

New combination of IntraSPINE device and posterior lumbar interbody fusion for rare skipped-level lumbar disc herniation: a case report and literature review

Journal of International Medical Research

48(8) 1–9

© The Author(s) 2020

Article reuse guidelines:

sagepub.com/journals-permissions

DOI: 10.1177/0300060520949764

journals.sagepub.com/home/imr

Shitong Feng*, Zihan Fan*, Jiashuai Ni,
Yong Yang[#] and Qi Fei[#]

Abstract

Posterior lumbar interbody fusion is an open surgical technique that has been widely used for the treatment of degenerative lumbar disease. However, traditional lumbar spinal fusion, especially long-segment fusion surgery, is associated with several complications. The IntraSPINE (Cousin Biotech, Wervicq-Sud, France) is a new device for non-fusion lumbar spine surgery that is used as an alternative for the treatment of degenerative lumbar disease. Although the designer of the IntraSPINE proposed indications for its use, including combination of the device with lumbar spinal fusion for the treatment of degenerative lumbar disease, use of the IntraSPINE has not been reported in the clinical literature. In the present case, we boldly combined the IntraSPINE device and posterior lumbar interbody fusion for the treatment of skipped-level lumbar disc herniation to explore the indications of the IntraSPINE and report its clinical outcomes.

Keywords

IntraSPINE, PLIF, posterior lumbar interbody fusion, skipped-level disc herniation, indications, clinical outcomes

Date received: 25 April 2020; accepted: 23 July 2020

*These authors contributed equally to this work.

[#]These author contributed equally to this work.

Corresponding author:

Yong Yang, Department of Orthopaedics, Beijing Friendship Hospital, Capital Medical University, Yong'an Road 95, Xicheng District, Beijing 100050, People's Republic of China.

Email: spineyang@126.com

Department of Orthopaedics, Beijing Friendship Hospital, Capital Medical University, Beijing, China



Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (<https://creativecommons.org/licenses/by-nc/4.0/>) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

Introduction

Posterior lumbar interbody fusion (PLIF) has been widely used for the treatment of various degenerative lumbar diseases because of its biomechanical stability and high rates of successful fusion.¹ However, complications after lumbar spinal fusion, including lumbar motor dysfunction, lumbar stiffness, and intractable low back pain, have been recently reported.² Notably, adjacent segment disease (ASD) is considered one of the most serious long-term complications of spinal arthrodesis.³ Clinical research has shown that the incidence of ASD ranges from 3.9% to 41.0%⁴; using only radiographic criteria, however, the incidence ranges from 8% to 100%.^{5,6}

Skipped-level disc degeneration (SLDD) is the unique occurrence of lumbar disc degeneration with healthy/normal discs between degenerated discs on magnetic resonance imaging (MRI).⁷ The underreporting of SLDD in the literature throughout the years indirectly suggests that this pattern of disc degeneration is less symptomatic than contiguous multilevel disc degeneration.⁸ The surgical techniques used for contiguous multilevel disc degeneration may not be suitable for SLDD.

Considering the potential complications after lumbar spinal fusion, non-fusion lumbar spine surgery is becoming a research hotspot. Tachibana et al.⁹ proposed that non-fusion devices that provide dynamic stabilization might offer new solutions for prevention of ASD. Different kinds of non-fusion devices for dynamic stabilization, including Wallis, Isobar, Coflex, and X-Stop, have been reported.¹⁰ However, all of these are interspinous devices rather than interlaminar devices.

The IntraSPINE (Cousin Biotech, Wervicq-Sud, France) is a new interlaminar dynamic stabilization device that was designed by Giancarlo Guizzardi and first used in the clinical setting in 2007. The core

material of the IntraSPINE is flexible medical silica gel, and the surface material is polyester fiber, which can enlarge the foramina, relieve the pressure on facets and discs, and stabilize the spine without sacrificing its natural motion (Figure 1). In his report, Guizzardi¹¹ stated that the indications for use of the IntraSPINE were low back pain caused by disc degeneration, lumbar instability, young patients after lumbar discectomy, and chronic low back pain caused by zygapophyseal joint syndromes, among others. Although the indications for the IntraSPINE were proposed by the designer, some of them (e.g., back pain caused by disc degeneration and combination of the device with lumbar spinal fusion) have not been reported in the clinical literature.

