients with lumbar disc herniation. Of the patients 23 had left-side radiculopathy and 23 right-side radiculopathy. Driving reaction time as well as back and leg pain were evaluated preoperatively, on the day of discharge from hospital and at the 5-week follow-up examination (FU). 31 healthy subjects were tested as controls.

Results Significant improvement in DRT was seen for both patient samples ($p < 0.05$). For patients with a right-side radiculopathy preoperative DRT was 664 ms (median, IQR: 241), which was reduced to 605 ms (median, IQR: 189) immediately postoperatively and to 593 ms (median,

IQR: 115) at FU. For patients with a left-side radiculopathy DRT was 675 ms (median, IQR: 247) preoperatively, 638 ms (median, IQR: 242) postoperatively and 619 ms (median, IQR: 162) at FU. Pain was moderately correlated to DRT. Control subjects had a driving reaction time of 487 (median, IQR: 116), which differed significantly from patients at all three testing times ($p < 0.001$).

Conclusion Our data indicate a positive effect of the surgery on driving ability. Therefore, we would suggest that for both patient samples it is safe to continue driving after hospital discharge. However, patients have to be informed about increased DRT caused by radiculopathy already before surgery.

Keywords Driving reaction time · Lumbar disc surgery · Radiculopathy · Disc herniation

Introduction

Lumbar disc surgery is the most commonly performed procedure for surgical decompression of radiculopathy caused by lumbar disc herniation. [1–3]. Numerous works have been published on patient outcome, complications, cost analysis, subjective health measurements, long-term follow up of clinical factors and ability to return to work or to sports associated with lumbar disc surgery [1–7]. Patients scheduled for lumbar disc surgery frequently request information on the potential effect of the surgery on their driving ability. However, no publications dealing with driving safety and lumbar disc surgery were found. Driving reaction time (DRT), as measured with various car simulators, is one of the most important factors responsible for driving safety [8, 9]. Driving reaction time has been investigated in the context of treatments of the

M. Thaler and R. Lechner have contributed equally to this work.

M. Thaler (✉) · R. Lechner · B. Foedinger · C. Haid
Department of Orthopaedic Surgery, Innsbruck Medical
University, Anichstrasse 35, 6020 Innsbruck, Austria
e-mail: martin.thaler@uki.at

P. Kavakebi
Department of Neurosurgery, Hospital Feldkirch,
Anichstr. 35, 6020 Innsbruck, Austria

K. Galiano
Department of Neurosurgery, Spine Center Kettenbruecke,
Innsbruck, Anichstr. 35, 6020 Innsbruck, Austria

A. Obwegeser
Department of Neurosurgery, Innsbruck Medical University,
Anichstr. 35, 6020 Innsbruck, Austria

musculoskeletal system, like nerve root blocks [8], total hip replacement [10, 11], total knee replacement [9, 12, 13], anterior cruciate ligament reconstruction [14, 15], arthroscopic knee surgery [16] and lumbar fusion surgery [17]. Based on their findings, the authors of these studies recommend a 1- to 12-week interval after surgery before resuming driving. To date there is no official DRT threshold. Road authorities, like the German Commission on Reaction Times, the Royal Automobile Club of Victoria, or the Department of Transport in Britain recommend a wide range of safe DRTs ranging from 700 to 1,500 ms [18–20].

The aim of the present study was to investigate the effect on DRT by right- and left-side lumbar radiculopathy without paresis. Furthermore, we also analysed the effect of lumbar disc surgery on DRT 3 days and 6 weeks after surgery. In addition, we compared DRT in patients with sciatica caused by disc herniation with DRT of healthy individuals.

Materials

Participants

Forty-six consecutive patients scheduled to surgery from November 2010 to March 2011 were included in the present study. Depending on the intraoperative presentation sequesterectomy or subtotal discectomy was performed. All patients considered for inclusion had a valid driving licence. Patients with coexisting neurological disorders (e.g., multiple sclerosis), acute trauma, cauda equina syndrome, pathologic or infectious aetiology, spinal stenosis, spondylolisthesis, scoliosis and a motor deficit of less than 5 on the Medical Research Council Scale for Assessment of Muscle Power were excluded from the study. Of these patients 23 had left-side- and 23 right-side radiculopathy. All patients failed to improve with non-surgical therapy and presented with radicular pain due to lumbar disc herniation lasting more than 6–8 weeks. In all patients MRI confirmed disc herniation with distinct nerve root compression. Total intravenous anaesthesia (TIVA) was used in all patients.

