

# Dynesys system vs posterior decompression and fusion for the treatment of lumbar degenerative diseases

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## Abstract

**Background:** The Dynesys dynamic stabilization system is an alternative to rigid instrumentation and fusion for the treatment of lumbar degenerative disease. The purpose of this study is to evaluate the clinical efficacy between Dynesys and posterior decompression and fusion for lumbar degenerative diseases.

**Methods:** The computer was used to retrieve the Cochrane library, Medline, Embase, CNKI, Wanfang database and Chinese biomedical literature database; and the references and main Chinese and English Department of orthopedics journals were manually searched. All the prospective or retrospective comparative studies on the clinical efficacy and safety of Dynesys and posterior decompression and fusion were collected, so as to evaluate the methodological quality of the study and to extract the data. The RevMan 5.2 software was used for data analysis.

**Results:** A total of 17 studies were included in the meta-analysis. There were no significant differences in Oswestry disability index and visual analogue score for leg pain, visual analogue score for back pain, L2–S1 ROM between Dynesys and fusion group. Operation time, blood loss, length of stay and complications in the Dynesys group were significantly less than that in the fusion group. Adjacent-segment degeneration in the fusion group was significantly higher than that in the Dynesys group. In addition, postoperative operated segment ROM was significantly less in the fusion group as compared to the Dynesys group.

**Conclusions:** Our meta-analysis suggests that Dynesys system acquires comparable clinical outcomes compared to fusion in the treatment of lumbar degenerative diseases. Moreover, compared with fusion, Dynesys could remain ROM of surgical segments with less operation time, blood loss, length of stay, adjacent-segment degeneration, and lower complication. Further studies with large samples, long term follow up and well-designed are needed to assess the two procedures in the future.

**Abbreviations:** ASD = adjacent-segment degeneration, NOS = Newcastle-Ottawa quality assessment scale, ODI = Oswestry disability index, OR = odds ratio, RCT = randomized controlled trial, VAS = visual analogue score, WMD = weighted mean difference.

**Keywords:** Dynesys, fusion, lumbar degenerative diseases

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HW, JP, and QZ contributed equally to this work.

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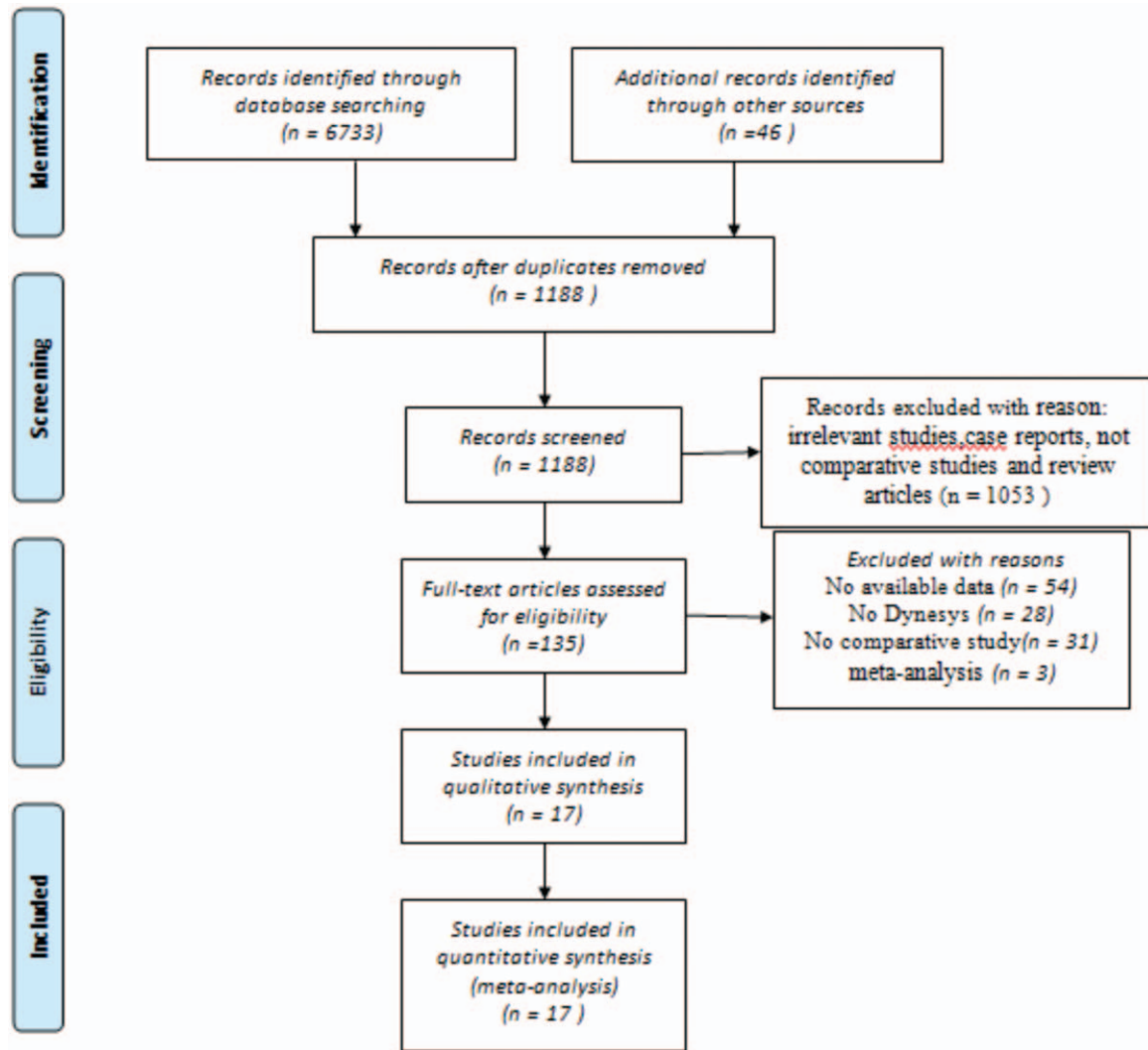
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## 1. Introduction

With the application of new techniques and devices, lumbar fusion surgery has been the standard surgical treatment of various lumbar degenerative diseases. However, there is evidence showing that fusion procedure usually results in several adverse effects such as adjacent-segment degeneration (ASD), pseudarthrosis, nonunion, and instrumentation failure.<sup>[5,13]</sup>

Owing to the disadvantages associated with fusion, researchers have explored some motion preserving surgeries including artificial lumbar disk replacement and dynamic stabilization.<sup>[1,4,6,8,14,17,25]</sup> The Dynesys dynamic stabilization system is an alternative to rigid instrumentation and fusion for the treatment of lumbar degenerative disease. In theory, they offers the advantage of preservation of adjacent segmental motion and less loading on the adjacent discs and facet joints.<sup>[18]</sup> However, previous study reported that there are no long-term data available to show whether dynamic stabilization decreases the rate of ASD.<sup>[3]</sup> Moreover, there are no clinical data from comparative studies supporting the use of dynamic stabilization devices over standard fusion techniques.<sup>[3]</sup> Therefore, it is still unclear that such devices lead to better outcomes compared with traditional fusion, and it is unclear if it truly leads to a decrease in ASD. Thus, the objective of this meta-analysis is to evaluate the radiological



**Figure 1.** The flow chart shows the article selection process we performed.

and clinical outcomes of Dynesys dynamic stabilization system and fusion in the treatment of lumbar degenerative diseases.

