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CASE REPORT

Lumbar disc rehydration in the bridged segment using the BioFlex dynamic stabilization system: A case report and literature review

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Abstract

BACKGROUND

In recent years, the mechanical concept of intervertebral disc regeneration has become more and more popular due to the increasing awareness of the importance of preservation of spine movement. Interestingly, there is increasing evidence, however, that dynamic stabilization systems may compensate non-physiological loads, limit pathological movement, normalize disc height and intradiscal pressure, and provide an adaptive environment for disc regeneration.

CASE SUMMARY

The patient was a 54-year-old man, who presented with a 10-year history of mechanical back pain, which had become progressively serious and radiated into the left lower limb with numbness 3 mo prior. He had decreased muscle strength (class IV) of the left dorsal extensor and plantar flexor. Magnetic resonance imaging scans showed L3-S1 disc degeneration and L4-L5 disc herniation. Because the patient did not respond to various conservative treatments, he underwent a posterior L4-5 discectomy with fixation of the BioFlex dynamic stabilization system (Bio-Spine, Seoul, Korea). Preoperative symptoms were relieved and lumbar function was markedly improved after the operation. L4-L5 disc rehydration of instrumented segment was noted on magnetic resonance imaging at the 2-year follow-up.

CONCLUSION

Rehydration of the degenerated disc in our patient indicates that the BioFlex dynamic stabilization system may promote disc regeneration. Further research is needed to provide more evidence to support lumbar disc rehydration in the bridged segment using this system.

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Core tip: The mechanical concept of intervertebral disc regeneration has become more and more popular due to the increasing awareness of the importance of preservation of spine movement. Interestingly, there is increasing evidence that dynamic stabilization systems may provide an adaptive environment for disc regeneration. In this study, we showed supporting evidence of rehydration of a degenerated disc after implantation of the BioFlex dynamic stabilization system, and reviewed the relevant medical literature.

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INTRODUCTION

Degeneration of intervertebral disc is commonly accompanied by alterations of disc height, intradiscal pressure, load distribution, and motion patterns[1]. Since these alterations are subsequent results following disc degeneration, it is unlikely that regeneration will occur without first restoring the physiological status of the affected spinal segment[1]. Dynamic stabilization systems (DSS) are currently designed to restore physiological motion patterns and disc height and to normalize intradiscal pressure. Theoretically, they may have the potential to provide an adaptive environment for disc regeneration. Recently, both animal and clinical studies have indicated that disc distraction[2] or application of lumbar DSS[3-16] can enhance hydration in the degenerated disc and, therefore, regeneration.

This article describes a case whose lumbar disc showed rehydration in the implanted segment using the BioFlex DSS, and reviews the existing literature.

CASE PRESENTATION

Chief complaints

A 54-year-old man presented with a 10-year history of mechanical back pain, which became worse with activities and was reduced after bed rest. In the last 3 mo, his back pain had progressively increased and radiated into the left lower limb with numbness.

History of past illness

He had no relevant traumatic history.

Physical examination

Physical examination revealed a stiff lumbar spine with limited range of flexion, extension, and lateral bending. There were tenderness and percussion pain over the L4-L5 lumbar spine. Bilateral lower limb dermatomal sensation was normal, but he had decreased muscle strength (class IV) of the left hallux dorsal extensor. Lower extremity muscle tension, bilateral straight leg raising test, and strengthening test were all normal.

Laboratory examinations

Laboratory data showed no infectious or inflammatory findings.

Imaging examinations

The initial plain radiographs revealed a decrease in height of the L4-L5 disc space. No instability was noted on the dynamic radiographs of flexion and extension of the lumbar spine (Figure 1A and 1B). Magnetic resonance imaging (MRI) scans showed L3-S1 disc degeneration with associated low signal intensity and L4-L5 disc herniation

(Figure 1C and 1D).

FINAL DIAGNOSIS

The final diagnosis was lumbar disc herniation (L4-L5).

TREATMENT

Before admission to our hospital, the patient had accepted various forms of conservative treatments such as physiotherapy, exercise, and drug therapy in a local clinic for 3 mo, but these therapies did not relieve his symptoms. Therefore, a posterior L4-L5 discectomy with fixation of a dynamic stabilization system (BioFlex system, Bio-Spine, Seoul, Korea) was recommended for this patient. During surgical decompression, left L4-5 laminotomy was performed with resection of the superior half of the L5 lamina and the inferior half of the L4 lamina along with preservation of left L4/5 facet joint.

