ORIGINAL ARTICLE

UDC: 616.8-089:616.711-08
DOI: https://doi.org/10.2298/VSP250418018Z

Comparative study between the efficacy of Isobar TTL and Isobar EVO systems for lumbar degenerative diseases and their effects on adjacent segment degeneration

Komparativna studija efikasnosti Isobar TTL i Isobar EVO sistema u lečenju lumbalnih degenerativnih bolesti i njihovog uticaja na degeneraciju susednih segmenata

[1]Xiaozhe Zhang*, [1]Jianbin Guan†, Kesong Shi*, Tongzheng Wang‡, Yaqi Zhang†, Wei Li§, Tao Zhang*, Xing Yu†, Ziyi Zhao§

***Beijing Changping Hospital of Integrated Chinese and Western Medicine, Department of Orthopedics, Beijing, China; †Beijing University of Chinese Medicine, Dongzhimen Hospital, Department of Orthopedics, Beijing, China; ‡Puyang TCM Hospital, Department of Orthopedics, Henan, China; §Beijing Hospital of Traditional Chinese Medicine, Department of Orthopedics, Beijing, China**

[1]the authors share equal contribution

Abstract

Background/Aim. Lumbar degenerative diseases (LDD) are diseases that occur due to normal aging and degeneration of the lumbar spine. In addition to conservative therapies, surgical procedures become necessary to achieve satisfactory clinical outcomes. The aim of this study was to evaluate the effectiveness of the Isobar TTL and Isobar Evolution (EVO) systems of dynamic internal stabilization in the treatment of LDD and their effects on adjacent segment degeneration. **Methods.** This research involved 78 LDD patients treated with Isobar TTL or Isobar EVO dynamic internal stabilization devices. Patients were divided into two groups: TTL (n = 40) and EVO (n = 38). Visual analog scale (VAS) pain ratings, Oswestry Disability Index (ODI) scores, and modified MacNab criteria effectiveness evaluations were performed preoperatively, 1 and 3 months postoperatively, and at the final follow-up. Range of motion (ROM) and intervertebral space ratio (IVSR) were measured preoperatively and after the final follow-up. **Results.** In almost two years, 37 TTL and 33 EVO patients completed every examination. After surgery, VAS and ODI ratings in both groups improved significantly compared to preoperative levels ($p < 0.05$). The surgical effectiveness of the TTL and EVO groups was rated as excellent or good using the modified MacNab criteria (91.89% and 93.94%, respectively). Preoperative ROM and IVSR values did not differ between the groups ($p > 0.05$). At the final follow-up, the EVO group had a significantly higher ROM than the TTL group (4.46 ± 1.19° vs. 2.58 ± 0.71°; $p < 0.05$) and the ROM of adjacent segments in the TTL group was significantly higher than that of the EVO group (6.74 ± 1.55° vs. 5.83 ± 1.32°; $p < 0.05$). The IVSR of the operated and surrounding segments did not change substantially from preoperative to final follow-up ($p > 0.05$). Moreover, there was no significant difference in IVSRs between the two groups for the operated and neighboring segments at the final follow-up ($p > 0.05$). **Conclusion.** Isobar TTL and Isobar EVO dynamic stabilization systems demonstrated good clinical outcomes. The ability of Isobar EVO to inhibit neighboring segment motion may prevent degeneration.

Keywords:
lumbar vertebrae; orthopedic procedures; osteoarthritis, spine; spinal diseases; spinal fusion.

Apstrakt

Uvod/Cilj. Lumbalne degenerativne bolesti (*lumbar degenerative diseases* – LDD) su bolesti koje nastaju usled normalnog starenja i degeneracije lumbalne kičme. Pored konzervativnih terapija, hirurške procedure postaju neophodne da bi se postigli zadovoljavajući klinički ishodi. Cilj rada bio je da se proceni efikasnost *Isobar* TTL i *Isobar Evolution* (EVO) sistema dinamičke unutrašnje stabilizacije u lečenju LDD, kao i njihov uticaj na degeneraciju susednog segmenta. **Metode.** Istraživanje je obuhvatilo 78 obolelih od LDD, lečenih primenom sistema unutrašnje dinamičke

Correspondence to: Xing Yu, Beijing University of Chinese Medicine, Dongzhimen Hospital, Department of Orthopedics, Beijing, China. E-mail: yuxing34@sina.com

