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Immediate Effect of Flexion-Distraction Spinal Manipulation on Intervertebral Height, Pain, and Spine Mobility in Patients with Lumbar Degenerative Disc Disease

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Objective: This study aimed to investigate the short-term effects of flexion-distraction spinal manipulation on intervertebral height, pain, spine mobility in patients with lumbar degenerative disc disease.

Design: Randomized controlled trial with a pretest-posttest control group design

Methods: A total of 96 participants with degenerative disc disease participated in the study and were randomly divided into two groups. Both groups received intervention for 3-5 minutes a day. The experimental group (n=48) underwent flexion-distraction spinal manipulation for 3-5 minutes, and the control group (n=48) was maintained in the same position as the experimental group for 5 minutes without any intervention. The intervertebral height was measured by computed tomography, pain was assessed using visual analog scale, and the spine in flexion mobility was measured using the finger-to-floor distance test and passive straight leg raise test. Pre-test and post-test measurements were obtained.

Results: The experimental group showed significant improvement in intervertebral height, degree of pain, and spinal mobility ($p < 0.05$). The intervertebral height increased from 6.32±1.90 to 6.93±1.85 mm ($p < 0.05$), lower back pain decreased from 69.17±13.35 mm to 48.48±12.20 mm ($p < 0.05$), lumbar spine mobility changed from 17.37±4.49 to 12.69±4.34 cm ($p < 0.05$), and passive straight leg raise test range increased from 46.94±13.05° to 56.01±12.20° ($p < 0.05$).

Conclusions: This study suggests that flexion-distraction spinal manipulation could be an effective treatment for decreasing pain and improving function in patients with degenerative disc disease.

Key Words: Intervertebral disc degeneration, Range of motion, Articular

Introduction

Worldwide, lower back pain is associated with high economic costs, disability, and decreased productivity. Although there are various guidelines on the management of lower back pain, its overall management, including diagnosis and treatment, still remains controversial [1-2].

Various conservative treatments are used to improve and recover from neurological symptoms of degenerative disc disease [3]. Of such treatment methods, traction treatment maintains the intervertebral height in degenerative disc disease patients, slows down the degenerative changes of discs [4], decreases lower back pain, and reduces the compression of discs within the vertebrae [5-6]. However, other studies have reported that the effects of traction are unclear [7], and the effects remain controversial[8-9].

Flexion-distraction spinal manipulation, which is a type of low-velocity variable amplitude spinal

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manipulation method conducted to cause traction, provides slow traction and mobility through clinician's manual manipulation and special manipulation treatment equipment[10].

Flexion-distraction spinal manipulation maintains the intervertebral height, thereby preventing degeneration of the peripheral annulus fibrosus, which is sensitive to pain. Through this, the disc pressure is reduced, and the resulting centripetal force repositions the laterally displaced nucleus pulposus to the center [11]. Moreover, the manipulation recovers the subluxation of the spinal facet joint to maintain posterior spinal mobility, and it decreases pain while improving physical function through improved mobility and posture [11-12].

Decreases in the intervertebral height result from the compression created by fluid leaking from discs and spinal endplates and changes in elasticity [13]. Repeated compression of spinal endplates gradually causes degeneration of the nucleus pulposus, delivers greater loads to the annulus fibrosus around the nucleus pulposus, and destroys the structure of the nucleus pulposus, ultimately leading to decreased intervertebral height [14].

Spinal manipulation decreases pain and leads to functional improvement in patients with symptoms of lumbar degenerative disc disease by influencing how the body processes pain [15-16]. However, other previous studies have reported that flexion-distraction spinal manipulation does not improve pain [17-18].