OUTCOME AND FOLLOW-UP

Surgery was successful and his symptoms were clearly relieved and lumbar function was markedly improved. The visual analogue scale score of back pain, left leg pain and Oswestry disability index decreased from 6, 8, and 58 preoperatively to 1, 0, and 0 at 24 mo, respectively, after the procedure. Partial motion of the implanted level was noted on postoperative flexion-extension plain radiographs (Figure 2A and 2B). An increasing signal intensity in the L4-L5 disc was noted on T2-weighted MRI (Figure 2C and 2D) after 2 years of follow-up after the operation.

DISCUSSION

A degenerate intervertebral disc is associated with significant structural failure such as nucleus pulposus dehydration, endplate sclerosis, annular protrusion, internal disc disruption, and disc space narrowing[1,17]. As the disc starts to degenerate, the water content of the nucleus pulposus is reduced, which is well tracked through MRI evaluation. A well-hydrated disc has bright signal intensity on T2-weighted MRI, whereas a degenerated disc appears gray to dark according to the severity of degeneration[17].

Regenerative strategies, such as transplantation of stem cells into nucleus pulposus, have been attempted to reverse disc degeneration experimentally and clinically[18]. However, the lack of an appropriate microenvironment and impaired capacity of diffusion of nutrients across a calcified endplate in the degenerated disc have hampered the survival of the transplanted stem cells[17]. The biomechanical concept for disc regeneration has grown popular in recent years with the improved understanding of the importance of spinal movement preservation. There is increasing evidence, however, that lumbar DSS may compensate non-physiological loads, limit pathological movement, normalize intradiscal height and pressure, and provide an adaptive microenvironment for disc regeneration[1,3,5,7,13,19]. However, controversial results still exist[20,21].

Currently, two kinds of available DSS are applied clinically including pedicle screw-based DSS and interspinous process spacers. The former includes Graf ligamentoplasty (Neoligaments, Leeds, United Kingdom), and the Dynesys system (Zimmer, Inc., Warsaw, IN, United States), FASS system (AO International, Davos, Switzerland), cosmic system (Ulrich GmbH and Co. KG, Ulm, Germany), TOPS system (Premia Spine USA, Philadelphia, PA, United States), FPSS system (Spine Vision, Paris, France), Accuflex system (Globus Medical, Inc., Audubon, PA, United States), Safinaz (Medikon AS, Medikon, Turkey), and BioFlex system (Bio-Spine) among others. The latter includes Wallis (Abbott Spine, Bordeaux, France), DIAM (Medtronic, Memphis, TN, United States), X-Stop (St. Francis Medical Technologies, Concord, CA, United States), and Coflex (Paradigm Spine LLC, New York, NY, United States).

In this study, we showed evidence of rehydration of a degenerated disc after implantation of the BioFlex system and reviewed the relevant medical literature. PubMed, the Cochrane Library, Medline, and EMBASE were searched using the following keywords, "disc rehydration" and "dynamic stabilization system, "which

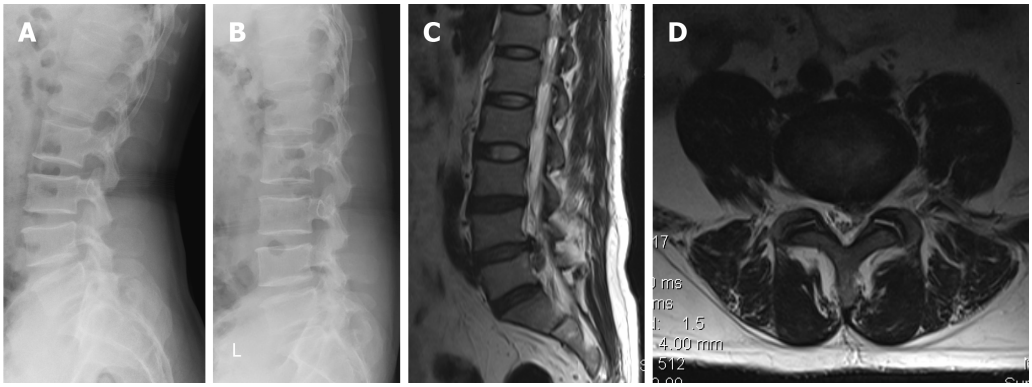

Figure 1 Preoperative imaging assessment. A and B: Preoperative extension-flexion radiographs suggested decreased height without instability in the disc space (L4-5); C and D: Magnetic resonance imaging confirmed L3-S1 disc degeneration with associated low signal intensity and lumbar disc herniation (L4-5) on T2-weighted and axial images.