stabilizacije *Isobar* TTL ili *Isobar* EVO. Bolesnici su bili podeljeni u dve grupe: TTL (n = 40) i EVO (n = 38). Procena bola pomoću skorova vizuelne analogne skale (VAS) i *Oswestry Disability Index* (ODI), kao i procena efikasnosti prema modifikovanim MacNab kriterijumima sprovedeni su preoperativno, 1 i 3 meseca postoperativno, kao i na završnom kontrolnom pregledu. Preoperativno i nakon poslednjeg kontrolnog pregleda mereni su obim pokreta (*range of motion* – ROM) i odnos intervertebralnog prostora (*intervertebral space ratio* – IVSR). **Rezultati.** Za skoro dve godine 37 bolesnika iz TTL grupe i 33 iz EVO grupe završila su sve kontrolne preglede. Nakon operacije, skorovi VAS i ODI u obe grupe značajno su se poboljšali u poređenju sa preoperativnim vrednostima ($p < 0,05$). Hirurška efikasnost u TTL i EVO grupama ocenjena je korišćenjem modifikovanih MacNab kriterijuma kao odlična ili dobra (91,89% i 93,94%, redom). Preoperativne vrednosti ROM i IVSR nisu se razlikovale između grupa ($p > 0,05$). Na poslednjem kontrolnom pregledu EVO grupa imala je značajno veći ROM nego TTL grupa (4,46 ± 1,19° vs. 2,58 ± 0,71°; $p < 0,05$), a ROM susednih segmenata u TTL grupi bio je značajno veći nego u EVO grupi (6,74 ± 1,55° vs. 5,83 ± 1,32°; $p < 0,05$). IVSR operisanih i okolnih segmenata nije se značajno promenio od preoperativnog do poslednjeg kontrolnog pregleda ($p > 0,05$). Takođe, nije bilo značajne razlike u IVSR između dve grupe za operisane i susedne segmente na poslednjem kontrolnom pregledu ($p > 0,05$). **Zaključak.** Sistemi dinamičke stabilizacije *Isobar* TTL i *Isobar* EVO pokazali su dobar klinički učinak. Sposobnost *Isobar* EVO sistema da ograniči pokretljivost susednih segmenata može doprineti sprečavanju njihove degeneracije.

Ključne reči:
pršljenovi, lumbalni; ortopedske procedure; kičma, osteoarthritis; kičma, bolesti; kičma, fuzija pršljenova.

Introduction

The term lumbar degenerative diseases (LDD) refers to disorders resulting from the natural aging and degeneration of the lumbar spine, which can produce symptoms such as lower back and leg discomfort, lower limb numbness, intermittent claudication, and bladder, bowel, or sexual dysfunction. After receiving conservative therapies, including oral prescription medication and epidural steroid injection, the majority of individuals with lumbar degenerative disorder get some degree of alleviation. Nevertheless, all individuals respond to conservative management, and surgical procedures become necessary for achieving satisfactory clinical outcomes [1, 2]. Currently, surgical lumbar posterior pedicle screw fixation includes two main types: rigid internal fixation and dynamic internal stabilization. A popular dynamic stabilization tool is the Scient'x Isobar TTL dynamic system. According to an earlier study, using the Isobar TTL system may improve the biomechanical conditions after surgery and prevent adjacent segment degeneration (ASD) [3]. However, the impact of the first-generation Isobar TTL system on preventing ASD remains to be fully validated [4, 5]. The Isobar Evolution (EVO) system is a new-generation dynamic internal stabilization system with improved three-dimensional flexibility, including increased Isobar rod rotation from ± 2° to ± 4.5° and a longitudinal displacement range of ± 0.2 mm to ± 0.8 mm [6]. These modifications increase the mobility of the operable segment, which lessens the adverse effects of compensatory mobility on the neighboring section. However, the efficacy of the Isobar EVO system and its protective effects on ASD remain to be further verified in clinical practice.

The aim of this study was to evaluate the efficacy of both Isobar TTL and Isobar EVO dynamic internal stabilization systems in the treatment of LDD and their effects on ASD.

Methods

A total of 78 patients suffering from single-segment LDD were operated on at the Department of Orthopaedics at Dongzhimen Hospital, Beijing University of Traditional Chinese Medicine, China, from June 2015 to April 2017. The operation was performed using either the Isobar TTL (n = 40) or Isobar EVO (n = 38) dynamic stabilization systems. The study was approved by the Ethics Committee of the Dongzhimen Hospital, Beijing University of Chinese Medicine (No. DZMEC-KY-2019-190, from December 6, 2019).

To evaluate the effectiveness of both systems and their protective impact on ASD, the clinical efficacy and radiological changes of a total of 70 individuals who had the necessary exams over two years were compared. From the original 78 patients, 70 were followed up for more than two years. For the TTL group, L2–3 (1 case), L4–5 (16 cases), and L5–S1 (20 cases) were the particular operated segments, whereas L4–5 (19 cases) and L5–S1 (14 cases) were the specific operated segments for the EVO group. In the EVO group, 28 patients had lumbar disc herniation, 2 had lumbar spinal stenosis, and 3 had lumbar degen-erative spondylolisthesis. In the TTL group, the corresponding numbers were 31, 4, and 2 patients, respectively.

Inclusion criteria were as follows: patients with a definitive diagnosis of single-segment LDD; lumbar spine radiological changes consistent with clinical symptoms and no significant instability (degenerative spondylolisthesis within II°); symptoms not effectively relieved after more than 6 months of conservative treatment; patients who gave their informed consent.

Exclusion criteria included: prior lumbar spine surgery; lumbar spondylolysis and lumbar degenerative spondylolisthesis ≥ II°; severe osteoporosis, ankylosing spondylitis, or other conditions unsuitable for surgery.