All 31 healthy subjects in the control group (19 females, 12 males; mean age 52 years; SD 7.7 years) had a valid driving licence, at least 10 years of driving experience and no history of spinal pathology.

The study was approved by the local ethics committee, and all patients gave informed consent prior to participation.

Procedure

Driving reaction time was tested with a custom-built car simulator, described and validated in published literature [8, 11]. An adjustable car seat was fixed on a frame with hanging pedals mounted on rubber-damped pivots (Fig. 1).

Fig. 1 Custom-made car simulator for measuring driving reaction time. *Top right:* external box containing the logic gate electronics, clock, green and red lamps

As requested in a previous report, the position of the seat regarding seat inclination, head rest and seat-pedal distance was adjustable to simulate the patient's accustomed driving position [21]. An external box containing the logic gate electronics and a green and a red lamp was positioned on a table at a constant distance in front of the car simulator. When the accelerator was fully depressed the green lamp lit up, indicating that the patient was not driving in a "ready to brake fashion." After an interval of 5–10 s, the observer pushed an external trigger, invisible to the patient, which activated the red lamp and the electronic clock. When the patients recognized the red light, they were instructed to push the brake as quickly as possible with the right leg. Then the patient's right foot was moved from the gas pedal to the break pedal and the break pedal was pushed. The left leg stayed on the clutch pedal during the entire test. The time interval from the appearance of the red light to the patient operating the brake was measured in ms. Each patient performed three dry runs. Then DRT was measured ten times at an interval of 5–10 s between each measurement. All patients were given the same standardized instructions. Reproducibility tests were not performed, because we adhered to previously published study protocols [11].

The first test (preoperative: pre-op) was performed 1 day before surgery, the second test before hospital discharge (3.1 days (mean, SD (standard deviation): 1.27) and the third test at follow-up (FU: 34.82 days (mean; SD 5.65)) examination.

Clinical testing

On each test occasion the intensity of right or left leg pain and back pain was measured for all patients with a Visual Analogue Scale (VAS), ranging from 0 for no pain to 10

for very severe pain. Leg and back pain were recorded under routine conditions and during testing. Driving frequency (never, once a month, once a week, and daily) and intake of analgesics were assessed on each test occasion.

Statistical analysis

Data were processed using the Statistical Package for Social Sciences (SPSS17 Norusis/SPSS Inc., Chicago, IL, USA). Driving reaction time were not normally distributed and therefore regarded as ordinal variables. Median (median) and interquartile ranges (IQR) were used as descriptive statistics. To compare DRT values DRT means (10 measurements) were calculated at each time-point for each patient. For inferential statistics, the Friedman test was used to test for longitudinal differences in DRT. p values < 0.05 were defined as statistically significant. In the case of significant results, Wilcoxon tests were performed for post hoc analysis (pre-/post-op comparison, post-op/FU comparison); p values < 0.025 were defined as statistically significant. The Spearman Rho coefficient was used to identify correlations (0.0–0.4 no correlation; 0.4–0.7 moderate correlation; 0.7–1.0 strong correlation). Cross-sectional testing (independent variables) was performed with the Mann–Whitney U test at an alpha level of 0.05.

Results

Driving reaction time measurement and clinical investigation were performed 3.1 days (mean, SD (standard deviation) 1.27) after surgery for post-op testing and 34.82 days (mean; SD 5.65) after surgery for FU testing. Table 1 summarizes the demographic and baseline characteristics of the study patients. No statistical difference was found between VAS under routine conditions and during testing. VAS for back pain and leg pain for both patient samples at all three test times is shown in Table 2. Right- and left-side radiculopathy patients showed a significant decrease in leg pain immediately after surgery ($p < 0.01$). Back pain decreased for both groups until FU ($p < 0.01$).

