Clinical Biomechanics 39 (2016) 100–108

Contents lists available at ScienceDirect

Clinical Biomechanics

journal homepage: www.elsevier.com/locate/clinbiomech

Paravertebral spinal injection for the treatment of patients with degenerative facet osteoarthropathy: Evidence of motor performance improvements based on objective assessments

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ARTICLE INFO

Article history:
Received 1 May 2016
Accepted 7 October 2016

Keywords:
Spine injection
Low back pain
Motor performance
Wearable technology
Osteoarthropathy
Balance

ABSTRACT

Background: This study examined short- and long-term improvements in motor performance, quantified using wearable sensors, in response to facet spine injection in degenerative facet osteoarthropathy patients.
Methods: Adults with confirmed degenerative facet osteoarthropathy were recruited and were treated with medial or intermediate branch block injection. Self-report pain, health condition, and disability (Oswestry), as well as objective motor performance measures (gait, balance, and timed-up-and-go) were obtained in five sessions: pre-surgery (baseline), immediately after the injection, one-month, three-month, and 12-month follow-ups. Baseline motor performance parameters were compared with 10 healthy controls.
Findings: Thirty patients (age = 50 (14) years) and 10 controls (age = 46 (15) years) were recruited. All motor performance parameters were significantly different between groups. Results showed that average pain and Oswestry scores improved by 51% and 24%, respectively among patients, only one month after injection. Similarly, improvement in motor performance was most noticeable in one-month post-injection measurements; most improvements were observed in gait speed (14% normal walking, $P < 0.02$), hip sway within balance tests (63% eyes-open $P < 0.01$), and turning velocity within the timed-up-and-go test (28%, $P < 0.02$). Better baseline motor performance led to better outcomes in terms of pain relief; baseline turning velocity was 18% faster among the responsive compared to the non-responsive patients.
Interpretations: Spinal injection can temporarily (one to three months) improve motor performance in degenerative facet osteoarthropathy patients. Successful pain relief in response to treatment is independent of demographic characteristics and initial pain but dependent on baseline motor performance. Immediate self-reported pain relief is unrelated to magnitude of gradual improvement in motor performance.

1. Introduction

Low back pain (LBP) is the second most common cause of disability in the United States, 80% of individuals suffer LBP during their lifetimes, and is responsible for over seven billion dollars of lost productive work time per year in the middle-aged population alone (Control and Prevention, 2001; Ricci et al., 2006; Toosizadeh et al., 2012). Treatments for LBP are costly, with an annual amount that is estimated to be $100–$200 billion (Katz, 2006). One reason for LBP is degenerative facet osteoarthropathy (DFO), a clinical and pathological construct that involves the functional failure and inflammation of the synovial facet joints resulting in chemical or mechanical stimulation of the facets with consequent, chronic pain in the lower back (Gellhorn et al., 2013; Lakemeier et al., 2013). DFO is a very common entity; among community-dwelling adults, moderate or severe lumbar DFO on CT imaging is present in an estimated 36% of adults age 45 years and younger, 67% of adults age 45–64 years, and 89% of those age 65 years and older (Suri et al., 2011).

One common method for treating chronic pain caused by DFO is steroid injection into the facet joint(s). Various techniques including intraarticular injections, medial branch blocks, and radiofrequency denervation of lumbar facet joint have been used and both the short-

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http://dx.doi.org/10.1016/j.clinbiomech.2016.10.007
0268-0033/

and long-term efficacies in pain relief have been explored (Bartynski et al., 2013; Furman et al., 2010; Kader et al., 2012; Lakemeier et al., 2013; Lee et al., 2010; Manchikanti et al., 2008; Toosizadeh et al., 2015). Overall, studies of spinal injections reported a success rate of LBP remittance from 10% to 63% depending upon the type of injection materials and procedures (Carette et al., 1991). Furthermore, studies have shown a sustained improvement from three to 12 months after spinal facet joint injections (Carette et al., 1991; Leung et al., 2015; Manchikanti et al., 2015).

Although several studies have been conducted to evaluate the efficacy of spinal injection in DFO patients, none of them, to the best of our knowledge, has used objective sensor-based motor performance assessments. Within these studies, the severity of LBP was commonly assessed according to the degree of subjective pain, disability, and physical impairment, using questionnaires such as visual analog pain scales, Roland-Morris, Health Survey, and Oswestry. One potential problem with these patient-reported outcome measures (PROMs) is that they incorporate psychological factors, which along with patient attitudes and beliefs, might bias outcome evaluations (McGregor et al., 1998). Objective methods of motor performance assessments, may improve diagnoses and surgical efficacy evaluations (Beurskens et al., 1995), especially when used to assess improvements in motor performance longitudinally following spinal treatment procedures (Toosizadeh et al., 2015c; Yen et al., 2016). Therefore, the purpose of the current study was to assess short- and long-term improvements in motor performance following facet spine injection in DFO patients. Sensor-based gait, balance, and timed-up-and-go (TUG) motor performance was measured, investigating three questions: 1) How long are motor performance improvements sustained after treatment? 2) What percentage of DFO patients benefit from the treatment, and what are the baseline differences in motor performance between those who benefit and those who receive no pain relief from the treatment? and 3) What are the correlations between the level of subjective pain score and motor performance measures? We hypothesized that pain relief from spinal injection would positively influence gait, balance, and TUG performance; however, we believed the effect would be short-term (less than one year) according to previous research based on subjective pain evaluations (Carette et al., 1991; Manchikanti et al., 2008). Furthermore, since previous research showed a negative association between pain severity and success rate of spinal injection (Ashraf et al., 2015; Marks et al., 1992), we expected to see that DFO patients with less pain and better baseline motor performance would benefit more from spinal injection than would those with more pain and poorer baseline motor performance. Lastly, we explored the feasibility of performing in-clinic motor performance measurements using wearable sensor technology, noting the time burden for measurements, as well as identifying tests that are more representative of motor impairments in DFO patients.