Operative procedures

Both patients from the EVO and TTL groups had identical surgical procedures. After successful anesthesia, the patient was placed in a prone position on a lumbar cushion with the abdomen suspended, followed by standard disinfection and sterile draping. The surgeon then incised the skin, subcutaneous tissue, and lumbar fascia layer by layer while assuming the median position of the waist. The spi-

nous processes of the index level and the lamina to the facet joint were exposed by dissecting the bilateral sacral spine muscles. Particular care was taken to preserve the facet joint capsule. Universal pedicle screws were inserted sequentially after identification of the index level using a C-arm X-ray system. The screws were fixed in place to prevent further adjustment after the direction of the screw tip was aligned as close as possible to the end plate of the vertebral body. The spinous process and part of the lamina at the stenotic level of the lumbar spine were then removed using a rongeur. To preserve the facet joint, the hypertrophied ligamentum flavum and hyperplastic epiphysis were carefully excised. The central spinal canal and nerve root canals were fully decompressed using lateral recess decompression. The herniated nucleus pulposus tissue was identified and removed. Unless the affected intervertebral disc was compressing the nerve root, it was not treated. Efforts were made to minimize disruption of the intervertebral space (IVS) at the operative segment. After complete decompression, the surgeon placed the dynamic rod in the appropriate position and tightened the locking bolts. Following adequate hemostasis and irrigation, an epidural drainage tube was placed, and the incision was closed layer by layer.

Clinical and radiologic evaluation

Clinical evaluation included assessment of the visual analog scale (VAS) and Oswestry Disability Index (ODI) scores preoperatively, at 1 and 3 months postoperatively, and at the final follow-up. At the final follow-up, surgical outcomes were also assessed using the modified MacNab criteria. Intraoperative blood loss, operation time, and postoperative complications, such as broken screws and rods, were also recorded.

Radiologic evaluation was performed before the procedure and at the final follow-up using lumbar spine X-rays obtained in the standing lateral and flexion-extension positions. Two radiological parameters were assessed: range of motion (ROM), which is the ratio of the mean heights of the trailing and leading edges of the IVS over the height of the anterior vertebral body (Figure 1a, b) [7], and the IVS ratio (IVSR), which is the ratio of the leading and trailing edges of the IVS over the height of the anterior vertebral body (Figure 1c) [8].

Statistical analysis

Statistical analysis was performed using SPSS version 19.0. The findings were shown as mean ± standard deviation. Quantifiable variables from preoperative and postoperative periods, as well as across the groups, were compared using paired samples *t*-tests or independent samples *t*-tests. Chi-square analysis was used to compare categorical data expressed as absolute counts. Statistical significance was set at $p < 0.05$.

Results

Patient's basic information

Initial operations were successfully performed on all patients. Among them, 33 patients in the EVO group and 37 in the TTL group completed all required evaluations over more than two years of follow-up. No complications, such as implant failure (e.g., screw or rod breakage) or adjacent segment instability or deformity, were observed at the final follow-up. Among the two groups, there were no appreciable variations in gender distribution, mean age, follow-up duration, surgery time, or bleeding volume ($p > 0.05$) (Table 1).

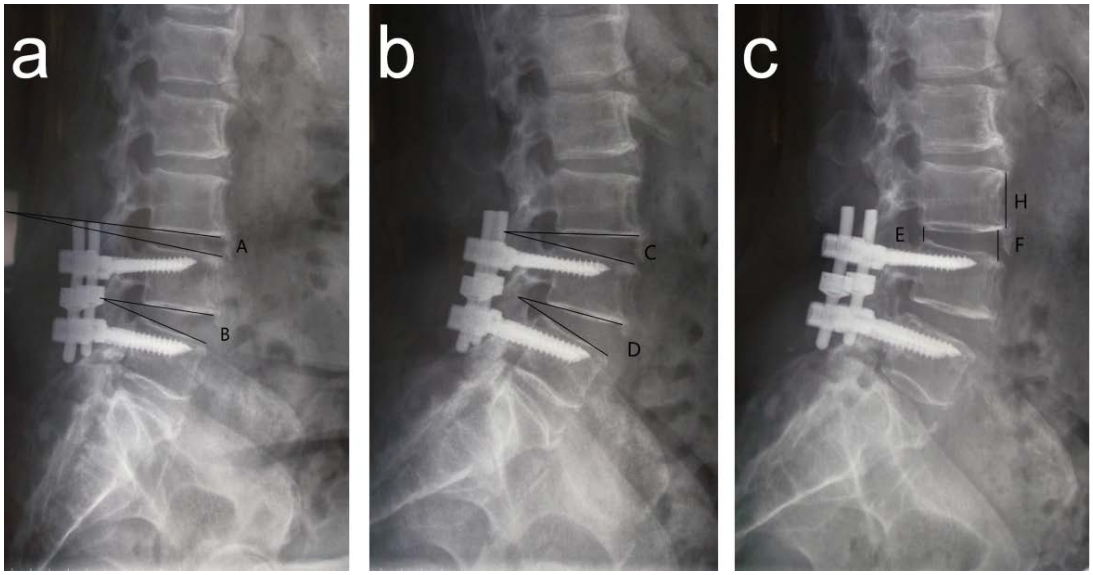

Fig. 1 – Lumbar range of motion (ROM) measurements: the anterior flexion angles (a, b) and the posterior extension angles (c). Dynamic stabilized segment ROM = D - B, adjacent upper segment ROM = C - A. Measurement of intervertebral space ratio (IVSR): F and E correspond to the height of the anterior and posterior intervertebral space, respectively, whereas H represents the height of the anterior upper vertebral body. IVSR = (E+F)/2H. ImageJ software was used in the study to measure angles and heights.

