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Proprioceptive use and sit-to-stand-to-sit after lumbar microdiscectomy: The effect of surgical approach and early physiotherapy

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ABSTRACT

Background: Individuals with non-specific low back pain show decreased reliance on lumbosacral proprioceptive signals and slower sit-to-stand-to-sit performance. However, little is known in patients after lumbar microdiscectomy.

Methods: Patients were randomly assigned into transmuscular ($n = 12$) or paramedian lumbar surgery ($n = 13$). After surgery, the same patients were randomly assigned into individualized active physiotherapy starting 2 weeks after surgery ($n = 12$) or usual care ($n = 13$). Primary outcomes were center of pressure displacement during ankle and back muscles vibration (to evaluate proprioceptive use), and the duration of five sit-to-stand-to-sit movements, evaluated at 2 (baseline), 8 and 24 weeks after surgery.

Findings: Two weeks after surgery, all patients showed smaller responses to back compared to ankle muscles vibration ($P < 0.05$). Patients that underwent a transmuscular surgical procedure and patients that received physiotherapy switched to larger responses to back muscles vibration at 24 weeks, compared to 2 weeks after surgery ($P < 0.005$), although not seen in the paramedian group and usual care group ($P > 0.05$). Already 8 weeks after surgery, the physiotherapy group needed significantly less time to perform five sit-to-stand-to-sit movements compared to the usual care group ($P < 0.05$).

Interpretation: Shortly after lumbar microdiscectomy, patients favor reliance on ankle proprioceptive signals over lumbosacral proprioceptive reliance to maintain posture, which resembles the behavior of patients with non-specific low back pain. However, early active physiotherapy after lumbar microdiscectomy facilitated higher reliance on lumbosacral proprioceptive signals and early improvement of sit-to-stand-to-sit performance. Transmuscular lumbar surgery favoured recovery of lumbosacral proprioception 6 months after surgery.

Clinical Trial Number: NCT01505595

1. Introduction

Up to 78% of the low back pain (LBP) patients relapse into a pain episode (Airaksinen et al., 2006). When persistent nerve root compression caused by disc herniation is present, lumbar microdiscectomy is recommended. Despite the high success rate of first-time lumbar microdiscectomy in terms of neural repair, residual functional complaints are not infrequent (Loupasis et al., 1999). Short term after surgery, lumbar microdiscectomy provides more rapid recovery than non-operative treatment, but no difference in functionality and pain is found in the long run (Jacobs et al., 2011b; Loupasis et al., 1999). The underlying mechanisms of these residual complaints remain largely unknown, although identification of these factors is listed as a high research priority in this research area (Costa et al., 2013; McGregor et al., 2006).

Optimal postural control is indispensable to carry out functional activities. An essential daily functional activity, which necessitates postural control (Lord et al., 2002), is the sit-to-stand-to-sit (STSTS) task (Dall and Kerr, 2010). In LBP patients, the STSTS task is more energy demanding (Shum et al., 2009) and associated with altered movement patterns (Jacobs et al., 2011a). Decreased postural control is a potential

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factor in the etiology of recurrent non-specific LBP. A possible mechanism for this is reduced lumbosacral proprioception. When lumbosacral proprioceptive signals lose reliability due to LBP, individuals are likely to rely dominantly on ankle proprioceptive signals, irrespective of the postural demands (Brumagne et al., 2008; Claeys et al., 2011, 2015). Consensus on the effect of lumbar surgery on postural control is lacking. One study showed that individuals recovered the ability to control their postural sway in the early postoperative period (Sipko et al., 2010), although another study showed no full recovery 3 months after surgery (Leinonen et al., 2003). Even 3 years after surgery, postural control was still impaired, even in those who were pain-free (Bouche et al., 2006).

Enhancing postural control may play a role in the resolution of long-term residual functional complaints after lumbar surgery. However, no studies exist on the effect of rehabilitation on postural control after lumbar microdiscectomy. Active over passive treatment after lumbar surgery (Carragee et al., 1999), and an early start of physiotherapy is suggested (Hebert et al., 2010; Millisdotter and Strömqvist, 2007). However, utilization of these parameters appears to be low (Williamson et al., 2007), and significant variability in routine treatment and advice in outpatient care after surgery is observed (Karikari and Isaacs, 2010; Williamson et al., 2007). Moreover, until now only low-quality evidence of physiotherapy after lumbar microdiscectomy was found, due to the lack of individualized and targeted care (Oosterhuis et al., 2014).

Also, different lumbar surgery procedures have been used. Since classic paramedian surgical approaches require more muscle damage, minimally invasive transmuscular approaches have been developed, although clinical evidence is discussed nowadays (Kamper et al., 2014). Adequate function of the paraspinal trunk muscles, potentially to be damaged by surgery, is indispensable for postural control (Hides et al., 1996). However, the influence of the transmuscular versus paramedian approach of lumbar microdiscectomy on lumbosacral proprioceptive acuity has not been investigated yet. Taken together, it remains unknown whether the impaired postural control in lumbar microdiscectomy patients might be attributed to altered proprioceptive use, and whether it affects STSTS performance. Moreover, it is unclear whether these parameters are affected by surgical technique and physiotherapy.

