

Is Dynesys dynamic stabilization system superior to posterior lumbar fusion in the treatment of lumbar degenerative diseases?

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Author contributions: Peng BG and Gao CH conceived the idea for the manuscript and reviewed the manuscript.

Conflict-of-interest statement: The author declares that he has no current financial arrangement or affiliation with any organization that may have a direct influence on his work.

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Manuscript source: Invited manuscript

Specialty type: Orthopedics

Country/Territory of origin: China

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Abstract

Dynesys, a pedicle-based dynamic stabilization system, was introduced to overcome some undesirable complications of fusion procedures. Nevertheless, the theoretical advantages of Dynesys over fusion have not been clearly confirmed. The purpose of this editorial was to compare clinical and radiological outcomes of patients who underwent Dynesys system with those who underwent posterior lumbar fusion according to the existing literature and to see if the application of the Dynesys system is superior to the traditional lumbar fusion surgery. According to published clinical reports, the short-term effects of the Dynesys dynamic stabilization system are similar to that of traditional lumbar fusion surgery. Three comparative studies of Dynesys dynamic stabilization and fusion surgery with medium-term follow-up are encouraging. However, the results from four single-treatment-arm and small-sample studies of case series with long-term follow-up were not encouraging. In the present circumstances, it is not possible to conclude that the Dynesys dynamic stabilization system is superior to fusion surgery for lumbar degenerative diseases.

Key Words: Dynamic stabilization system; Lumbar fusion; Lumbar degenerative diseases; Complication

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Core Tip: At present, it is not appropriate to conclude that the posterior dynamic stabilization system is superior to fusion surgery. As there are still many unresolved issues, we should not overemphasize the application of these dynamic stabilization systems in treatment of degenerative lumbar diseases.

Citation: Peng BG, Gao CH. Is Dynesys dynamic stabilization system superior to posterior

Peer-review report's scientific quality classification

Grade A (Excellent): 0
 Grade B (Very good): 0
 Grade C (Good): C
 Grade D (Fair): 0
 Grade E (Poor): 0

Received: June 11, 2020

Peer-review started: June 11, 2020

First decision: September 13, 2020

Revised: September 19, 2020

Accepted: October 19, 2020

Article in press: October 19, 2020

Published online: November 26, 2020

P-Reviewer: Bianco L

S-Editor: Zhang L

L-Editor: Filipodia

P-Editor: Liu JH



lumbar fusion in the treatment of lumbar degenerative diseases? *World J Clin Cases* 2020; 8(22): 5496-5500

URL: <https://www.wjgnet.com/2307-8960/full/v8/i22/5496.htm>

DOI: <https://dx.doi.org/10.12998/wjcc.v8.i22.5496>

INTRODUCTION

In the past 30 years, lumbar fusion surgery has been the mainstream method for the treatment of lumbar degenerative diseases. Fusion surgery is associated with some adverse complications, such as pseudoarthrosis and adjacent segment degeneration (ASD). Therefore, the concept of retaining motion in the treatment segment came into being, and then various nonfusion techniques were developed and applied to clinical practice. Pedicle-based dynamic stabilization (PDS) is a nonfusion technique that was introduced to overcome the shortcomings in the fusion procedure. A dynamic stabilization system can control the abnormal movement of unstable and painful segments and promote healthy load transfer thereby preventing degeneration of the adjacent segment.

In 1994, Stoll *et al*^[1] first introduced Dynesys (Zimmer, Inc.), a pedicle-based dynamic stabilization system. Many *in vitro* and biomechanical studies showed that this system can limit flexibility through a polyethylene-terephthalate cord and polycarbonate urethane spacer^[2,3]. Subsequently, some early clinical studies reported that the system was an effective choice for the treatment of degenerative diseases of the lumbar spine, and the system's indications included lumbar disc herniation, spinal stenosis, degenerative lumbar spondylolisthesis, and degenerative lumbar scoliosis^[4,5]. In theory, stabilizing the posterior elements in this way can reduce the burden on the facet joints and posterior intervertebral disc and partially retain the movement of the treatment segment. However, the theoretical advantages of nonfusion PDS compared with lumbar fusion (for example, prevention of ASD) have not been clearly demonstrated or established. The length of the spacer determines the degree of dispersion or compression of each lumbar motion segment.

At present, the Dynesys system is the most widely used dynamic stabilization system worldwide. Although the early results are encouraging, the long-term effects remain controversial. In addition, many recently published studies report conflicting results, which indicate that Dynesys may not provide a clear advantage for the results^[6-9]. The purpose of this editorial is to compare the clinical and radiologic results of patients treated with the Dynesys system and patients treated with posterior lumbar fusion according to the existing literature and to observe whether the application of the Dynesys system is superior to the traditional lumbar fusion.