Table 1

Patient's basic information

Variable	Groups		*p*
	TTL (n = 37)	EVO (n = 33)	
Gender			
male	20	14	0.350
female	17	19	
Age, years	47.43 ± 9.63	49.76 ± 9.02	0.306
Surgery time, min.	168.65 ± 25.16	167.58 ± 19.57	0.844
Amount of bleeding, mL	179.19 ± 59.37	172.73 ± 68.57	0.674
Follow-up, months	38.27 ± 4.47	36.42 ± 3.27	0.055

n – number; min. – minutes.
All values are given as numbers or mean ± standard deviation.
***Note*: The chi-square test was used for gender comparison between the two groups; the independent samples *t*-test was used to compare other data between the two groups.**

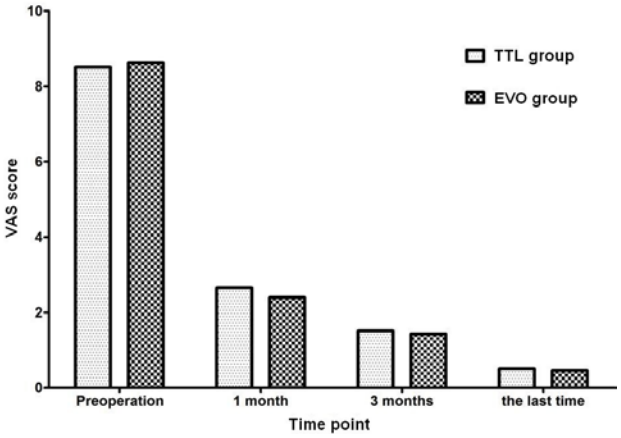

Fig. 2 – Different time points were used to calculate visual analog scale (VAS) values for the TTL and EVO groups.

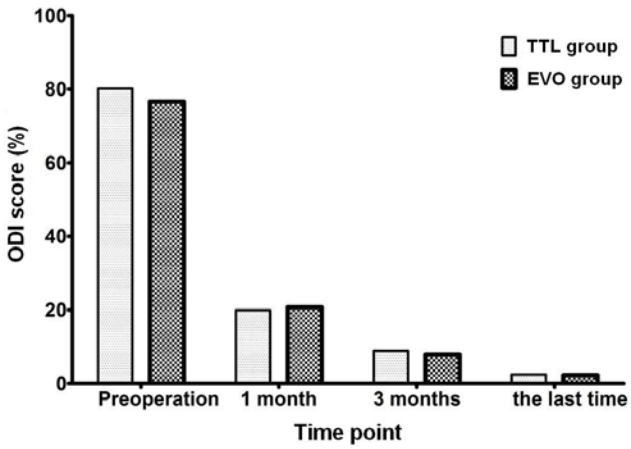

Fig. 3 – Oswestry Disability Index (ODI) scores of TTL and EVO groups at diverse time points.

Table 2

VAS and ODI score variations among the two groups at various time points

Variable	Groups		p_1	p_2	p_3
	TTL (n = 37)	EVO (n = 33)			
VAS (1–10)					
preoperative	8.08 ± 1.19 (5–10)	8.18 ± 1.04 (6–10)	0.709		
1 month postoperative	2.65 ± 1.23 (0–5)	2.39 ± 1.27 (0–5)	0.398	< 0.001	< 0.001
3 months postoperative	1.46 ± 1.32 (0–5)	1.48 ± 1.25 (0–4)	0.935	< 0.001	< 0.001
final follow-up	0.49 ± 0.84 (0–3)	0.48 ± 0.76 (0–3)	0.993	< 0.001	< 0.001
ODI (0–100)					
preoperative	79.43 ± 12.30 (46–98)	77.21 ± 20.95 (37.78–100)	0.586		
1 month postoperative	19.78 ± 5.75 (8.89–33.33)	20.99 ± 6.94 (11.11–40)	0.429	< 0.001	< 0.001
3 months postoperative	8.57 ± 3.98 (0–17.78)	8.17 ± 5.73 (0–22.22)	0.733	< 0.001	< 0.001
final follow-up	2.32 ± 3.18 (0–11.11)	2.44 ± 3.79 (0–15.56)	0.887	< 0.001	< 0.001

VAS – visual analog scale; ODI – Oswestry Disability Index; n – number.
All values are given as mean ± standard deviation (range).
***Note*: p_1 is a comparison between the TTL group and EVO group at the same time, using an independent samples *t*-test; p_2 is compared with preoperative in the TTL group, using a paired samples *t*-test; p_3 is correlated with preoperative in the EVO group, using a paired samples *t*-test.**

Changes in the visual analog scale score and Oswestry Disability Index score in patients

The VAS and ODI ratings in both groups significantly improved postoperatively compared to preoperative levels ($p < 0.05$) (Figures 2 and 3). Throughout the whole trial, there were no discernible differences between the two groups at any time intervals (preoperatively, 1 and 3 months postoperatively, and at the final follow-up) ($p > 0.05$) (Table 2).

Evaluation of the efficacy of surgery using modified MacNab measures

At the most recent follow-up, the surgical effectiveness of the TTL and EVO groups was judged as outstanding or good using the modified MacNab criteria (91.89% and 93.94%, respectively). There was no discernible difference between the two groups ($p = 0.933$) (Table 3).

Radiologic evaluation results

In both groups, the ROM of the surgically treated segments at the final follow-up was significantly lower than preoperative values (TTL: 6.82 ± 1.46°; EVO: 6.59 ± 1.85°). However, the ROM of the EVO group was substantially greater than that of the TTL group (4.46 ± 1.19° vs. 2.58 ± 0.71°) ($p < 0.05$). In both groups, the ROM of adjacent segments at the final follow-up was significantly higher than the preoperative values (TTL: 4.98 ± 1.12°; EVO: 4.87 ± 1.37°). Additionally, the TTL group exhibited a significantly greater ROM of adjacent segments (6.74 ± 1.55°) compared with the EVO group (5.83 ± 1.32°) ($p < 0.05$). There were no statistically significant intragroup changes in IVSR at either the operated or adjacent levels between the preoperative assessment and the final follow-up ($p > 0.05$). No significant differences were observed between the groups (Table 4).