identified all possible studies published up to July 2019. References from these articles were also reviewed. We found 14 original studies on this topic. The detailed clinical information and device choices of all 15 studies are shown and summarized with the current case in Table 1. A study performed by Fay *et al*[7] found that Dynesys may stop or reverse disc degeneration in young patients but not in older patients. Instead, Vaga *et al*[14] discovered that the Dynesys was able to stop and partially reverse the disc degeneration, especially in a seriously degenerated disc. However, most studies on this topic are case reports[13] or case series[3-5,7-12,15,16] with low-quality and small samples. Degenerated disc rehydration has often been found serendipitously[4-6,10-12,15].

Physiologic motion, load distribution, and intradiscal pressure are mandatory for disc viability. Because a degenerate disc cannot regenerate itself, external devices may provide preconditions for biological attempts of regeneration[1]. Guehring *et al*[2] demonstrated that disc distraction can enhance disc rehydration of the degenerated disc and may also improve disc nutrient diffusion *via* the endplates. Furthermore, the authors thought that disc rehydration after distraction was probably related to the upregulated expression of the matrix genes collagen 1, collagen 2, decorin, and biglycan and the decline of apoptosis[2]. Wilke and colleagues found that changing positions are crucial to promoting fluid flow (nutrition) to the disc[22]. In addition, disc loading pattern with high load, low volume, and low frequency might impart healing or regeneration of the intervertebral discs[23]. DSS can not only result in disc distraction but also limit disc extension reasonably. Physiological spine motion and optimal intradiscal pressure after implantation of DSS may be maintained, which may provide optimal preconditions for disc rehydration and even further regeneration. Biological attempts of disc regeneration including stem cell, gene, and protein therapies combined with mechanical DSS may be optimal options. However, challenges still exist regarding the long-term tolerance of dynamic implants especially on the screw bone interface, and the fatigability of the composite materials[12]. In addition, there may be risk of bias by industry influence in our study. At the same time, our study is a case report and more evidence is needed to support lumbar disc rehydration in the bridged segment using the BioFlex system in the future.

CONCLUSION

Rehydration of a degenerated disc occurred after implantation of the BioFlex System in an adult patient after 2 years of follow-up.

Table 1 Related research to evaluate the potential mutual relationship between dynamic stabilization systems and disc rehydration

Ref.	Types of implants	Age in yr	Number of patients	Follow-up in mo	Proportion of disc rehydration	Assessment method	Main findings	Comments
Bordes-Monmeneu *et al*[15], 2005	Dynesys	46.4 (26-68)	20	9	9/20 (45%)	MRI, signal intensity	Disc rehydration occurred in some patients	Retrospective study, case series
Vaga *et al*[14], 2009	Dynesys	43.5 ± 9	10	6	3/10 (30%)	Molecular MRI, Pfirrmann grading	The Dynesys was able to stop and partially reverse the disc degeneration, especially in seriously degenerated disc and Pfirrmann grading was not sensitive enough to detect the disc change	Prospective study
Cho *et al*[13], 2010	BioFlex	22	1	12	1/1 (100%)	MRI, signal intensity	Increased disc height and disc rehydration occurred after BioFlex system	Case report
Reyes-Sánchez *et al*[12], 2010	Accuflex	44.05 (24-60)	20	24	3/18 (16.67%) 2 cases lost follow	MRI, Pfirrmann grading	Three patients showed disc rehydration with one grade higher on the Pfirrmann classification and the Accuflex system stopped the degenerative process in 83% the patients	Prospective study, consecutive case series
Sandu *et al*[11], 2011	Wallis	67 (39-79)	15	12	NA	MRI, Modic grading	Wallis implantation could lead to disc rehydration	Retrospective study, case series
Heo *et al*[9], 2012	BioFlex	59.0 ± 8.4	25	> 24	2/13 (15.4%) Exclude discectomy cases	MRI, modified Pfirrmann grading	BioFlex system might not prevent adjacent level degeneration completely. However, disc rehydration of the implantation segment occurred in 2 patients	Prospective study, case series
Xu *et al*[10], 2012	Wallis	41.5 (21-68)	96	28 ± 14	NA	MRI, signal intensity	Disc rehydration of the implantation segment occurred in some patients	Retrospective study, case series
Zagra *et al*[8], 2012	FPSS system	51.65 (25-65)	32	12	8/32 (25%)	MRI, Pfirrmann grading	FPSS system was able to provide a potential disc rehydration	Prospective study, case series