## 2. Materials and methods

### 2.1. Search strategy and study selection

We searched for studies published that compared clinical effectiveness of Dynesys system and posterior decompression and fusion in the treatment of lumbar degenerative diseases since the date of inception to June, 2019. The databases included Cochrane library, Medline, Embase, CNKI, Wanfang database and Chinese biomedical literature database with no language restriction; and the references and main Chinese and English Department of orthopedics journals were manually searched. We used the following search terms: Dynesys OR dynamic AND fusion. Reference lists of all included studies were scanned to identify additional potentially relevant studies. Two reviewers independently screened the titles and abstracts of identified papers, and full text copies of all potentially relevant studies were obtained. Inconsistencies were resolved through discussion until a consensus was reached.

### 2.2. Inclusion criteria

Studies were included if they met the following criteria:

- (1) randomized or non-randomized controlled study;
- (2) directly comparing Dynesys system with fusion in patients 18 years or older with degenerative spine disease (including spinal stenosis, spondylosis, spondylolisthesis, and/or degenerative disc disease);
- (3) the study reported at least one following outcome: the Oswestry disability index (ODI), ASD, the Japanese Orthopedic Association (JOA) scale, the back and leg pain visual analogue (VAS) scale, the intraoperative blood loss, the operation time, complications and the fusion outcomes. Studies did not meet the above criteria were excluded from selection.

### 2.3. Quality assessment of included studies

We performed the quality assessment based on the Newcastle-Ottawa quality assessment scale (NOS) for non-randomized trials. The modified Jadad scale was used to evaluate the methodological quality of the included randomized controlled trial (RCT). Two

**Table 1****Characteristics of included studies.**

Study ID	Design	Country	Number of Patient	Mean Age	Outcomes	Follow-up Time (months)
Cakir et al	Retrospective Comparative	Germany	D: 11 F:15	D: 57.1 ± 12.0 F: 57.9 ± 9.4	ROM	D:37.5(24–56) F:45.3(30–72)
Fei et al	Prospective Comparative	China	D: 95 F: 81	D: 47.3 ± 12.9 F: 52.9 ± 11.2	VAS, ODI, ROM, BL,OT,LS,C	D:24 F:24
Yu et al	Retrospective Comparative	Taiwan	D:27 F:26	D: 52.22 ± 8.31 F: 55.52 ± 6.98	VAS,ODI, ROM,BL,OT,LS,C	D:36 F:36
Haddad et al	Retrospective Comparative	UK.	D:32 F:32	D: 40.6 ± 6.46 F: 46.5 ± 10.7	ODI, VAS,	D:48 F:48
Wang et al	Retrospective Comparative	China	D:45 F:40	D: 42.8 ± 6.7 F: 56.8 ± 6.2	VAS, ODI,C, ROM	D:30 F:30
Yang et al	Retrospective Comparative	China	D:62 F:51	D: 44.31 ± 13.01 F: 46.59 ± 12.06	ODI, VAS, ROM,C, BL, OT,ASD, LS	D:48 F:48
Wang et al	Retrospective Comparative	China	D:48 F:50	D: 51.44 ± 10.62 F: 53.16 ± 9.42	ODI, VAS, ROM,C, BL,OT, LS	D:24 F:24
Yang et al	Retrospective Comparative	China	D:14 F:18	D:43 F:47	ODI, VAS, ROM	D:17 F:15
Zhang et al	Retrospective Comparative	China	D:46 F:50	D: 48.1 ± 12.3 F: 52.3 ± 15.7	ODI, VAS, ROM,ASD	D:24 F:24
Peng et al	Retrospective Comparative	China	D:28 F:28	D: 57.1 ± 12.0 F: 57.9 ± 9.4	ODI, VAS, BL,OT, LS	D:24 F:24
Wei et al	Retrospective Comparative	China	D:21 F:21	D: 48.38 ± 12.32 F: 50.57 ± 11.5	ODI, VAS,BL,OT,	D: 39.1 ± 3.58 F: 41.2 ± 3.06
Bao et al	Retrospective Comparative	China	D: 28 F:28	D: 57.1 ± 12.0 F: 57.9 ± 9.4	ODI, VAS	D:48 F:48
Xiao et al	Retrospective Comparative	China	D:35 F:41	D: 48.1 ± 12.3 F: 52.3 ± 15.7	ODI, VAS, ROM BL,OT,	D: 33.4 ± 6.6 F: 35.3 ± 5.6
Li et al	Retrospective Comparative	China	D:59 F:59	D: 59.32 ± 8.05 F: 57.69 ± 9.11	ODI, ROM, BL,OT, LS	D:12 F:12
Yang et al	Retrospective Comparative	China	D:26 F:34	D: 45.24 ± 12.15 F: 57.9 ± 9.4	ODI, VAS, ROM BL,OT, LS	D:36 F:36
Yang et al	Retrospective Comparative	China	D:30 F:45	D: 55.96 ± 7.68 F: 54.69 ± 3.26	ODI, VAS,C, BL,OT,	D:24 F:24
Kaner et al	Prospective Comparative	Turkey	D:26 F:20	D: 63.65 ± 11.34 F: 58.10 ± 8.53	ODI, VAS,C	D:38(24–55) F:44(24–64)

ASD = adjacent segment degeneration, BL = blood loss, C = complication, D = Dynesys, F = fusion, JOA = Japanese Orthopedic Association, LS = length of stay, ODI = Oswestry disability index, OT = operative time, ROM = range of motion, VAS = visual analogue scale.

**Table 2****Newcastle-Ottawa quality assessment scale (NOS) for non-randomized trials.**

Study	Selection	Comparability	Exposure	Total score
Cakir et al	***	**	***	8
Fei et al	***	**	**	7
Yu et al	***	**	***	8
Haddad et al	***	**	***	7
Wang et al	**	**	***	8
Yang et al	***	**	***	8
Wang et al	***	**	**	7
Yang et al	***	**	**	7
Zhang et al	***	**	***	8
Peng et al	**	**	**	6
Wei et al	***	**	***	7
Bao et al	***	**	**	8
Xiao et al	***	**	**	8
Li et al	***	**	***	8
Yang et al	**	**	***	7
Yang et al	***	**	***	8

The Newcastle–Ottawa scale contains 8 items that are divided into 3 categories: selection (4 items, 1 star each), comparability (1 item, up to 2 stars), and exposure/outcome (4 items, 1 star each).