In particular, structural changes observed in degenerative disc disease decrease the intervertebral height as well as spinal mobility [19]. It would also be significant to verify the effects of flexion-distraction spinal manipulation on lumbar joints of patients with degenerative disc disease since decreased hip flexion mobility influences the load on the lumbar vertebrae [19-20]. In addition, a study applied flexion-distraction spinal manipulation to patients with herniated discs in straight leg raise range [21]. However, research on the influence of flexion-distraction spinal manipulation on intervertebral height, pain, and lumbar spinal mobility has been lacking. In other words, there is a need to investigate how flexion-distraction spinal manipulation influences pain and lumbar spinal mobility of degenerative disc disease patients. Therefore, this study aimed to investigate the short-term effect of flexion-distraction spinal manipulation on intervertebral height, pain, spine mobility in this population through computed tomography (CT).

Methods

Participants

The study was conducted on 96 patients who met the selection criteria among a total of 132 patients. Study participants were 96 patients with lower back pain who presented to S Hospital in Seoul. The inclusion criteria for the study were as follows: patients diagnosed with degenerative disc disease of L5-S1 on magnetic resonance imaging, those aged between 20 and 60 years, those who have had more than 3 months of continued lower back pain,1 those who have not had flexion-distraction spinal manipulation for 3 months prior to this study, those whose Korean Oswestry Disability Index score was 21 or above [22], those whose pain was rated as 45 mm or above on visual analog scale,10 and those whose straight leg raise test was positive at angles smaller than 70° [23].

Of these patients, those taking analgesics, with cauda equina syndrome, with spondylolisthesis or spondylolysis, who had previous spinal surgeries, with symptoms of radiculopathy, with central nervous system injuries, and contraindicated for spinal manipulation were excluded from the study.

Study methods and experiments

The purpose, methods, and other pertinent information were explained in detail to all participants, and they were also informed that they may withdraw from the study whenever they desire. They all signed written consent forms. The present study was approved by the institutional review board (approval number: 2-1040781-AB-N-01-2016107HR). To minimize bias through single blinding, one physical therapist with 7 years of clinical experience made measurements and another physical therapist with more than 10 years of clinical experience provided the interventions.

Participants with similar general characteristics were paired and numerically coded. The numbers were placed in an envelope and drawn randomly to assign 48 participants to the experimental group and the remaining 48 to the placebo group. There was no dropout of participants, and the data collected from 48 experimental group participants and 48 placebo group participants were used for statistical analysis.

A Zenith Cox flexion table (Zenith Cox flexion table, Standex company, USA), which comprises three pieces (head, thoracic/lumbar spine, and lower extremities) that can move spine joints, was used for flexion-distraction spinal manipulation. The participants were lying in a prone position so that their anterior superior iliac spine was positioned at the end of the thoracic/lumbar spine piece of the table. The spinous process of the participants' L5 was positioned in between the thenar and hypothenar eminence of one hand of the therapist, and the therapist's other hand was placed on the end handle of the table used to cause distraction with flexion, lateroflexion, and rotation. Both ankles of the participants' were fixed with a belt.

The therapist pushed their hand on the patient's L5 spinous process superio-anteriorly to fix the spinous process and manipulated the table inferio-anteriorly to create a distraction with flexion, lateroflexion, and rotation.

The manipulation was repeated according to the patient's responses. When the patient did not have any abnormal symptoms, one set (2-3 seconds of distraction with flexion and lateroflexion *5 and 4 seconds of distraction with rotation *5) was applied. Three sets comprised the intervention, which took 3-5 minutes. The distraction was created in a direction that allowed for flexion and all other physiological mobility [24].

The participants in the placebo treatment group were lying down in a prone position on the Cox flexion table in the same environment as for those receiving flexion-distraction spinal manipulation. The therapist only maintained light touch to the site of the lesion without any mechanical manipulation, and the treatment was maintained for 3-5 minutes.