Optimizing clinical outcomes after lumbar surgery is recognized as a priority for future research (McGregor et al., 2006). Identifying specific and adaptable underlying mechanisms can support the development of tailored interventions (van der Windt and Dunn, 2013). Therefore, the first aim of this study was to evaluate the specific use of proprioception during postural control after two types of lumbar microdiscectomy. We hypothesized that proprioceptive use during postural control and STSTS performance are impaired after lumbar microdiscectomy, and that a transmuscular approach creates less impairment than a paramedian approach. The second aim was to confirm the presence of these impairments after lumbar microdiscectomy by investigating the effect of early active individualized physiotherapy on it. We hypothesized that early active individualized physiotherapy enables lumbar microdiscectomy patients to increase reliance on lumbosacral, rather than ankle, proprioceptive signals during postural control and improves STSTS performance. This proof-of-principle would confirm the presence of proprioceptive impairments as one underlying mechanism of the residual complaints after lumbar microdiscectomy.

2. Methods

2.1. Participants

One hundred and nine patients after lumbar microdiscectomy were assessed for eligibility by the neurosurgeon. Patients were included if their age ranged between 18 and 60 years old, if they had a first-time single-level (L4–L5 or L5–S1) paramedian disc herniation indicative for surgical intervention and if they reported a score of at least 10% on the Oswestry Disability Index (version 2.1.a, adapted Dutch version) (ODI-2) after surgery (Fairbank and Pynsent, 2000). Participants were excluded from the study in case of previous spinal surgery, median disc herniation, vestibular or neurological disorders, significant neurological deficit (paresis > 4/5), lower limb problems, or work accident. Twenty-five eligible participants were included and four independent groups were created (Fig. 1): transmuscular surgery + physiotherapy ($n = 6$), transmuscular surgery + usual care ($n = 6$), paramedian surgery + physiotherapy ($n = 6$), and paramedian surgery + usual care ($n = 7$). These groups were clustered by a mixed group design because power analysis (Brumagne et al., 2008; Claeys et al., 2011, 2012, 2015; Janssens et al., 2015) revealed a sample size of 11 participants to provide adequate power (0.80 with a two-tailed alpha level of 0.05) to detect a clinically relevant difference in center of pressure displacement on unstable support surface (our primary outcome measure with smallest effect size). First, they were randomly allocated (blinded by computer algorithm) for surgical approach into a transmuscular group ($n = 12$; 7 women/5 men) and paramedian group ($n = 13$; 7 women/6 men). Subsequently, the same patients were re-allocated into a physiotherapy group ($n = 12$; 7 women/5 men) and a usual care group ($n = 13$; 7 women/6 men). Before surgery, all participants completed a number of questionnaires. Severity of pain was scored by the Numerical Rating Scale (NRS) (Jensen et al., 1986). The Fear-Avoidance Beliefs Questionnaire (FABQ) was completed to identify to which extent fear of LBP affects their work and physical activity (Waddell et al., 1993). The Hospital Anxiety and Depression Scale (HADS) was completed to assess anxiety and depression (Zigmond and Snaith, 1983). The Pain Catastrophizing Scale (PCS) was completed to assess the amount of catastrophizing associated with their LBP (Sullivan et al., 1995). Finally, motivation for study participation was scored on the Numerical Rating Scale (NRS) (0-10).

The participants' characteristics before lumbar microdiscectomy are summarized in Table 1. All participants gave their written informed consent. The study conformed to the principles of the Declaration of Helsinki (1964) and was approved by the local Ethics Committee of Biomedical Sciences, Katholieke Universiteit Leuven and registered at www.clinicaltrials.gov (NCT01505595).

2.2. Study design

The objectives of this study were, first, to investigate proprioceptive use during postural control and STSTS performance after two surgical approaches of lumbar microdiscectomy and, second, to investigate the effect of early active individualized physiotherapy on these parameters. These primary outcomes were evaluated at 2 (baseline), 8 and 24 weeks after surgery. These primary outcomes were not evaluated before surgery due to pre-surgery disability. Secondary outcomes were severity of pain and LBP-related disability and kinesiophobia, evaluated before and 2 (baseline), 8, 24 weeks, and 1 year after surgery. Global perceived effect of the intervention (0–10), duration of work absence (days), and recurrence rate were scored 1 year after surgery. Fig. 1 displays the flowchart of the study.

2.3. Materials

2.3.1. Surgical procedures of lumbar microdiscectomy

2.3.1.1. Transmuscular approach. A 2-cm incision was made at two cm from the midline at the spinal level of the disc herniation (L4–L5 or L5–S1). A Kirschner pin was inserted and directed toward the facet joint, confirmed by fluoroscopy. Subsequently, dilators were introduced over the Kirschner pin. A final tubular retractor (18 mm outer diameter, METRx system, Medtronic) was inserted over the sequential dilators and seated firmly on the bony anatomy. The tubular retractor was then attached to a fixation arm, connected with the surgical table. Using microscope magnification, the caudal part of the lamina was removed, and the ligamentum flavum was opened. The thecal sac and