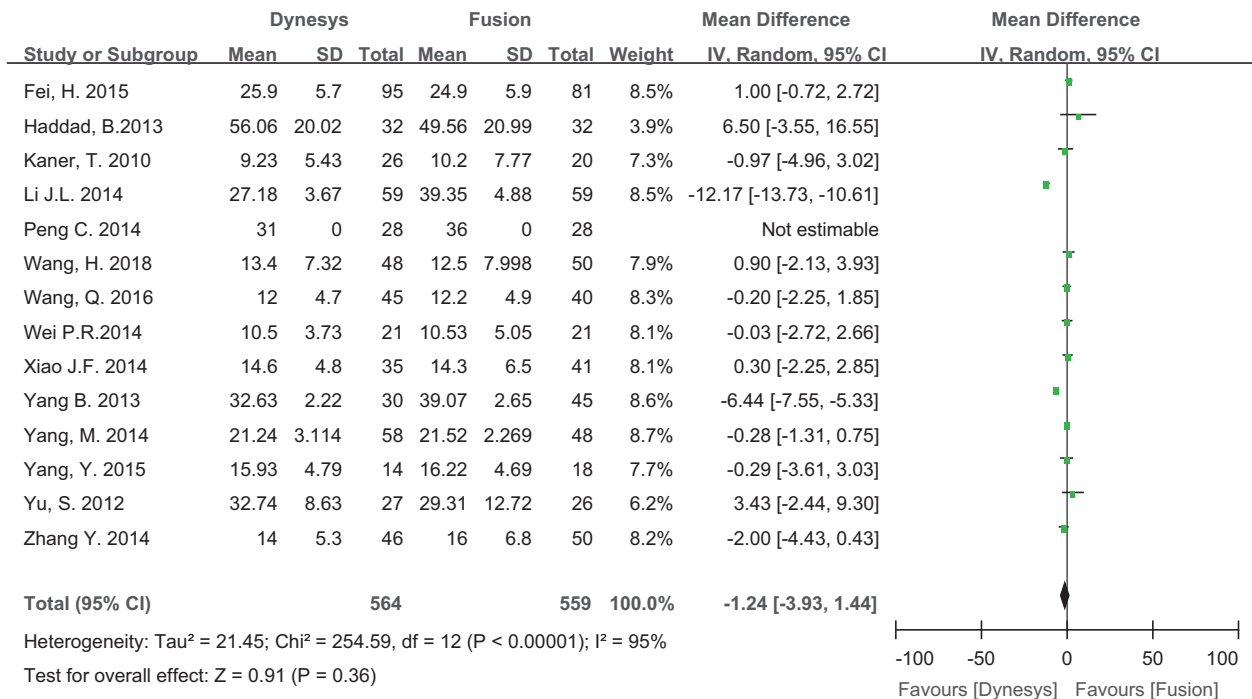
reviewers independently evaluated these studies, and any discrepancies were resolved by discussion and consensus.

**2.4. Data analysis**

We performed all meta-analyses with the Review Manager software (RevMan Version 5.1; The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark). Heterogeneity was tested using Chi square test and quantified by calculating  $I^2$  statistic, for which  $P < .1$  and  $I^2 > 50\%$  was considered to be statistically significant. For the pooled effects, weighted mean difference (WMD) or standard mean difference (SMD) was calculated for continuous variables according to the consistency of measurement units, and odds ratio (OR) was calculated for dichotomous variables. Continuous variables are presented as mean differences and 95% confidence intervals (CI), whereas dichotomous variables are presented as odds ratios and 95% CI. Random-effects or fixed-effects models were used depending on the heterogeneity of the studies included.

**3. Results**

Through electronic searches and from the references of potentially relevant articles, we identified 6779 publications



**Figure 2.** Forest plot of postoperative ODI between the Dynesys and fusion groups. ODI = Oswestry disability index.

(Fig. 1). By screening the titles and abstracts, 6644 references were excluded due to duplicates, irrelevant studies, case reports, not comparative studies and review. The remaining 135 reports underwent a detailed and comprehensive evaluation. Finally, 17 studies were included in this meta-analysis.<sup>[2,7,9,11,12,19,20,22-24,26-33]</sup> Tables 1 and 2 summarize the base line characteristics assessment and quality of included studies, respectively.

### 3.1. Clinical outcome

#### 3.1.1. Postoperative functional performance (VAS and ODI).

VAS and ODI scores are the most frequently used variables to assess the postoperative function performance of patients. Fourteen trials provided ODI scores, no significant difference was detected between Dynesys and fusion groups [ $P=.36$ , WMD:  $-1.24$  ( $-3.93, 1.44$ )] (Fig. 2). Eleven studies assessed VAS for back pain, which was not significantly different between Dynesys and fusion groups [ $P=.85$ , WMD:  $-0.03$  ( $-0.34, 0.28$ )] (Fig. 3). Six studies assessed VAS for leg pain, which was not different between the 2 groups either [ $P=.68$ , WMD:  $-0.07$  ( $-0.4, 0.26$ )] (Fig. 3).

**3.1.2. Adjacent segment degeneration.** Two studies reported ASD. Pooled data from the two relevant studies revealed ASD in the fusion group were significantly higher than that in the Dynesys group with no evidence of statistical heterogeneity (OR 0.28, 95% CI 0.14, 0.58,  $I^2=0\%$ ,  $P=.006$ ) (Fig. 4).

**3.1.3. Operation time, blood loss, and length of stay.** Shown as a forest plot in Figure 5 are the results of meta-analysis of operation time. There was statistically significant difference in operation time between Dynesys and fusion group [ $P=.0002$ , WMD:  $-33.07$  ( $-50.31, -15.83$ )] (Fig. 5).

Blood loss was assessed in 9 eligible studies and the results of the meta-analysis are presented in Figure 6. Overall, Dynesys

group required a significantly less blood loss as compared with fusion group [ $P<.00001$ , WMD:  $-117.97$  ( $-114.12, -91.83$ )] (Fig. 6).

Seven studies reported length of stay, there was a statistically significant difference between Dynesys and fusion group [ $P=.01$ , WMD:  $-2.49$  ( $-4.38, -0.60$ )] (Fig. 7)

### 3.2. Complications

Data regarding complications were provided in 9 studies. Complications was significant less in Dynesys group groups compared with fusion group (OR=0.63, 95% CI 0.4, 0.99,  $I^2=0\%$ ,  $P=.04$ ; Fig. 8)

### 3.3. Postoperative L2–S1 ROM

Details regarding postoperative L2–S1 ROM were available in 4 studies. The pooled data revealed no significant differences in L2–S1 ROM between Dynesys and fusion group [ $P=.13$ , WMD:  $2.53$  ( $-0.77, 5.83$ )] (Fig. 9).

### 3.4. Postoperative ROM of operated segment

Nine studies provided data regarding operated segment ROM. Postoperative operated segment ROM was significantly less in the fusion group as compared to the Dynesys group [ $P<.00001$ , WMD:  $2.24$  ( $2.18, 2.29$ )] (Fig. 10).