Measurement tools and data collection

CT (Alexion 16, Toshiba Co., Japan) was used to measure intervertebral height, and the CT scanner had an error range of 2% (±0.2 mm) when tested in 2016. Cross-section images obtained from the scanner were reconstructed into sagittal images to obtain mid-sagittal images, which were then sent to PACS (ViewRex, TechHeim, Republic of Korea). The images were zoomed in twice to measure the intervertebral height between L5 and S1 (Figure 1).

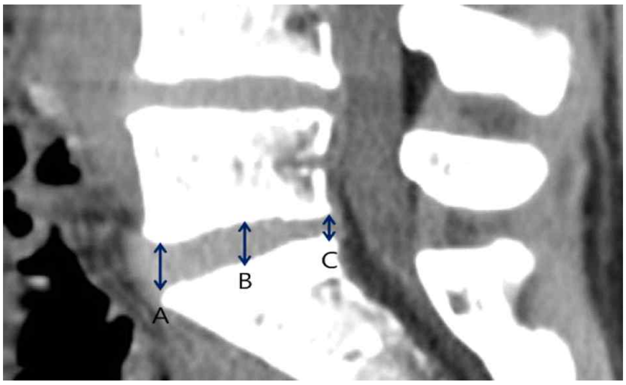

Figure 1. Measurement of intervertebral height

For measurement of the intervertebral height, anterior and posterior heights were measured at the anterior and posterior ends of the vertebral bodies, and the mid-intervertebral height was measured by connecting the center of the upper and lower ends of the disc [25]. The anterior intervertebral height (A), mid-intervertebral height (B), and posterior intervertebral height (C) were summed and divided into 3 (A+B+C/3) to obtain the intervertebral height used for analysis [26].

Visual analog scale was used to measure lower back pain. The visual analog scale included an ungraduated horizontal 100-mm line. Zero defined no pain and 100 defined the most severe pain, and the participants were asked to mark the current level of their subjective pain within the range between 0 and 100 mm. The visual analog scale is an effective, appropriate method to measure chronic and acute pain, and intra-rater reliability is r=0.87 in the test-retest measurement [27].

Finger-to-floor distance test was used to measure lumbar mobility. This test measures the maximal possible spinal flexion range, and the participants bent their body forward until there was a functional limitation. (The test is easy to administer and has a high inter-rater reliability of r =0.96-0.98 [28].

Passive straight leg raise test was used to measure the range of motion of lower extremities. A smartphone application (Clinometer-level and Slope Finder, Plaincode Software Solutions, Germany) was used to measure the

Table 1. Test of homogeneity of the participants in terms of general characteristics, medical characteristics, and dependent variables (n=96)

Category	Flexion-distraction spinal manipulation (n=48)	Placebo treatment group (n=48)	t (p)
Sex (male/female)	22/26	23/25	0.202 (0.840)
Age (years)	43.31±11.25ba	42.27±13.27	0.456 (0.649)
Height (cm)	165.85±7.94	166.44±10.345	-0.310 (0.757)
Weight (kg)	64.96 ±9.26	66.25±14.93	-0.509 (0.612)
K-ODI (score)	24.42±2.99	24.15±2.81	0.457 (0.649)
Intervertebral height (mm)	6.32±1.90	6.41±1.70	-0.217 (0.828)
VAS (mm)	69.17±13.35	66.90±12.40	0.863 (0.390)
FFDT (cm)	17.37±4.49	18.33±3.59	-1.155 (0.251)
PSLR (°)	46.94±13.35	50.02±9.73	-1.312 (0.193)

Values are presented as mean±standard deviation or number
FFDT: finger-to-floor distance test, K-ODI: Korean Oswestry disability index, PSLR: passive straight leg raise, VAS: visual analog scale.

angle, and a smartphone was placed on the center of lateral thighs of the participants to measure the angle. The application has high reliability: intra-rater reliability of r=0.78 and inter-rater reliability of r=0.90 [29]. Passive straight leg raise is easy to administer and is highly reliable with r=0.87 [30].