Discussion

The safety and efficacy of fusion surgery, especially for spinal surgery, have been shown in several clinical investigations, where fusion has become a major surgical treatment option. However, it has also been well recognized that the subsequent increase of the stress load after fusion surgery at the adjacent segments may lead to an increased risk of ASD [9–13]. In a follow-up research, Liu et al. [14] discovered that the incidence of ASD following lumbar non-flexible fusion was 13.6%. A separate study of 101 patients with posterior lumbar interbody fusion surgery showed that ASD mainly occurred in the upper adjacent segments [15]. In the attempt to avoid an increase of biomechanical stress at the adjacent segments and prevent ASD, multiple dynamic stabilization systems utilizing posterior pedicle screws, such as the Graf, Dynesys, Cosmic, Isobar TLL, CD Horizon Agile, NFlex, AXIENT, Accuflex rod, PEEK rod, Stabilimax NZ systems have been developed [16].

Table 3

Comparison of the modified MacNab's effectiveness in both groups

Variable	Groups	
	TTL (n = 37)	EVO (n = 33)
Excellent	28 (75.68)	26 (78.79)
Good	6 (16.22)	5 (15.15)
Fair	3 (8.11)	2 (6.06)
Poor	0 (0)	0 (0)
Excellent or good, %	91.89	93.94
χ^2	0.138	
p	0.933	

n – number.
All values are given as numbers (percentages).
***Note*: The chi-square test was used for data comparison between the two groups.**

Table 4

Comparisons of ROM and IVSR of the operated and adjacent segments between the TTL and EVO groups

Variable	Groups		p_1	p_2	p_3
	TTL (n = 37)	EVO (n = 33)			
Operated segment					
ROM, °					
preoperative	6.82 ± 1.46 (5.03–11.23)	6.59 ± 1.85 (2.94–10.28)	0.564		
last follow-up	2.58 ± 0.71 (1.25–4.25)	4.46 ± 1.19 (2.55–7.55)	0.000	0.000	0.000
IVSR, %					
preoperative	36.91 ± 6.06 (22.34–47.56)	37.40 ± 9.21 (19.95–53.63)	0.791		
last follow-up	36.74 ± 8.81 (20.83–58.33)	37.73 ± 7.91 (21.69–58.63)	0.624	0.841	0.653
Adjacent segment					
ROM, °					
preoperative	4.98 ± 1.12 (3.13–8.48)	4.87 ± 1.37 (2.19–7.85)	0.705		
last follow-up	6.74 ± 1.55 (4.17–11.47)	5.83 ± 1.32 (4.03–9.69)	0.011	0.000	0.000
IVSR, %					
preoperative	40.82 ± 6.77 (27.55–57.22)	41.58 ± 6.78 (28.45–55.84)	0.637		
last follow-up	39.76 ± 7.49 (25.28–56.51)	41.03 ± 6.95 (27.76–56.14)	0.465	0.054	0.322

ROM – range of motion; IVSR – intervertebral space ratio.
All values are given as mean ± standard deviation (range).
***Note*: p_1 is a comparison between the TTL group and EVO group at the same time, using an independent samples *t*-test; p_2 is correlated with preoperative in the TTL group, using a paired samples *t*-test; p_3 is compared with preoperative in the EVO group, using a paired samples *t*-test.**

The load transfer behavior of the operated segment appears to resemble the physiological process with micromotion pedicle screw systems more than with rigid fixation, thereby reducing the stress load on the pedicle screw. These systems have the potential to prevent degeneration of the adjacent segmental intervertebral disc and lumbar facet joint, as well as alleviate pseudoarthrosis, osteoporosis, and additional mechanical damage [17–20].

Despite the above advantages, new issues related to the application of dynamic stabilization have emerged. Twenty-two individuals with PEEK rod lumbar fusion participated in a 2-year follow-up study by Oikonomidis et al. [21] which found that implant failure occurred in 4 patients, and 3 patients developed ASD in the upper neck. According to research, the Dynesys system's ability to maintain mobility may increase the risk of internal fixation, and the ROM of the operated segment gradually decreased, with unexpected small joint fusion occurring during follow-up [22, 23]. According to Peng and Gao [24], the Dynesys dynamic stabilization device should be chosen over fusion surgery for lumbar degenerative illnesses, although it is too soon to draw that conclusion.

Previous reports suggested that the Isobar TTL system may have the potential to delay ASD, improve pain relief and quality of life in patients with LDD, and have excellent long-term clinical and radiological results [25].

However, as reported in a systematic review, the existing research evidence is insufficient to demonstrate that the Isobar semi-rigid system has better clinical efficacy compared to titanium rods [26]. The three-dimensional mobility of the Isobar rod is only ± 2°, which is significantly lower than the physiological mobility of the lumbar segments [27]. Therefore, it is not surprising that some patients treated with the Isobar TTL system still develop ASD. A study using magnetic resonance imaging (MRI) to identify ASD reported an incidence of more than 39% (14/37) among patients undergoing Isobar TTL treatment [4]. It should be noted that the high resolution of MRI images may have enhanced the sensitivity in the detection of disc degeneration and thus contributed to the higher reported rate of ASD in that study.