### 3.5. Publication bias

Assessment of publication bias for all included studies was performed by the funnel plot. The funnel plots demonstrated a symmetry in VAS scores (Fig. 11A), complications (Fig. 11B),

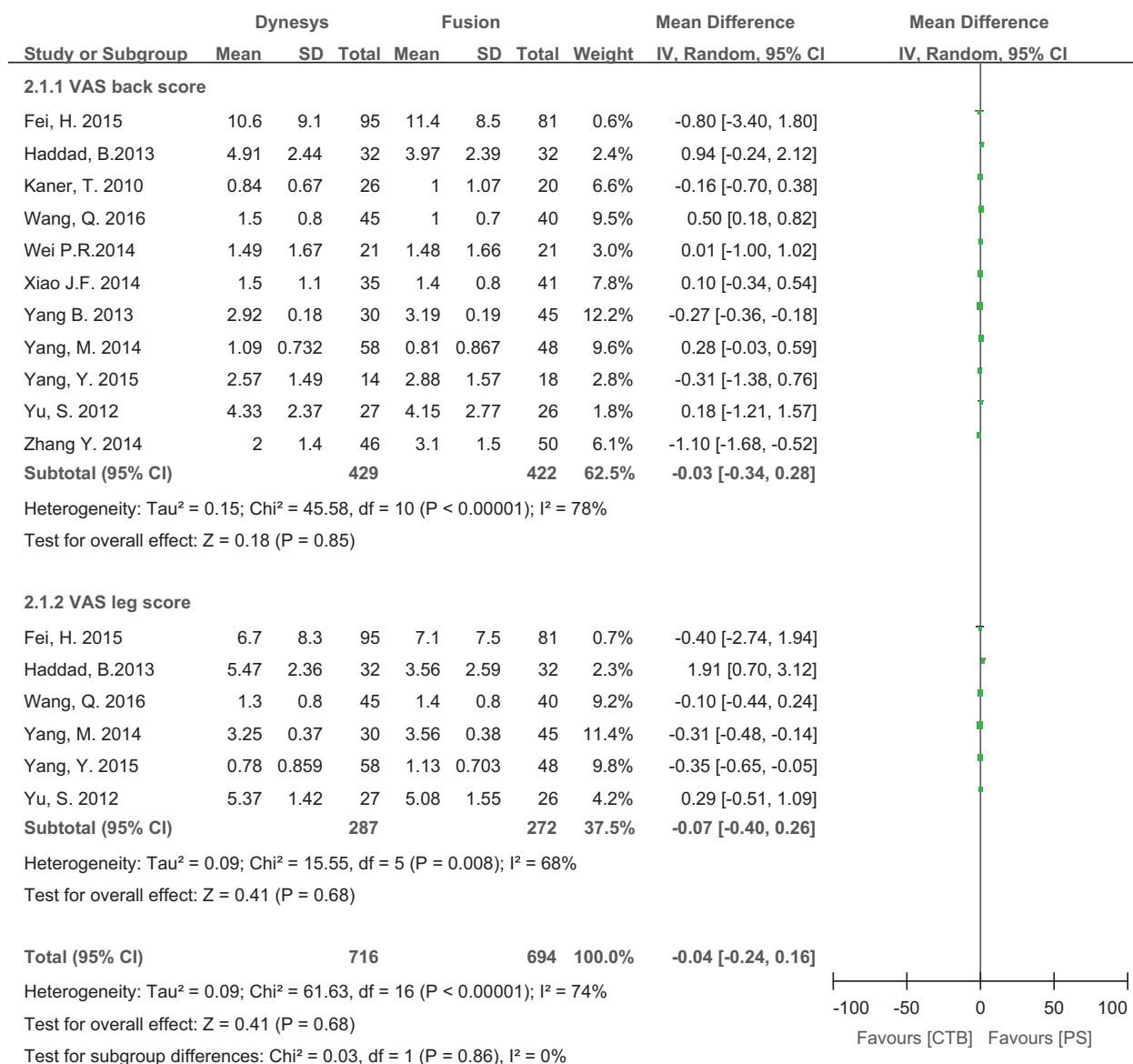


Figure 3. Forest plot of VAS for back and leg pain between the Dynesys and fusion groups respectively. VAS = visual analogue score.

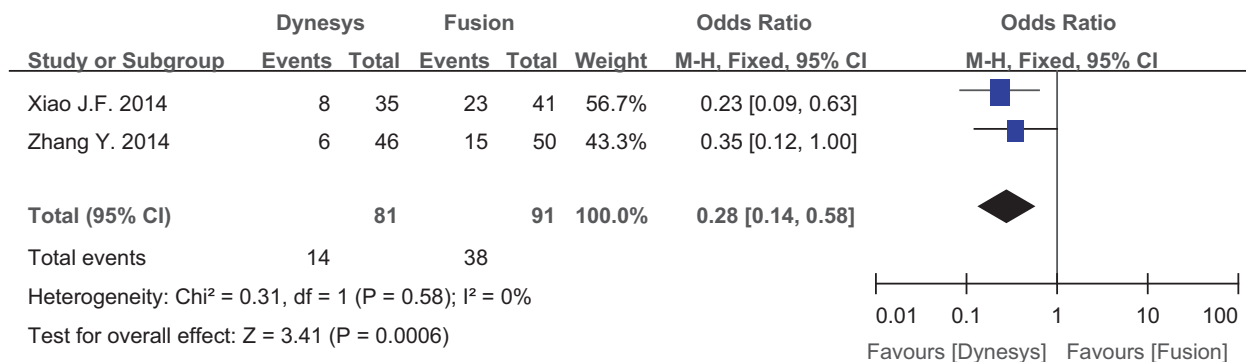


Figure 4. Forest plot of postoperative ASD between the Dynesys and fusion groups. ASD = adjacent-segment degeneration.

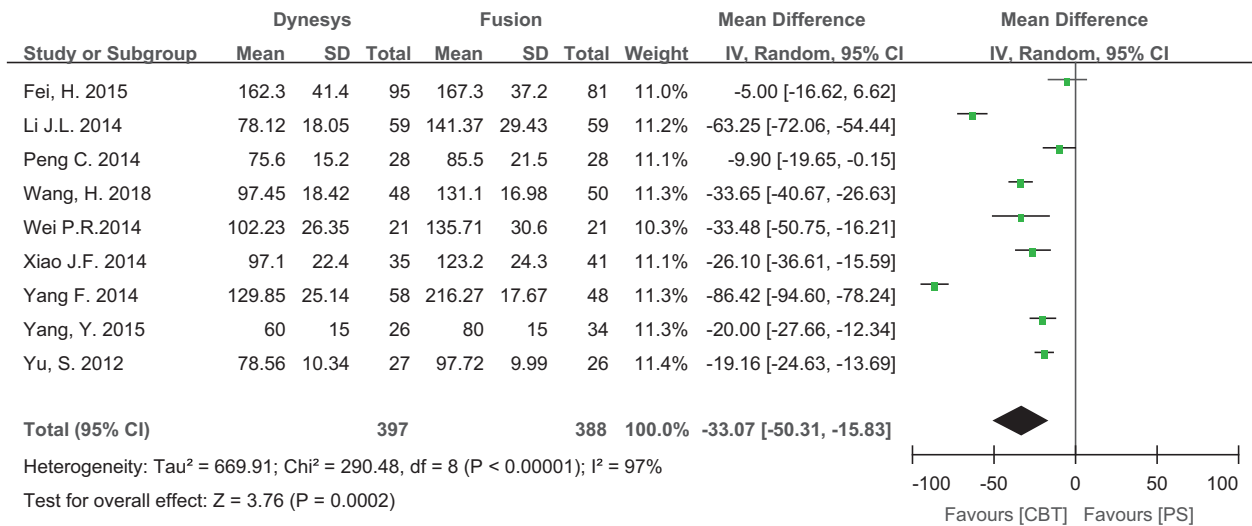


Figure 5. Forest plot of operation time between the Dynesys and fusion groups.