2. Methods

2.1. Participants

DFO patients, with acute pain in low back region were consecutively approached for participation from Banner University of Arizona Health Orthopedic Clinic from January 2014 to September 2015, after DFO diagnosis using plain film radiography, and confirmation using CT and MRI images. Eligibility included: older than 18 years, history of LBP symptoms for longer than one month so as to minimize the chance of spontaneous recovery, and ability to walk 20 m without assistance. Exclusion criteria included: previous spine, hip, or lower-extremity surgeries within one month prior to spinal injection, or opioid usage, as well as severe comorbidities that could affect gait- and balance-centered motor performance, including Parkinson's disease, stroke, diabetic neuropathy, or diagnosed peripheral vascular disease. A sample of healthy, who were frequency matched on age, with no self-reported history of LBP (including DFO), current or recent injuries, acute illnesses, musculoskeletal disorders, or other health-related disabilities was recruited in order to compare motor performance measures within a normal range. The study was approved by the University of Arizona Institutional Review Board. Written informed consent according to the principles expressed in the Declaration of Helsinki (Association, 2013) was obtained from all subjects before participation.

2.2. Paravertebral facet injection

DFO participants were treated with 1 cm^3 of Isovue 300, 3.5 cm^3 of 1% lidocaine plain, 3.5 cm^3 of 0.25% Marcaine plain, and 2 cm^3 of 40 mg per cm^3 of Triamcinolone combined in a 10 cm^3 syringe. All injections were done in the operating room with spinal needles and by the same orthopedic surgeon (MD). Patient were placed prone on the radiolucent table under fluoroscopic guidance and were injected after skin preparation with chloraprep. The spinal needle was inserted and advanced to the center of the pedicle cephalad border for a medial or intermediate branch block, and the pericapsular or intracapsular areas were then injected following the recommendations of the North American Spine Society (Laxmaiah Manchikanti and Boswell, 2009). After injection, patients' lower backs were cleaned again with chloraprep, Band-Aids were placed on the points of entry, and patients were asked to ambulate immediately following the injection.

2.3. PROMs

Patient-reported pain, health condition, and disability were obtained in five sessions: pre-surgery within three days prior to injection (baseline), immediately after the injection, and one month, three month, and one year follow-ups after the injection. The 10-point visual analog scale (VAS) (Langley and Sheppeard, 1985) was used to assess pain at the moment of measurement and average pain within two weeks prior to measurement. The Oswestry questionnaire (Fairbank and Pynsent, 2000) was used to evaluate LBP functional disability. In addition, subjective measures of SF-12 health survey (Ware et al., 1996) and short Falls Efficacy Scale-International (Short FES-I) (Kempen et al., 2008) were performed. Since the Oswestry, SF-12, and Short-FES-I inquire about assessments for the prior two-week period, only VAS pain was collected at the immediate session following the injection. Except for the Oswestry questionnaire not being filled out by healthy samples, all PROMs were collected from all participants.

2.4. Objective motor performance measurements

To assess changes in motor performance after spinal injection, participants performed gait, postural balance, and TUG tests at baseline, and then immediately after, one month, three month, and one year after the treatment. For all measurements, participants were asked to wear five inertial sensors (LEGSys™, Biosensics LLC, Cambridge, MA, USA). Sensors were attached to each shin, thigh, and lower back using elastic straps as described in our previous publication (Schwenk et al., 2015). Validated algorithms were used to quantify spatio-temporal parameters of gait during walking (Aminian et al., 2002b, 2004; Lindemann et al., 2008; Najafi et al., 2009) and body sway (Najafi et al., 2010, 2015) during balance tests. Gait was assessed within a minimum of 25 steps under two conditions: 1) normal walk; and 2) fast walk. Gait outcome measures were steady-state spatio-temporal gait parameters, and included gait speed, stride length, gait cycle time, double support, and mid-swing velocity (see Table 1 for parameter definitions (Aminian et al., 2002a; Toosizadeh et al., 2015a,b; Zampieri et al., 2010)). Each participant performed four 30-s trials of balance assessment. In each trial, participants stood upright with their feet as close together as possible without touching, and with arms crossed. In the first two trials, participants were instructed to keep their eyes open (eyes-open trials), with no visual target specified. In the third and fourth trials, participants kept their eyes closed (eyes-closed trials). In each trial, the