Analysis

All statistical analyses were conducted on SPSS 19.0 (ver. 19.0, IBM Co., USA). Descriptive statistics were used for the general characteristics of the participants, and socio-demographic variables were analyzed in real numbers. Medical characteristics were analyzed as mean and standard deviation. Paired-sample t-tests were conducted to assess the differences in the dependent variables within groups according to intervention, and independent samples t-tests were conducted to assess between-group differences according to intervention. The level of statistical significance (α) of all data was set as 0.05.

Results

In this present study, 132 patients were initially recruited, and 36 patients who did not satisfy the selection criteria were excluded. As a result, there were a total of 96 participants.

When the homogeneity of the two groups was assessed in terms of general characteristics and dependent variables, the groups did not differ significantly (Table 1).

In the flexion-distraction spinal manipulation group, the intervertebral height increased from 6.32±1.90 mm to 6.93±1.85 mm, with a significant difference of 0.61±0.26 mm ($p<0.05$) (Figure 2) and lower back pain decreased from 69.17±13.35 mm to 48.48±12.20 mm, with a significant difference of 20.69±9.26 mm ($p<0.05$) (Table 2, Figure 3). The treatment group also had a significant decrease in lumbar spine mobility of 4.68±1.05 cm, from 17.37±4.49 cm to 12.69±4.34 cm ($p<0.05$) (Figure 4), and a significant increase in passive straight leg raise test range of 9.07±3.95° from 46.94±13.05° to 56.01±12.20° ($p<0.05$) (Table 2, Figure 5).

Discussion

Maintenance of intervertebral height decreases burdens on spinal facet joints and recovers spinal mobility, whereas recovery of intervertebral height widens respective intervertebral foramina, distracts the posterior annulus fibrosus, and increases the diameter

Table 2. Pre-posttest changes after intervention (n=96)

Category		Intervertebral height (mm)	VAS (mm)	FFDT (cm)	PSLR (°)
Flexion-distraction spinal manipulation group (n=48)	Pretest	6.32±1.90a	69.17±13.35	17.37±4.49	46.94±13.05
	Posttest	6.93±1.85	48.48±12.20	12.69±4.34	56.01±12.20
	Pre-posttest difference	0.61±0.26	20.69±9.26	4.68±1.05	9.07±3.95
	t (p)[a]	16.312 (0.001)*	15.485 (0.001)*	30.85 (0.001)*	15.92 (0.001)*
Placebo treatment group (n=48)	Pretest	6.41±1.70	66.90±12.40	18.33±3.59	50.03±9.73
	Posttest	6.40±1.71	66.83±12.37	18.36±3.63	50.02±9.73
	Pre-posttest difference	0.00±0.01	0.06±0.98	-0.03±0.14	0.01±0.02
	t (p)[a]	0.616 (0.541)	0.443 (0.659)	-1.316 (0.194)	1.770 (0.083)
t (p)[b]		16.259 (0.001)*	15.353 (0.001)*	30.743 (0.001)*	15.911 (0.001)*

Values are presented as mean±standard deviation or number
FFDT: finger to floor distance test, PSLR: passive straight leg raise, VAS: visual analog scale.
[a]Statistical difference within group ($p<0.05$), [b]Statistical difference between group ($p<0.05$).
*$p < 0.05$

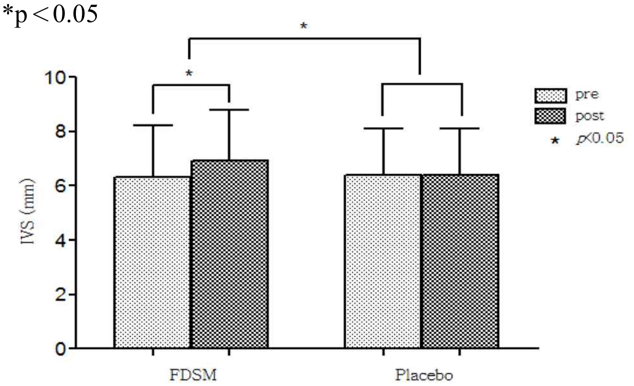

Figure2. Pre-posttest changes in intervertebral height after intervention
FDSM: flexion-distraction spinal manipulation,
IVS: intervertebral space.