L2–S1 ROM (Fig. 11C), and ROM of operated segment (Fig. 11D), which indicated there was no publication bias. Therefore, it suggested this was a reliable analysis.

#### 4. Discussion

Spinal fusion surgery is an effective method in the treatment of lumbar degenerative diseases. Fusion indications in adult degenerative disk disease of the lumbosacral spine include isolated disk resorption, primary and secondary instability, recurrent disk herniation, and pseudarthrosis. However, previous literature reported that instrumented spinal fusion is known to have potential complications such as ASD, instrumentation failure, pseudoarthrosis, nonunion, infection, and donor site pain.<sup>[5,15,16]</sup> Dynamic semirigid stabilization was introduced in 1994 in an attempt to overcome the drawbacks of fusion. It is

supposed to preserve motion at the treated levels, while avoiding hypermobility and thus spondylosis at the adjacent levels.<sup>[9]</sup> Previous study reported the Dynesys stabilization and decompression can achieve satisfactory short-term and long-term clinical outcomes in lumbar degenerative disease.<sup>[10,26]</sup> This procedure system not only reduces back and leg pain, but also preserves the mobility of fixed segments, minimizes tissue injury and avoids taking bone for spinal fusion.<sup>[10]</sup>

In our meta-analysis, from the literature search up to June 2019, 17 studies were considered to be of sufficient methodological quality and were included. Meta-analysis results showed that no significant difference was found in ODI and VAS score, L2–S1 ROM between Dynesys and fusion group. In contrast, fusion group was associated with significantly more operation time, blood loss, length of stay, significant higher complications and ASD as compared with Dynesys group. What is more,

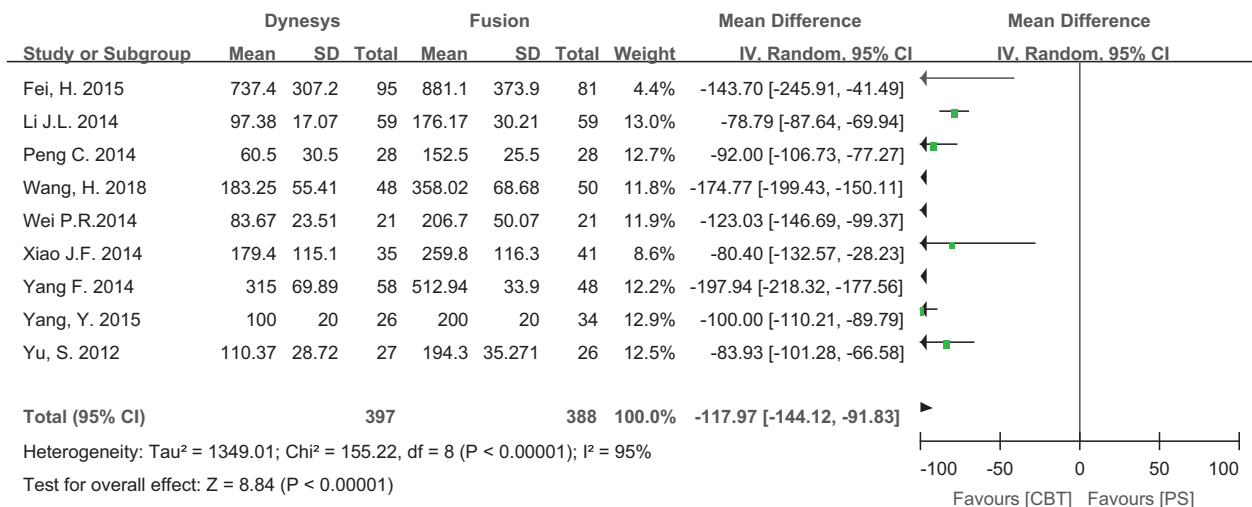


Figure 6. Forest plot of blood loss between the Dynesys and fusion groups.

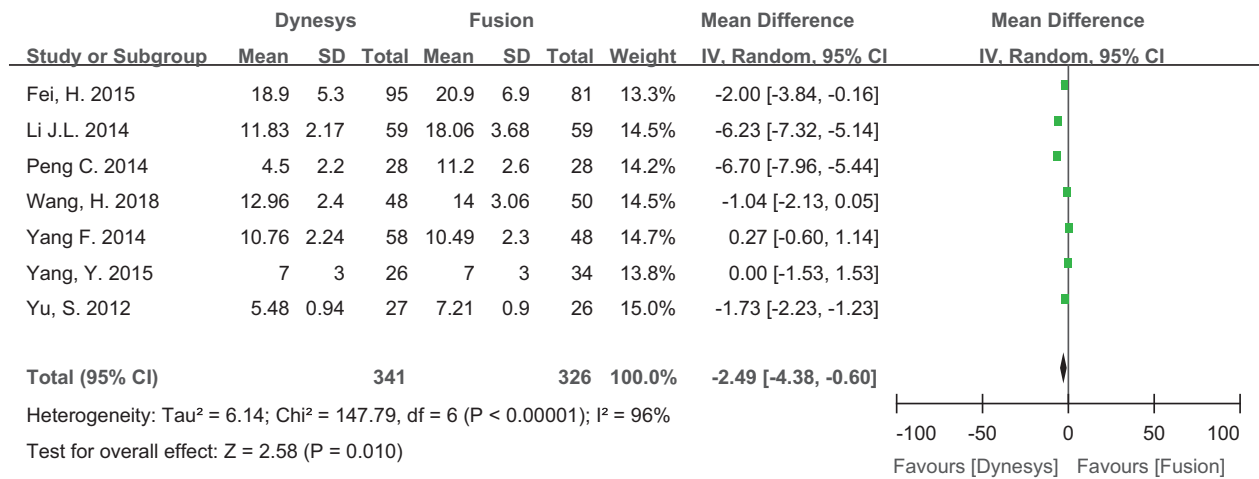


Figure 7. Forest plot of length of stay between the Dynesys and fusion groups.