A statistically significant difference in DRT in longitudinal course was seen for both patient samples ($p = 0.019$) (Table 3). In both groups extreme DRT values resolved till FU (Figs. 1, 2). Post hoc analysis at the alpha level of 0.025 revealed significant differences between DRT pre-op and DRT post-op for the right-side radiculopathy group ($p = 0.018$), as well as between DRT post-op and DRT FU ($p = 0.09$) for the left-side radiculopathy group. Cross-sectional testing of DRT revealed no significant difference at any of the testing times (Fig. 3).

Table 1 Comparison of demographic data and descriptive statistics on DRT in left-side and right-side radiculopathy patients

	Right-side radiculopathy	Left-side radiculopathy	Controls
Age [mean (sd)] (year)	47.9 (12.1)	50.0 (12.9)	52.0 (7.7)
Female (n)	8	9	19
Male (n)	15	14	12
Herniation level			
L3/L4	2	3	
L4/L5	11	12	
L5/S1	10	8	
DRT pre-op (ms)	664 (241)	675 (247)	487 (116)
DRT post-op (ms)	605 (189)	638 (242)	
DRT FU (ms)	593 (115)	619 (162)	

Data presented as median (IQR)

Table 2 VAS values at all three testing times: pre-op (preoperative), post-op (postoperative) and FU (Follow-up)

	Pre-op	Post-op	FU
Right-sided radiculopathy			
Back pain	4 (5)	0 (2)	0 (0)
Leg pain	5 (3)	0 (1)	0 (1)
Left-sided radiculopathy			
Back pain	4 (5)	3 (4)	0 (2)
Leg pain	3 (4)	0 (5)	0 (2)

Data are expressed as Median (IQR)

No correlation was found between DRT at any measurement point and driving experience.

Moderate correlations were found between VAS for back pain pre-op and DRT pre-op in left-side radiculopathy patients ($r = 0.45$, $p = 0.031$) and VAS for back pain post-op and DRT post-op in left-side radiculopathy patients ($r = 0.43$, $p = 0.037$). Throughout the entire study the average DRTs for both radiculopathy groups were significantly longer than the DRTs for the control group.

Discussion

When giving informed consent and after lumbar disc surgery, patients frequently asked when they would be allowed to drive a car again. The influence of lumbar discectomy on DRT has not been previously investigated.

Our results showed significant improvement in DRT in the longitudinal comparison for both radiculopathy groups, demonstrating a positive impact of surgery on DRT (Table 2). The increase in median DRT approximately 3 days after discectomy was 59 ms for the right-side

Table 3 Longitudinal and cross-sectional comparison of DRT in patients with right- and left-side paresis caused by lumbar disc herniation

	Pre-op		Wilcoxon		Post-op		Wilcoxon		FU	Friedmann
Right-side radiculopathy	664 (241)	←	0.018	→	605 (189)	←	1.36	→	593 (115)	0.019
Mann–Whitney <i>U</i>	0.668				0.249				0.328	
Left-side radiculopathy	675 (247)	←	0.927	→	638 (242)	←	0.009	→	619 (162)	0.009

Data in frames: *p* values of longitudinal ($\alpha = 0.025$) and cross-sectional ($\alpha = 0.05$) comparison. Bold data in frames: brake response time as median (interquartile range) (msec)

pre-op preoperative, *post-op* postoperative, *FU* follow-up

Fig. 2 Box plots showing the preoperative (pre), postoperative (post) and at follow-up (FU) DRT values for *right-side* radiculopathy patients. Data are expressed as median, interquartile range and extreme values

Fig. 3 Box plots showing the preoperative (pre), postoperative (post) and at follow-up (FU) DRT values for *left-side* radiculopathy patients. Data are expressed as median, interquartile range and extreme values

radiculopathy patients and 37 ms for patients with left-side radiculopathy.