The Isobar EVO system is designed to protect adjacent segments while preventing the development of ASD by allowing greater motion at the operated segment, thereby more closely simulating normal biomechanical characteristics. A related study has shown the potential of the Isobar EVO system to maintain the mobility of operated segments and to prevent further degradation of adjacent segments [6].

Published clinical trials have shown that using the Isobar TTL dynamic stabilization device to treat lumbar disc herniation reduces pain successfully (VAS score), improves lumbar function (ODI and Japanese Orthopaedic Association score), and reduces inflammatory markers such as C-reactive protein, interleukin-6, and tumor necrosis factor-α levels in serum [27, 28]. Our current study also showed significant early improvements observed in VAS and ODI scores at 30 days postoperatively in both groups of patients. Moreover, the above scores decreased further during subsequent follow-up. The VAS and ODI scores, however, did not differ significantly between the TTL and EVO groups at 1 month, 3 months, or at the final follow-up, indicating that both dynamic fixation systems successfully reduce symptoms and enhance patients' day-to-day functioning and capacity for work for at least 2 years. Both methods yielded excellent clinical outcomes over the study period, as evidenced by high excellent/good evaluations based on the modified MacNab criteria for both groups at the final follow-up (91.89% for the TTL group and 93.94% for the EVO group). These recent findings suggest that the two systems performed similarly in clinical outcomes.

According to Qian et al. [7], the ROM of the operated segment was 3.46 ± 1.02° preoperatively and 2.25 ± 0.79° at 12 months postoperatively in patients treated with the Isobar TTL dynamic internal stabilization system ($p > 0.05$). According to these authors, the Isobar TTL system could successfully maintain the mobility of operational sections. In our investigation, the ROM of the adjacent segments increased, whereas the ROM of the operated segments decreased at the final follow-up in both groups. Although the ROM of the operated segments in the EVO group (4.46 ± 1.19°) was greater than that in the TTL group (2.58 ± 0.71°), the ROM of adjacent segments in the EVO group (5.83 ± 1.32°) was lower compared to that of the TTL group (6.74 ± 1.55°). These findings indicate that both systems can only partially retain mobility in the operated segments, and that the increase in mobility at adjacent segments cannot be completely avoided. However, the compensatory increase in mobility of the adjacent segments by the Isobar EVO system was less severe and may be beneficial in reducing the risk of ASD.

Chou et al. [12] compared the "topping-off" technique (dynamic stabilization or less rigid fixation) with firm fusion fixation. They found that the firm fusion was associated with higher rates of degeneration in the two adjacent segments detected by X-ray (52.6%), symptom occurrence (11.6%), and secondary surgery (8.1%). When supra-ASD was detected by X-ray in the hybrid fixation group, it occurred at a lower rate (10.5%) than in the firm fusion cohort (24.7%). Thus, the scientists concluded that "topping-off" technology might significantly reduce the incidence of ASD.

In a comparison of the Isobar TTL system as well as a firm fixation system, Gao et al. [29] discovered that the apparent diffusion coefficient value of the dynamic fixation category was considerably better than that of the firm fixation group. This finding suggests that the Isobar TTL dynamic fixation system may be able to successfully prevent or delay intervertebral disc degeneration. In another study, Zhou et al. [30] discovered no significant differences in the relative grey-scale values of contiguous intervertebral discs in the Isobar TTL dynamic stabilization segment before and after surgery (23.98 ± 8.86 and 22.22 ± 6.25, respectively; $p = 0.46$). The authors concluded that this system might prevent the progression of ASD. In this manuscript, the IVS height ratio values at the final follow-up for the operated and adjacent segments were not significantly different from preoperative values in both groups. This indicates that both techniques were successful in preserving the IVS heights of the operative segment and preventing ASD. No significant difference in the IVS height ratio for the operated adjacent segments was observed between the two groups at the final follow-up. Therefore,

whether the two systems may perform differently in preventing ASD in the long run remains to be assessed.

Limitations of the study

We found no implant-related complications, such as screw loosening, screw breakage, or rod fracture, in patients treated with either system. Since the follow-up time was relatively short, the higher degree of mobility associated with the Isobar EVO system may lead to increased demands for repair of screws and rods. Whether the screws and rods can withstand the long-term clinical test remains to be evaluated. In addition, the sample size in this study was relatively small, and individual variability may have influenced the results. Larger studies are needed to further validate the clinical effectiveness of the Isobar EVO system and its impact on adjacent segments. Despite using the IVSR to assess the prevalence of ASD, previous research has shown that vertebral height is negatively correlated with age and follow-up duration [31]. The reliability of the IVS height ratio as a marker to assess the degeneration of the intervertebral disc may be affected, even if it may not be a severe problem in this short-term investigation.

It has been confirmed in relevant studies that using MRI to evaluate the intervertebral disc height index and Pfirrmann grading of intervertebral disc degeneration is a preferable option [32, 33].

Conclusion

The clinical efficacy of the Isobar TTL and Isobar EVO dynamic internal stabilization systems was satisfactory in the short term. Both systems partially retained the mobility of the operated segment and maintained the height of the intervertebral space of both the operated and the adjacent segments. More importantly, the Isobar EVO system restored the mobility of the operated segment to a greater extent than the Isobar TTL system. Therefore, the Isobar EVO system may have the potential to further reduce the risk of adjacent segment degeneration.