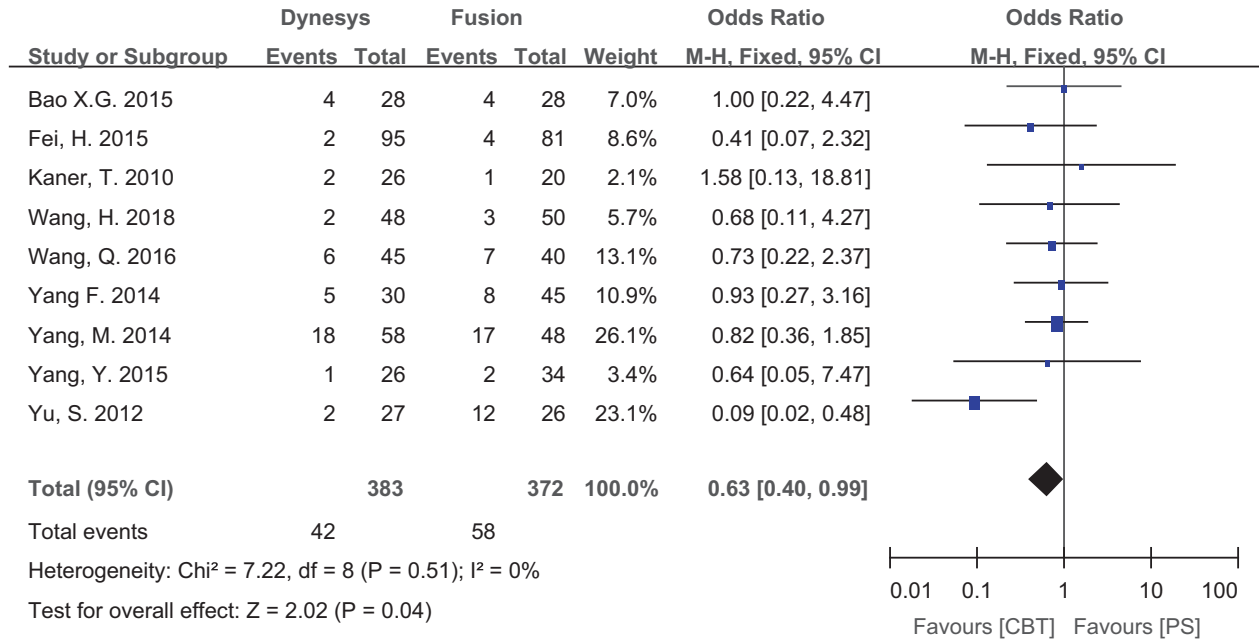


Figure 8. Forest plot of complications between the Dynesys and fusion groups.

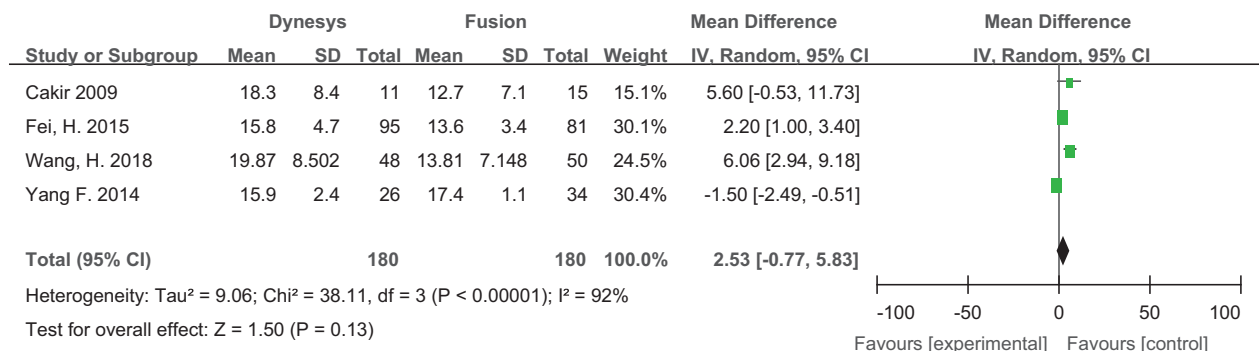


Figure 9. Forest plot of L2-S1 ROM between the Dynesys and fusion groups.

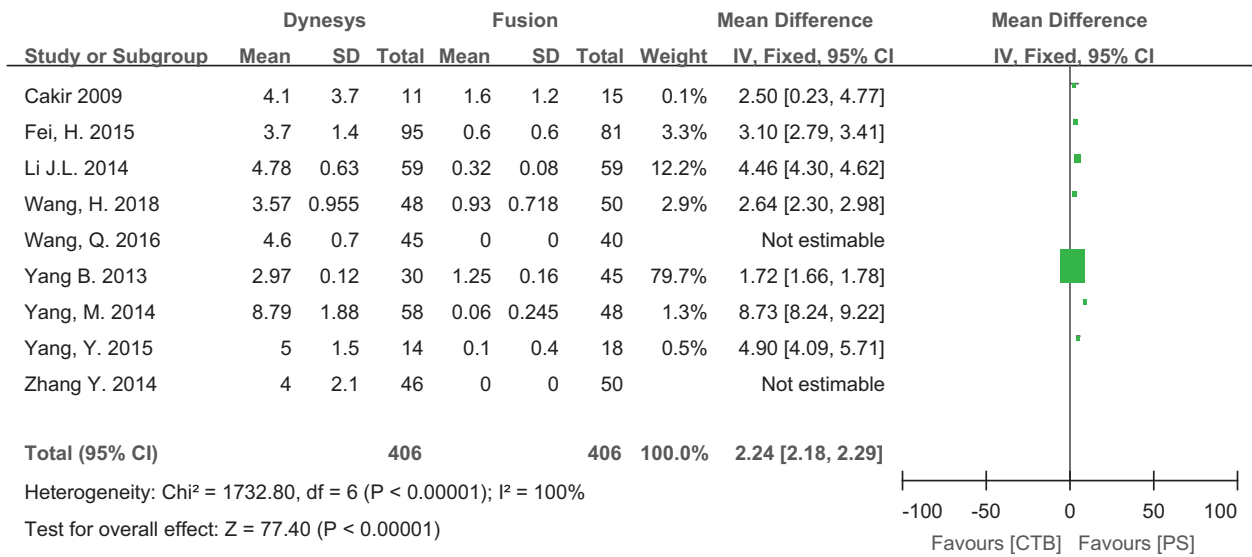


Figure 10. Forest plot of ROM of operated segment between the Dynesys and fusion groups.

postoperative operated segment ROM was significantly less in the fusion group as compared to the Dynesys group. Our findings are in line with previous study confirming that Dynesys system acquired comparable clinical outcomes compared to fusion in the treatment of lumbar degenerative diseases. Moreover, compared with fusion, Dynesys could remain ROM of surgical segments.