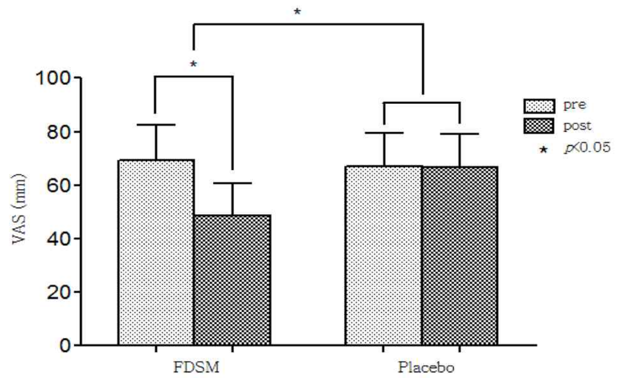

Figure 3. Pre-posttest changes in lower back pain after intervention
FDSM: flexion-distraction spinal manipulation,
VAS: visual analog scale.

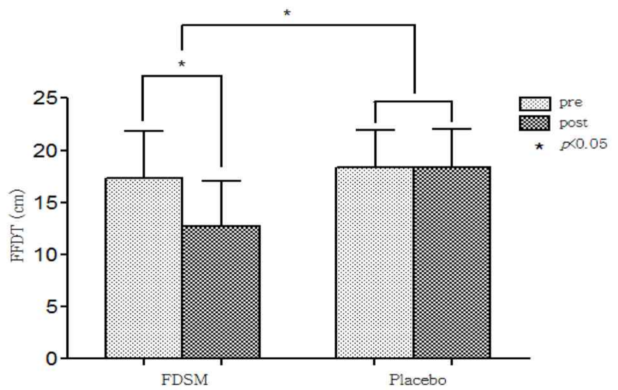

Figure 4. Pre-posttest changes in lumbar spinal mobility after intervention
FDSM: flexion-distraction spinal manipulation,
FFDT: finger-to-floor distance test.

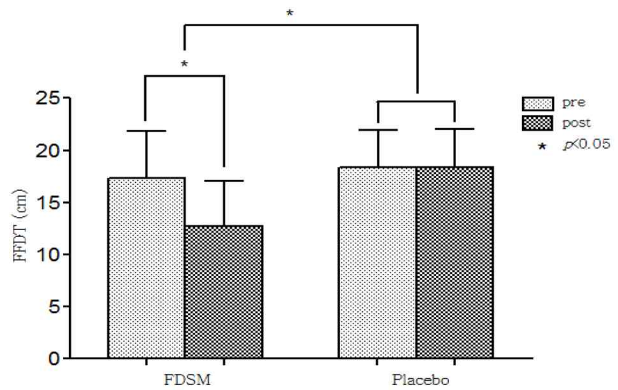

Figure 5. Pre-posttest changes in passive straight leg raise test range after intervention
FDSM: flexion-distraction spinal manipulation,
PSLR, passive straight leg raise.

of the central canal [31]. Moreover, the recovery of intervertebral height improves spinal alignment by indirectly widening the intervertebral foramen [32].

In this study, the intervertebral height increased significantly in the group that received flexion-distraction spinal manipulation. Decreased disc pressure during flexion-distraction spinal manipulation indicates decreased nucleus pulposus herniation within the annulus fibrosus [33]. This can be explained by the fact that flexion-distraction spinal manipulation changes the pressure stress on discs to a more uniform pattern, thereby recovering the intervertebral height and alleviating the pain [33].