Short-term outcomes

Some clinical studies have found that patients with lumbar degenerative diseases treated with the Dynesys system have better Oswestry disability index (ODI) and visual analogue scale (VAS) scores and recover faster than those treated with lumbar fusion surgery. In a meta-analysis, Lee *et al*^[10] compared clinical and radiological outcomes of the patients treated with the Dynesys system and with posterior lumbar interbody fusion (PLIF). A total of 506 patients were included in seven studies, of which 250 were Dynesys and 256 were PLIF. The Dynesys group showed a competitive advantage in mean operative time, bleeding volume, and length of hospital stay. After 2 years of follow-up, ODI and VAS scores were improved in both the Dynesys group and the PLIF group. There was no significant difference between ODI and VAS scores. The mean range of motion (ROM) of adjacent segment increased in both groups, but the difference was not statistically significant. The authors concluded that fusion is still an option for late degeneration and severe instability. However, the patients with or without grade I spondylolisthesis, especially those requiring faster recovery, are likely to be major indications of Dynesys.

The chief aim of dynamic stabilization system is to decrease ASD. Previous studies have had conflicting results regarding the protective effect on ASD^[8,9]. This meta-analysis showed that the Dynesys group had no competitive advantage. The reasons for these conflicting results are unclear. Perhaps due to the short follow-up time (2 years), long term follow-up may be able to see its superiority. The meta-analysis showed that the ROM of the treatment segment in the Dynesys group and the PLIF group decreased by 42.0% and 88.0%, respectively^[10]. In the Dynesys group, partial segmental motion was maintained, and the clinical and functional results were

comparable to those in the PLIF group. Another advantage of the Dynesys system is that it is less invasive than PLIF and allows patients to recover earlier.

Medium-term outcomes

Wu *et al*^[11] compared the mid-term clinical and imaging results of the Dynesys system and PLIF in the treatment of multiple segmental lumbar degenerative diseases. They evaluated 57 patients treated with the Dynesys stability ($n = 26$) or with PLIF ($n = 31$), with an average follow-up of 50.3 mo, ranging from 46.0 to 65.0 mo. VAS score and ODI of the two groups improved significantly at 3 mo and final follow-up, but there was no significant difference between the two groups. ROM decreased from 6.20° to 2.76° in the Dynesys group and 6.56° to 0.00° in the PLIF group at the final follow-up. The ROM of the proximal adjacent segment in the PLIF group was significantly larger than that in the Dynesys group. Compared with PLIF, Dynesys stabilization maintained the mobility of the stabilized segments and had little effect on adjacent segments, which helped to prevent the degeneration of adjacent segments. The authors considered the Dynesys system as a feasible surgical procedure for the treatment of multilevel lumbar degenerative diseases in the mid-term of follow-up.

In a retrospective study, Bredin *et al*^[12] compared 25 cases of lumbar posterolateral fusion with 32 cases of Dynesys dynamic stabilization for recurrent lumbar disc herniation or lumbar spinal canal stenosis and followed up at least 5.5 years. The results showed that VAS and ODI were significantly lower in the Dynesys group than the fusion group, SF-12 physical subscore was significantly higher in the Dynesys group than the fusion group, and ROM in the treated segment was significantly greater in the Dynesys group than the fusion group ($4.1 \pm 2.0^\circ$ vs $0.7 \pm 0.5^\circ$). Imaging ASD of the fusion group was significantly higher than that of the Dynesys group (36.0% vs 12.1%). Zhang *et al*^[13] retrospectively compared the clinical and imaging results of 96 cases of lumbar degenerative diseases treated by Dynesys and PLIF, including 46 cases in the Dynesys group and 50 cases in the PLIF group with an average follow-up time of more than 50 mo. At the final follow-up, ODI and VAS scores were significantly improved in both groups. ROM of stabilized segments in the Dynesys group decreased from an average of 7.1° down to 4.9° ($P < 0.05$), while the ROM of the stabilized segment of the PLIF group decreased from an average of 7.3° to 0° . At the last follow-up, the ROM of the proximal adjacent segments in both groups increased significantly, but the ROM of the PLIF group was higher than that of the Dynesys group. The incidence of ASD in the PLIF group was significantly higher than that in the Dynesys group. This study showed that the Dynesys system retained the ROM of the treated segment to a certain extent, limited the hypermobility of the proximal adjacent segment, and prevented the occurrence of ASD.

Long-term outcomes

At present, the literature on long-term outcomes of dynamic stabilizers is scarce. According to our literature review, only four long-term studies of the Dynesys system have been published so far^[14-17]. A comparative study of dynamic stabilization and fusion surgery with long-term follow-up is still lacking.

Hoppe *et al*^[14] reported 39 consecutive patients who had symptomatic degenerative lumbar spondylolisthesis and were treated with decompression bilaterally and Dynesys dynamic stabilization system at the L 4/5 level with an average follow-up time of 7.2 years, ranging from 5.0-11.2 yrs. At the final follow-up, 86% of the patients obtained improvement in back pain, and 89% obtained improvement in leg pain. Eighty-three percent of patients reported overall subjective improvement. Eight cases (21%) needed further surgical treatment due to symptomatic adjacent segment disease. In 9 cases, imaging progress in spondylolisthesis was found. Adjacent segment pathology, though not clinically relevant, was diagnosed at 17.9% in L 5/S 1 and 28.2% in L 3/4 segments.