Previous systematic review reported by Chou et al found that no significant differences were identified between fusion and dynamic stabilization with regard to VAS, ODI, complications, and reoperations.<sup>[3]</sup> There are no long-term data available to show whether dynamic stabilization decreases the rate of ASD.<sup>[3]</sup> However, for postoperative ASD and operated segment ROM,

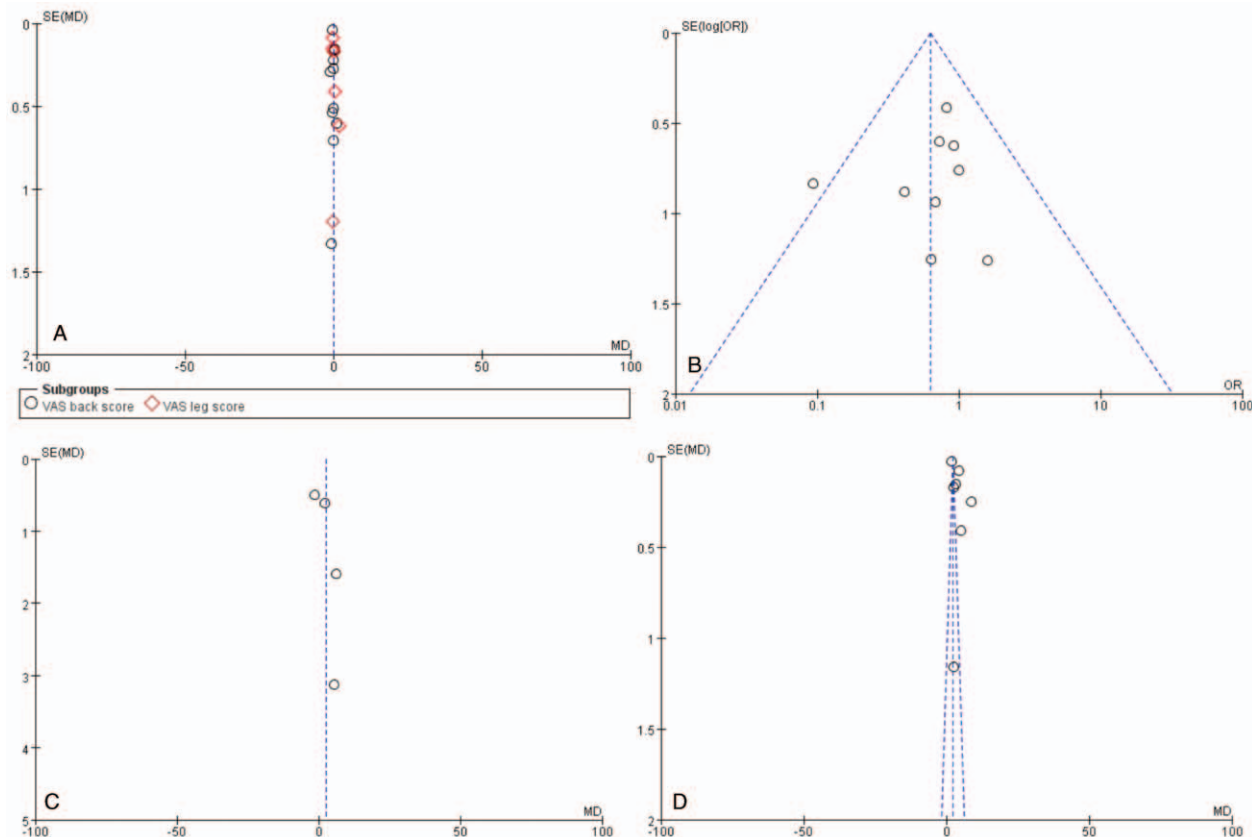


Figure 11. Funnel plots of VAS scores (A), complications (B), L2-S1 ROM (C), and ROM of operated segment (D). VAS = visual analogue score.



Dynesys are statistically significantly lower in these outcomes when compared to fusion. Our results are inconsistent with the results reported by others.

In the present study, no significant difference was found in back and leg pain VAS score between fusion and Dynesys, indicating that both methods were effective for the treatment of degenerative lumbar diseases. Previous literature also suggests that both groups demonstrated significant improvement in VAS back and leg pain and ODI. However, no significant difference has been found between the 2 groups at any time point.<sup>[19]</sup>

The chief advantage of dynamic stabilization is to preserve motion at the treated segment, which might benefit in reducing ASD. The potential reduction of ASD is mainly attributed to the avoidance of increased stress at the adjacent segments. Pooled data from our study revealed that ASD in the fusion group were significantly higher than that in the Dynesys group. However, with regards to the protective effect against ASD, previous studies have had conflicting results.<sup>[2,21,23]</sup> Cakir et al shows that monosegmental posterior dynamic stabilization with Dynesys has no effect with regard to adjacent segment mobility compared with monosegmental fusion.<sup>[2]</sup> Previous investigators insisted that Dynesys system reduces instability at the treated segment; the level of ASD prevention by Dynesys is unclear.<sup>[13]</sup> However, Wu et al reveals that compared with posterior lumbar interbody fusion (PLIF), Dynesys stabilization can maintain the mobility of the stabilized segments with less influence on the proximal adjacent segment and may help to prevent the occurrence of ASD.<sup>[21]</sup>

Our results reveals that fusion group is associated with significantly more operation time, blood loss, length of stay, significant higher complications compared with Dynesys group. This finding is similar with the results from previous studies. Wang et al suggests that both procedures can improve the clinical and radiographic outcomes for lumbar degenerative disease, but dynamic stabilization provides the additional benefits of less blood loss and shorter duration of operation compared with PLIF.<sup>[19]</sup>

The data shows that fusion group is associated with significantly higher complications as compared with Dynesys group. The result is similar with PLIF group. Yang et al reported similar results as well.<sup>[22]</sup> However, Wang et al reported that there were no differences in complications between the groups.<sup>[19]</sup>

Previous study reported that there was a significant reduction of the global ROM of the lumbar spine (L2–S1) and the segmental ROM at the index level in the fusion group, whereas adjacent level ROM did not change significantly.<sup>[2]</sup> In the Dynesys group, no significant changes of global lumbar spine ROM (L2–S1) and segmental ROM (index level and cranial/caudal adjacent levels) were seen.<sup>[2]</sup> In our study, postoperative operated segment ROM was significantly lower in Dynesys when compared to the PS group, whereas pooled data revealed no significant differences in L2–S1 ROM between Dynesys and fusion group.

We believe that our result is affected by several reasons. First, in this meta-analysis, all studies selected were not RCT, while it did not influence the credibility of the results. Because almost all the studies reported the baseline characteristics were matched for each group and the results for the meta-analysis of baseline characteristics also showed no significant difference between the 2 groups. Second, 8 of 17 studies were performed in China. The results have to be interpreted with caution because of uneven

regional distribution. Due to these limitations, the combined results of this meta-analysis should be cautiously accepted, and high-quality RCTs with long term follow-up and large sample size are needed.

## 5. Conclusions

In conclusion, our meta-analysis suggests that Dynesys system acquires comparable clinical outcomes compared to fusion in the treatment of lumbar degenerative diseases. Moreover, compared with fusion, Dynesys could remain ROM of surgical segments with less operation time, blood loss, length of stay, ASD and lower complication. Further studies with large samples, long term follow up and well-designed are needed to assess the 2 procedures in the future.