As a result, recovery of intervertebral height decreases pain by preventing the degeneration of the peripheral annulus fibrosus, which is sensitive to pain. Widened intervertebral height decreases disc compression, which repositions the laterally deviated nucleus pulposus to the center of the annulus fibrosus and creates a uniform pressure across the disc. Moreover, it recovers subluxation of spinal facet joints caused by decreased intervertebral disc height to increase posterior spinal mobility and increases the diameter of the central canal to decrease the compression of nerve roots. In addition, it decreases the adhesion of erector spinae tendons to aid the recovery of spinal nerves and surrounding structures [32].

In the experimental group that received flexion-distraction spinal manipulation, the visual analog score decreased by 20.69 mm from 69.17±13.35 mm to 48.48±12.20 mm. The reported minimal clinically important difference (MCID) for the visual analog scale score in lower back pain was 18-20 mm in chronic back pain patients and above 15 mm in another study [34].

Spinal joint edema due to mechanical stress causes chemical inflammatory responses and stimulates centripetal nerve fibers, which leads to secretion of pain mediators [35], as a result, the pressure within spinal joints increases, resulting in inflammatory responses in vessels and cells of the joints as well as pain [36]. Flexion-distraction spinal manipulation is thought to have widened the intervertebral foramen and decreased the stimulation of surrounding nerves or dorsal nerve roots, thus decreasing nerve root pain and stimulating the receptors responsible for the regulation of pain [12]. Moreover, the manipulation would have created movement in fixed joints, including spinal facet joints, which would have decreased the mechanical stress for tissues sensitive to pain and relieved pain[12,32].

Pain leads to decreased activity, which decreases muscle and joint use and ultimately decreased range of motion of spinal joints. Based on the finger-to-floor distance test conducted in participants who received flexion-distraction spinal manipulation, the distance increased by 4.68±1.05 cm from 17.37±4.49 cm to 12.69±4.34 cm, and this result is similar to those in previous studies. The MCID in the finger-to-floor distance test should be at least 4.5 cm [37]. Flexion-distraction spinal manipulation regulates the somatosensory system and suppresses the hyperactivity of paraspinal muscles, thus leading to functional improvement [38]. Spinal manipulation recovers the free range of motion of joints to recover the mobility of fixed joints, decreases muscular hyperactivity, decreases hyperstimulation and hyper irritation of nerves, and recovers normal reflexes [20]. Direct mechanical flexion on certain spinal segments would have improved the intersegmental flexion range [39], which would have lengthened the surrounding tissues and increased the flexion mobility of the lumbar spine [40].

When nerves are inflamed, tension during the straight leg raise test may lead to compression and stimulation of dorsal nerve roots, which can stimulate reflex muscle activities and limit the straight leg raise range [41], and nerve inflammation is associated with straight leg raise angle [42]. The MCID in the passive straight leg raise test in patients with lower back pain is 5.7-6.6° [43]. The passive straight leg raise range of the participants receiving flexion-distraction spinal manipulation increased by 9.07±3.95° from 56.01±12.20° to 46.94±13.05°, and this result was similar to previous research findings and was clinically significant as defined by MCID. In this study, spinal manipulation would have increased the mobility of spinal facet joints and decreased the protective reflex muscle contraction [20]. In another study reporting that the straight leg raise range increased from 35.60°±9.85 to 70.73°±14.46 after flexion-distraction spinal manipulation in patients with disc herniation, the manipulation would have decreased the hyperstimulation of nerves and led to muscle relaxation. [21].

However, this study has some limitations. It is difficult to generalize the treatment effect because only the results of the short-term treatment effect were seen. Because the subjects of this study were patients who came to the hospital for treatment, they were receiving various treatments in the hospital as well as spinal manipulation. Therefore, it was difficult to see the effect of pure flexion-distraction spinal manipulation when a follow-up experiment was conducted to see the long-term effect of flexion-distraction spinal manipulation, so only a short-term effect was investigated.

Conflict of interest

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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