Conflicts of interest

The authors declare no conflict of interest.

Acknowledgement

The authors appreciate the amenities provided by the institution.

Funding

The Ministry of Education's "New Century Excellent Talents" Support Program provided funding for the study (NCET-10-0249).

R E F E R E N C E S

1. *Ajiboye LO, Alimi M, Gbadegesin SA, Oboirien M.* Treatment outcome of quality of life and clinical symptoms in patients with symptomatic lumbar degenerative disc diseases: which treatment modality is superior? Int Orthop 2019; 43(4): 875–81. DOI: 10.1007/s00264-018-4248-5.
2. *Chiloiro G, Meldolesi E, Giraffa M, Capocchiano ND, Barbaro B, Coco C,* et al. Could the conservative approach be considered safe in the treatment of locally advanced rectal cancer in case of a clinical near-complete or complete response? A retrospective analysis. Clin Transl Radiat Oncol 2021; 28: 1–9. DOI: 10.1016/j.ctro.2021.02.009.
3. *Ji ZS, Yang H, Yang YH, Li SJ, Luo JX, Zhang GW,* et al. Analysis of clinical effect and radiographic outcomes of Isobar TTL system for two-segment lumbar degenerative disease: a retrospective study. BMC Surg 2020; 20(1): 15. DOI: 10.1186/s12893-020-0680-8.
4. *Li Z, Li F, Yu S, Ma H, Chen Z, Zhang H,* et al. Two-year follow-up results of the Isobar TTL Semi-Rigid Rod System for the treatment of lumbar degenerative disease. J Clin Neurosci 2013; 20(3): 394–9. DOI: 10.1016/j.jocn.2012.02.043.
5. *Bredow J, Löhrer L, Oppermann J, Scheyerer MJ, Sobottke R, Eysel P,* et al. Pathoanatomic Risk Factors for Instability and Adjacent Segment Disease in Lumbar Spine: How to Use Topping off? Biomed Res Int 2017; 2017: 2964529. DOI: 10.1155/2017/2964529.
6. *Guan J, Liu T, Feng N, Jiang G, Li W, Yang K,* et al. Comparison between single-segment Isobar EVO dynamic stabilization and Isobar TTL dynamic stabilization in the treatment of lumbar degenerative diseases: a single center retrospective study over 4 years. BMC Musculoskelet Disord 2022; 23(1): 998. DOI: 10.1186/s12891-022-05913-6.
7. *Qian J, Bao Z, Li X, Zou J, Yang H.* Short-Term Therapeutic Efficacy of the Isobar TTL Dynamic Internal Fixation System for the Treatment of Lumbar Degenerative Disc Diseases. Pain Physician 2016; 19(6): 853–61.
8. *Sasani M, Aydin AL, Oktenoglu T, Cosar M, Ataker Y, Kaner T,* et al. The combined use of a posterior dynamic transpedicular stabilization system and a prosthetic disc nucleus device in treating lumbar degenerative disc disease with disc herniations. SAS J 2008; 2(3): 130–6. DOI: 10.1016/SASJ-2008-0008-NT.
9. *Umehara S, Zindrick MR, Patwardhan AG, Havey RM, Vrbos LA, Knight GW,* et al. The biomechanical effect of postoperative hypolordosis in instrumented lumbar fusion on instrumented and adjacent spinal segments. Spine (Phila Pa 1976) 2015; 25(13): 1617–24. DOI: 10.1097/00007632-200007010-00004.
10. *Hilibrand AS, Carlson GD, Palumbo MA, Jones PK, Bohlman HH.* Radiculopathy and myelopathy at segments adjacent to the site of a previous anterior cervical arthrodesis. J Bone Joint Surg Am 1999; 81(4): 519–28. DOI: 10.2106/00004623-199904000-00009.
11. *Veeravagu A, Cole T, Jiang B, Ratliff JK.* Revision rates and complication incidence in single- and multilevel anterior cervical discectomy and fusion procedures: an administrative database study. Spine J 2014; 14(7): 1125–31. DOI: 10.1016/j.spinee.2013.07.474.
12. *Chou PH, Lin HH, An HS, Liu KY, Su WR, Lin CL.* Could the Topping-Off Technique Be the Preventive Strategy against Adjacent Segment Disease after Pedicle Screw-Based Fusion in Lumbar Degenerative Diseases? A Systematic Review. Biomed Res Int 2017; 2017: 4385620. DOI: 10.1155/2017/4385620.
13. *Kundu B, Eli I, Dailey A, Shah LM, Mazur MD.* Preoperative Magnetic Resonance Imaging Abnormalities Predict Symptomatic Adjacent Segment Degeneration After Anterior Cervical Discectomy and Fusion. Cureus 2021; 13(8): e17282. DOI: 10.7759/cureus.17282.