Zhang *et al*^[15] reported 38 patients with lumbar spinal stenosis who were treated with the Dynesys system with an average follow-up of 6.6 years (72-96 mo). At the final follow-up, both lumbar spine function and low back pain were significantly improved. The incidence of radiological and symptomatic ASD were 16% (6/38) and 3% (1/38), respectively.

Veresciagina *et al*^[16] followed up 36 patients with degenerative spondylolisthesis and stenosis for at least 10 years who were treated with decompression and Dynesys dynamic stabilization. Despite good clinical results, 17 cases and 8 cases of progressive degenerative osteochondrosis/spondylolisthesis were found in the adjacent segments, indicating that the Dynesys system did not prevent adjacent segment disease.

St-Pierre *et al*^[17] followed up 52 patients with lumbar degenerative disease who underwent Dynesys dynamic stabilization for at least 5 years. The study showed that

the Dynesys system was associated with a high incidence of ASD (15/52, 29%).

Complications

The Dynesys system is designed to replace rigid fixation and fusion for the treatment of degenerative lumbar diseases. Although many studies have shown good clinical outcomes, there is currently a lack of comprehensive reporting of complications associated with this system, especially compared with fusion surgery. One of the main arguments against PDS systems, including the Dynesys, is screw loosening. Fatigue fracture resistance is the biggest challenge for PDS because it requires a lifetime of continuous movement^[10]. The durability and mechanical strength of PDS implants were higher than that of fusion implants.

A meta-analysis^[10] of 506 patients (mean age 50.3 years) found screw loosening in 6 cases in the Dynesys group (2.54%) and 5 cases in the PLIF group (2.10%) during 2 years of follow-up. Symptomatic screw loosening was observed in 1 (0.42%) of the Dynesys patients and 3 (1.26%) of the PLIF patients, and subsequent revision surgery was performed. Pham *et al.*^[18] systematically reviewed the literature on all complications reported after using the Dynesys dynamically stabilized system. A total of 1166 patients participated in 21 studies with an average follow-up time of 33.7 mo and a range of 12.0-81.6 mo. In these studies, the rate of pedicle screw loosening was 11.7%, fracture rate was 1.6%, ASD rate was 7.0%, and reoperation was performed in 11.3% of patients. In patients with ASD, 40.6% underwent revision surgery. Compared with the published literature on lumbar fusion, the complication rate of the Dynesys dynamic stabilization system seems to be quite similar.

CONCLUSION

The pedicle screw-based system acts as a tension band, reducing the load on the disc and thus improving disc function. So far, the Dynesys system is still the most widely implanted posterior unfused pedicle screw system. The primary biomechanical objective of the pedicle screw-based system is to reduce spinal instability while maintaining as much movement as possible in order to achieve uniform load transfer. Numerous clinical studies have shown that the Dynesys system can maintain partial segmental motion and prevent degeneration of adjacent segments.

According to published clinical reports, the short-term effects of posterior dynamic stabilization system are similar to that of traditional lumbar fusion surgery. The curative outcomes mainly come from the roles of lumbar decompression and temporary stabilization. Three comparative studies of Dynesys dynamic stabilization and fusion surgery with medium-term follow-up are encouraging^[11-13]. The ASD happened more frequently in the fusion group than in the Dynesys group. Dynesys stabilization can indeed maintain the mobility of the stabilized segments, which has little impact on adjacent segments and helps to prevent ASD. However, the comparative clinical studies with long-term follow-up are lacking so far. The results from four single-treatment-arm and small-sample studies of case series with long-term follow-up were not encouraging^[14-17]. These studies showed that although the Dynesys maintains a good clinical effect, it is still associated with a high incidence of ASD in long-term follow-up.

In theory, posterior dynamic stabilization system is superior to lumbar rigid internal fixation and fusion, which can partially preserve the movement of fixed segments and prevent the degeneration of adjacent segments. But we must realize that the stabilization of lumbar rigid internal fixation is transient and that its function is completed once the osseous fusion occurs. A dynamic stabilization system must provide lifetime stabilization for fixed segments. After lumbar fusion surgery, if pseudoarthrosis occurs, instrumentation failure will be expected (screw or rod breakage). In order to maintain the long-term effect of the dynamic stabilization system, both the long-term bone interface matching relation between the pedicle screw and vertebral bone and the durability and mechanical strength of the PDS implant are needed, which is hard to achieve at the moment. In theory, we have not yet figured out how much motion the dynamic stabilization system should control and how much load it should share. With the progress of material science and biomechanics, these problems are expected to be solved.

Large-sample and long-term follow-up randomized controlled trials are expected to judge its safety and efficacy. In the present circumstances, it is not possible to conclude that the posterior dynamic stabilization system is superior to fusion surgery. At present, as there are still many unresolved issues, we should not overemphasize the

application of these lumbar dynamic stabilization systems in the treatment of degenerative lumbar diseases.

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