This difference between pre-op and FU DRT measurement would mean a difference in stopping distance of 1.97 m for right-side radiculopathy patients (difference 71 ms) and 1.56 m for left-side radiculopathy patients (difference 56 ms) at a speed of 100 km/h (27.78 m/s or 62.14 mph). Similar results seen by Al-khayer et al. [8], thus they compared DRT in radiculopathy patients after selective nerve root block. Al-khayer found significantly longer DRTs immediately, and 2 weeks after right nerve root block, but no significant differences in DRT at 6-week follow-up. Right- and left-side radiculopathy patients showed identical DRTs after nerve root block. Although he did not provide clear recommendations on when patients should resume driving, he recommended informing patients about the change in DRT following nerve root block. Liebensteiner et al. studied the influence of primary lumbar fusion on DRT. They showed significant DRT improvement at 3-month follow-up and recommended that driving be continued after hospital discharge [17].

Driving reaction time has been investigated before and after several orthopaedic surgeries. These studies based their recommendations for a driving abstinence on the difference to preprocedure values. For knee arthroscopy 1 week of driving abstinence has been recommended [16]. Four to eight weeks of non-driving are currently advised for patients undergoing total hip replacement [10, 11], while 10 days to 8 weeks of driving abstinence are recommended after total knee replacement [12, 13, 22]. Two and six weeks were found to be safe with regard to DRT for patients undergoing left- and right-side anterior cruciate ligament reconstruction, respectively [14, 15].

Our results reveal that both patient samples had significantly longer DRTs in all measurements than did the control group. Spinal pathologies like radiculopathy [8] and degenerative spinal disease [17] may cause a delay in neural signal transfer, and this may result in a longer DRT. Reflex inhibition causing pain and muscle weakness seems to be one of the most important ones [23].

General anaesthesia should not have an impact on driving ability, because the impairing effects of general anaesthesia should no longer persist after 24 h [13]. In addition pain medication seems to have no influence on DRT [17]. Currently available data do not recommend a driving abstinence, not even in patients receiving opioids [24, 25].

Our results show that back pain was moderately correlated with DRT preoperatively and immediately postoperatively in the left-side radiculopathy group. However, back pain was more severe at post-op and at FU examination in the left-side group. Similar results were published by Liebensteiner et al. [17] who showed a moderate correlation between DRT preoperative and back pain. It has already been reported that pain influences muscle performance and thus DRT [21]. However, in our opinion pain should not have an influence on “return to driving” recommendations, because of its subjectivity, variety and moderate influence on DRT.

Unfortunately, no universal threshold exists as reference value for DRT. A number of road authorities recommend different values for maximum DRT, ranging from 700 to 1,500 ms [18–20]. However, no generally accepted threshold for declaring a driver safe has been defined. The German Commission on Reaction Times suggests that a DRT within 1,500 ms is safe [18]. By contrast, the Royal Automobile Club of Victoria assumes 750 ms [20] and the Department of Transport in Britain found a DRT of 700 ms to be safe. DRTs in our patient group fell within this range on all test occasions [19]. When discussing a safe reaction time several factors should be considered, such as driver age, cognitive level, level of fatigue, alcohol and drug anamnesis as well as type and location of brake lights [26]. Therefore, for medico-legal aspects patients should be informed that their ability to brake might be additionally impaired when suffering from radiculopathy.

Limitations on the current study are that we did not assess the difference of the two individual DRT sub-periods: reaction time or movement time. Movement time is the motoric component of the DRT. This time period starts after recognition of the stimulus (red light). However, in routine traffic these two components are of less importance when a car has to be stopped quickly. Another shortcoming is that we performed only two postoperative measurements of DRT. More frequent postoperative tests would have yielded more detailed information on the improvement in DRT.

Conclusion

Because of the lack of a universal threshold, most published studies use preoperative DRT for postoperative recommendations. Our results show a decrease of 59 ms in

right-side radiculopathy patients before hospital discharge, which was statistically significant. Although there was no statistically significant difference for left-side patients, a decrease of 37 ms was detected before discharge from hospital. Therefore, we believe it is not justified to impair a patient's quality of social and occupational life post-surgery by imposing restrictions on driving, not even for left-side radiculopathy patients, but patients should be informed already before surgery that radiculopathy might affect safe driving.

From the improvements seen when comparing preoperative and postoperative DRTs, we conclude that it appears to be safe to continue driving after hospital discharge for patients with radiculopathy caused by lumbar disc herniation and treated with lumbar disc surgery.

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