14. *Liu ZZ, Zhang ZM, Jin DD.* Factors affecting adjacent segment degeneration after rigid lumbar internal fixation. Nan Fang Yi Ke Da Xue Xue Bao 2010; 30(5): 1134–7. (Chinese)
15. *Nakashima H, Kawakami N, Tsuji T, Ohara T, Suzuki Y, Saito T,* et al. Adjacent segment disease after posterior lumbar interbody fusion: based on cases with a minimum of 10 years of follow-up. Spine (Phila Pa 1976) 2015; 40(14): E831–41. DOI: 10.1097/BRS.0000000000000917.
16. *Kaner T, Ozer AF.* Dynamic stabilization for challenging lumbar degenerative diseases of the spine: a review of the literature. Adv Orthop 2013; 2013: 753470. DOI: 10.1155/2013/753470.
17. *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. DOI: 10.1016/j.wneu.2018.02.192.
18. *Liu C, Kamara A, Yan Y.* Investigation into the biomechanics of lumbar spine micro-dynamic pedicle screw. BMC Musculoskelet Disord 2018; 19(1): 231. DOI: 10.1186/s12891-018-2132-5.
19. *Barrey C, Perrin G, Champain S.* Pedicle-Screw-Based Dynamic Systems and Degenerative Lumbar Diseases: Biomechanical and Clinical Experiences of Dynamic Fusion with Isobar TTL. IVSRN Orthop 2013; 2013: 183702. DOI: 10.1155/2013/183702.
20. *Sengupta DK.* Dynamic stabilization devices in the treatment of low back pain. Orthop Clin North Am 2004; 35(1): 43–56. DOI: 10.1016/S0030-5898(03)00087-7.
21. *Oikonomidis S, Ashqar G, Kaulhausen T, Herren C, Sieve J, Sobottke R.* Clinical experiences with a PEEK-based dynamic instrumentation device in lumbar spinal surgery: 2 years and no more. J Orthop Surg Res 2018; 13(1): 196. DOI: 10.1186/s13018-018-0905-z.
22. *Tu J, Hua W, Li W, Liu W, Luo R, Li S,* et al. Short-term effects of minimally invasive dynamic neutralization system for the treatment of lumbar spinal stenosis: An observational study. Medicine (Baltimore) 2018; 97(22): e10854. DOI: 10.1097/MD.0000000000010854.
23. *Yeh MY, Kuo CH, Wu JC, Huang WC, Tu TH, Fay LY,* et al. Changes of Facet Joints After Dynamic Stabilization: Continuous Degeneration or Slow Fusion? World Neurosurg 2018; 113: e45–50. DOI: 10.1016/j.wneu.2018.01.148.
24. *Peng BG, Gao CH.* Is Dynesys dynamic stabilization system superior to posterior lumbar fusion in the treatment of lumbar degenerative diseases? World J Clin Cases 2020; 8(22): 5496–500. DOI: 10.12998/wjcc.v8.i22.5496.
25. *Li J, Li Q, Deng Z, Wang L, Wang L, Song Y.* Long-term Outcome of Isobar TTL System for the Treatment of Lumbar Degenerative Disc Diseases. Orthop Surg 2024; 16(4): 912–20. DOI: 10.1111/os.14025.
26. *Guan J, Liu T, Yu X, Li W, Feng N, Jiang G,* et al. Biomechanical and clinical research of Isobar semi-rigid stabilization devices for lumbar degenerative diseases: a systematic review. Biomed Eng Online 2023; 22(1): 95. DOI: 10.1186/s12938-023-01156-1.
27. *Zeng J, Liu H, Wang B, Gong Q, Yang Y, Chen H,* et al. Clinical outcome of ISOBAR TTL dynamic stabilization with pars bone grafting for treatment of lumbar spondylolysis. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi 2017; 31(1): 62–5. (Chinese) DOI: 10.7507/1002-1892.201609104.
28. *Liu YL, Yang H, Zhang M, Ruan TC, Li PF, Xiong YJ,* 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(3): 188–92. (Chinese) DOI: 10.3760/cma.j.issn.0376-2491.2019.03.007.
29. *Gao J, Zhao W, Zhang X, Nong L, Zhou D, Lv Z,* et al. MRI analysis of the ISOBAR TTL internal fixation system for the dynamic fixation of intervertebral discs: a comparison with rigid internal fixation. J Orthop Surg Res 2014; 9: 43. DOI: 10.1186/1749-799X-9-43.
30. *Zhou Q, Shi R, Kopjar B, Wang H, Chen D, Li H,* et al. Adjacent Intervertebral Disc Changes in Patients with Isobar Semirigid Dynamic Stabilization System. Global Spine J 2017; 4 (1_suppl): s-0034-1376699. DOI:10.1055/s-0034-1376699.
31. *Paholpak P, Wang Z, Sakakibara T, Kasai Y.* An increase in height of spinous process is associated with decreased heights of intervertebral disc and vertebral body in the degenerative process of lumbar spine. Eur Spine J 2013; 22(9): 2030–4. DOI: 10.1007/s00586-013-2764-y.
32. *Mallio CA, Vadalà G, Russo F, Bernetti C, Ambrosio L, Zobel BB,* et al. Novel Magnetic Resonance Imaging Tools for the Diagnosis of Degenerative Disc Disease: A Narrative Review Diagnostics (Basel) 2022; 12(2): 420. DOI: 10.3390/diagnostics12020420.
33. *Sun Y, Guan J, Chen H, Sun X, Yang K, Fang Q.* The value of fixed segment mobility in posterior dynamic stabilization: a single-center retrospective study. BMC Musculoskelet Disord 2025; 26(1): 96. DOI: 10.1186/s12891-025-08333-4.

Received on April 18, 2025
Revised on October 30, 2025
Revised on January 19, 2026
Accepted on January 28, 2026
Online First April 2026