Fay *et al*[7], 2013	Dynesys	53.0 ± 9.0	37	> 48	NA	MRI, CDS	Intervertebral disc rehydration was seen in younger patients and the Dynesys might stop or reverse the disc degeneration in the young age patients but not for the elderly patients	Retrospective study, case series
Gao *et al*[6], 2014	ISOBAR TTL	58.3 ± 13.5	24	28.7 ± 5.3	14/24 (58.33%)	MRI, Pfirrmann grading, ADC	ISOBAR TTL system could prevent or delay the degeneration of intervertebral discs	Retrospective study, comparative study
Canbay *et al*[5], 2015	cosmicMIA	38.7 ± 8.39	27	49.3 ± 18.35	4/27 (14.8%)	MRI, Pfirrmann grading, HIZ	Observations such as Pfirrmann grade improvements and disappearance of HIZs are concordant with improvements in VAS and ODI scores demonstrated that cosmicMIA systems might provide an environment for regeneration	Retrospective study, case series
Jiang *et al*[4], 2015	Wallis	47.6 (43-56)	26	66.8 (60-70)	NA	MRI, Pfirrmann grading	Rehydration of the nucleus was observed, however, there were no statistically significant changes in the Pfirrmann grade at the instrumented level	Retrospective study, case series
Yilmaz *et al*[3], 2017	Cosmic, Safinaz	46.5 (27-67)	59	86.8 (12-132)	20/59 (34%)	MRI, Pfirrmann grading	DSS might decelerate the degeneration process and appears to facilitate regeneration	Retrospective study, case series
Luo *et al*[16], 2018	Dynesys	40.6 (21-55)	23	39 (26-59)	6/13 (46.2%)	MRI, Woodend classification	Dynamic stabilization promoted disc regeneration to some extent	Retrospective study, case series
Li *et al*[1]	BioFlex	54	1	24	1/1 (100%)	MRI, signal intensity	Decreased disc height and disc rehydration occurred after BioFlex system	Case report

[1]The present study. MRI: Magnetic resonance imaging; NA: Not available; CDS: Calibrated disc signal; ADC: Apparent diffusion coefficient; HIZ: High-intensity zone; VAS: Visual analog scale; ODI: Oswestry disability index; DSS: Dynamic stabilization system.

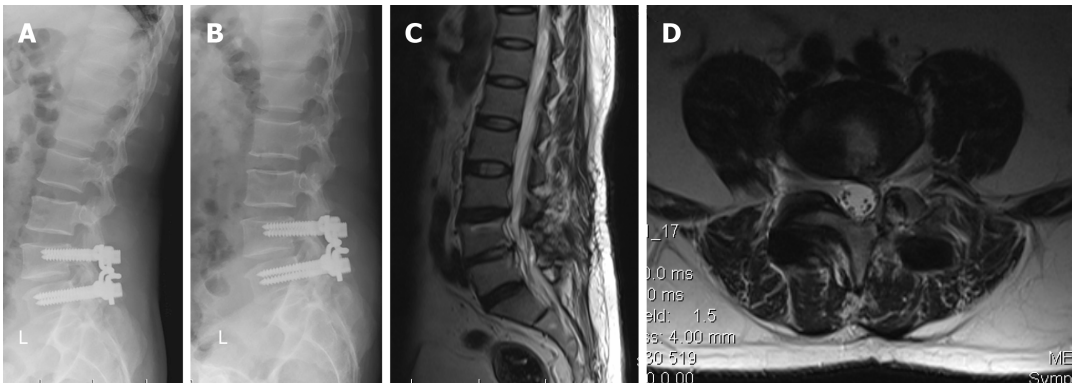

Figure 2 Postoperative imaging assessment. A and B: Postoperative extension-flexion radiographs revealed that partial movement was reserved in the implanted level; C and D: Magnetic resonance imaging demonstrated disc rehydration within L4-5 at the 2-yr follow-up.

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