## Author contributions

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## References

- [1] Abi-Hanna D, Kerferd J, Phan K, et al. Lumbar disk arthroplasty for degenerative disk disease: literature review. *World Neurosurg* 2018;109:188–96.
- [2] Cakir B, Carazzo C, Schmidt R, et al. Adjacent segment mobility after rigid and semirigid instrumentation of the lumbar spine. *Spine* 2009;34:1287–91.
- [3] Chou D, Lau D, Skelly A, et al. Dynamic stabilization versus fusion for treatment of degenerative spine conditions. *Evid Based Spine Care J* 2011;2:33–42.
- [4] Ciplak NM, Suzer T, Senturk S, et al. Complications of 2-level dynamic stabilization: a correlative clinical and radiological analysis at two-year follow-up on 103 patients. *Turk Neurosurg* 2018;28:756–62.
- [5] de Kunder SL, van Kuijk S, Rijkers K, et al. Transforaminal lumbar interbody fusion (TLIF) versus posterior lumbar interbody fusion (PLIF) in lumbar spondylolisthesis: a systematic review and meta-analysis. *Spine J* 2017;17:1712–21.
- [6] Fay LY, Chang CC, Chang HK, et al. A hybrid dynamic stabilization and fusion system in multilevel lumbar spondylosis. *Neurospine* 2018; 15:231–41.
- [7] Fei H, Xu J, Wang S, et al. Comparison between posterior dynamic stabilization and posterior lumbar interbody fusion in the treatment of degenerative disc disease: a prospective cohort study. *J Orthop Surg Res* 2015;10.
- [8] Formica M, Divano S, Cavagnaro L, et al. Lumbar total disc arthroplasty: outdated surgery or here to stay procedure? A systematic review of current literature. *J Orthop Traumatol* 2017;18:197–215.
- [9] Haddad B, Makkie D, Konan S, et al. Dynesys dynamic stabilization: less good outcome than lumbar fusion at 4-year follow-up. *Acta orthopaedica Belgica* 2013;79:97–103.
- [10] Hu Y, Gu Y, Xu R, et al. Short-term clinical observation of the Dynesys neutralization system for the treatment of degenerative disease of the lumbar vertebrae. *Orthop Surg* 2011;3:167–75.
- [11] Kaner T, Dalbayrak S, Oktenoglu T, et al. Comparison of posterior dynamic and posterior rigid transpedicular stabilization with fusion to treat degenerative spondylolisthesis. *Orthopedics* 2010;33.
- [12] Lee C, Jahng T, Hyun S, et al. Dynamic stabilization using the Dynesys system versus posterior lumbar interbody fusion for the treatment of degenerative lumbar spinal disease: a clinical and radiological outcomes-based meta-analysis. *Neurosurg Focus* 2016;40:E7.

- [13] Li JX, Phan K, Mobbs R. Oblique lumbar interbody fusion: technical aspects, operative outcomes, and complications. *World Neurosurg* 2017;98:113–23.
- [14] Liu YL, Yang H, Zhang M, et al. Short-term effect of Isobar dynamic stabilization system fixation combined with lumbar discectomy in patients with lumbar disc herniation. *Zhonghua Yi Xue Za Zhi* 2019;99:188–92.
- [15] Macki M, Bydon M, Weingart R, et al. Posterolateral fusion with interbody for lumbar spondylolisthesis is associated with less repeat surgery than posterolateral fusion alone. *Clin Neurol Neurosurg* 2015;138:117–23.
- [16] Makino T, Kaito T, Fujiwara H, et al. Risk factors for poor patient-reported quality of life outcomes after posterior lumbar interbody fusion: an analysis of 2-year follow-up. *Spine (Phila Pa 1976)* 2017;42:1502–10.
- [17] Ozer AF, Cevik OM, Erbulut DU, et al. A novel modular dynamic stabilization system for the treatment of degenerative spinal pathologies. *Turk Neurosurg* 2019;29:115–20.
- [18] Pham MH, Mehta VA, Patel NN, et al. Complications associated with the Dynesys dynamic stabilization system: a comprehensive review of the literature. *Neurosurg Focus* 2016;40:E2.
- [19] Wang H, Lv B. Comparison of clinical and radiographic results between posterior pedicle-based dynamic stabilization and posterior lumbar intervertebral fusion for lumbar degenerative disease: a 2-year retrospective study. *World Neurosurg* 2018;114:e403–11.
- [20] Wang Q, Liu J, Shi Y, et al. Short-term effects of a dynamic neutralization system (Dynesys) for multi-segmental lumbar disc herniation. *Eur Spine J* 2016;25:1409–16.
- [21] Wu H, Pang Q, Jiang G. Medium-term effects of Dynesys dynamic stabilization versus posterior lumbar interbody fusion for treatment of multisegmental lumbar degenerative disease. *J Int Med Res* 2017;45:1562–73.
- [22] Yang M, Li C, Chen Z, et al. Short term outcome of posterior dynamic stabilization system in degenerative lumbar diseases. *Indian J Orthop* 2014;48:574–81.
- [23] Yang Y, Hong Y, Liu H, et al. Comparison of clinical and radiographic results between isobar posterior dynamic stabilization and posterior lumbar inter-body fusion for lumbar degenerative disease: A four-year retrospective study. *Clin Neurol Neurosurg* 2015;136:100–6.
- [24] Yu S, Yang S, Ma C, et al. Comparison of Dynesys posterior stabilization and posterior lumbar interbody fusion for spinal stenosis L4L5. *Acta Orthop Belg* 2012;78:230–9.
- [25] Zhang Y, Zhang ZC, Li F, et al. Long-term outcome of dynesys dynamic stabilization for lumbar spinal stenosis. *Chin Med J (Engl)* 2018;131:2537–43.
- [26] Bao X, Sun T, Hou J, et al. Comparative analysis of Dynesys dynamic internal fixation and lumbar fusion. *J Nanjing Med Univ* 2015;35:225–7.
- [27] Li J, Liu J, Zhou P, et al. Comparison of Dynesys dynamic neutralization system and posterior intervertebral fusion in the treatment of lumbar degeneration. *Chin J Modern Med* 2014;24:104–7.
- [28] Peng C, He Z, Ma J, et al. Comparison of Dynesys dynamic stabilization system with posterior interlumbar fusion for lumbar degenerative diseases. *Chin Tissue Eng Res* 2014;7117–21.
- [29] Wei P, Zhou D, Chen X, et al. Comparison of clinical efficacy of posterior decompression Dynesys dynamic fixation and posterior decompression and fusion internal fixation in the treatment of single-segmental lumbar degenerative disease. *J Neck Back Pain* 2014;35:90–5.
- [30] Xiao J, Zhang Y, Li F, et al. Comparison of Dynesys dynamic internal fixation and fusion in the treatment of L4/5 single-stage degenerative disease. *Chin J Spinal Cord* 2014;24:873–8.
- [31] Yang B, Jiang T. A comparative study of dynamic neutralization system and posterior lumbar intervertebral fusion in the treatment of lumbar degeneration. *Chin J Repair Reconstr Surg* 2013;27:140–4.
- [32] Yang F, He D, Zhu X, et al. Clinical comparison of Dynesys dynamic fixation and lumbar fusion fixation in the treatment of lumbar degenerative diseases. *J Sec Milit Med Univ* 2014;35:1145–50.
- [33] Zhang Y, Li F, Shan J, et al. A comparative study of Dynesys dynamic internal fixation and fusion in the treatment of lumbar degenerative diseases. *J Spinal Surg* 2014;12:19–24.