In the present case report, we describe a patient with lumbar SLDD who underwent treatment with a combination of the IntraSPINE device and PLIF. This case report may help in exploring new indications for IntraSPINE that have been infrequently discussed in the literature.

Case presentation

A 64-year-old woman presented with a 10-year history of lumbago. Her symptoms had worsened during the most recent 6 months, with radiating pain in the front aspect of both thighs and posterolateral aspect of both shanks. She also exhibited intermittent neurogenic claudication while walking within 100 m. Preoperative physical examination demonstrated normal results of the bilateral femoral nerve stretch test and bilateral straight leg raise test. The patient also had hypesthesia, which was mainly distributed in the front aspect of both thighs, posterolateral aspect of both shanks, and both soles. Her bilateral muscle strength and sensation were normal, as were her bilateral patellar reflexes and Achilles tendon reflexes.

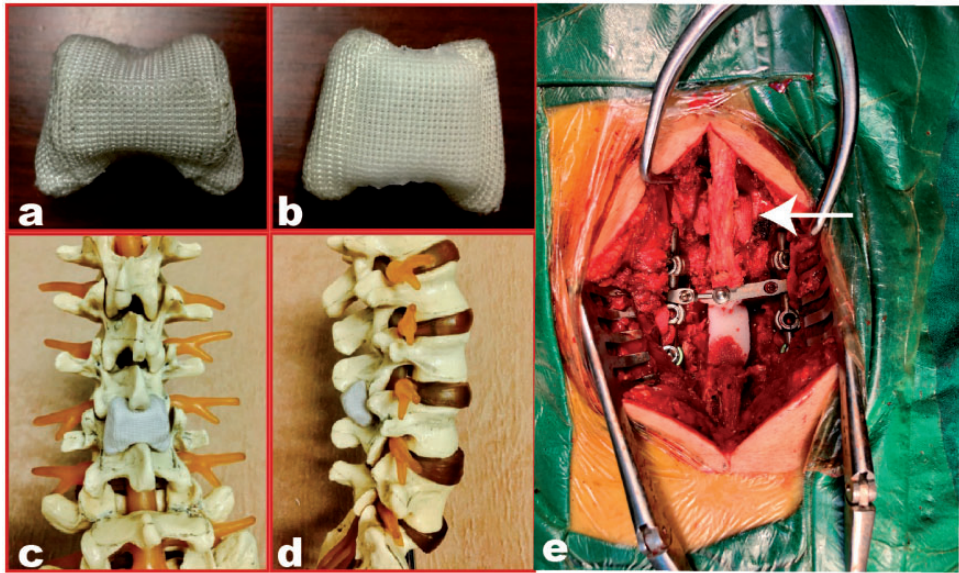


Figure 1. (a) Dorsal surface of IntraSPINE. (b) Ventral surface of IntraSPINE. (c, d) Placement location of IntraSPINE in the spine model. (e) Intraoperative image. The arrow indicates the location of the IntraSPINE.

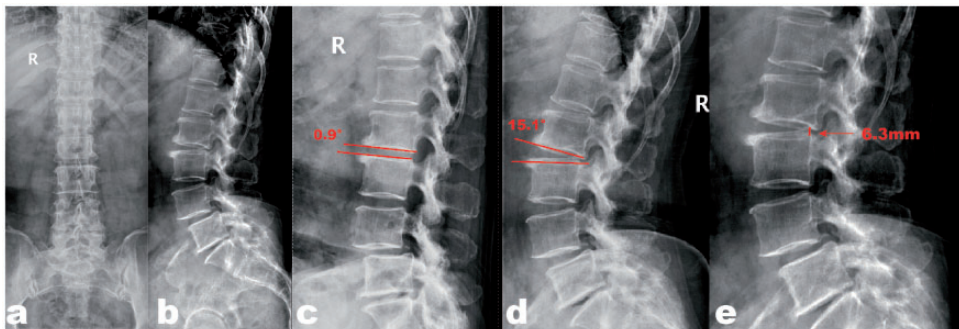


Figure 2. Preoperative X-ray examination. (a–d) Preoperative dynamic X-ray examination indicated instability of the L4–5 vertebral body. The range of motion at the L2–3 level was 14.2° ($15.1^\circ - 0.9^\circ = 14.2^\circ$). (e) The posterior disc height at the L2–3 level was 6.3 mm.

Dynamic X-ray imaging of the lumbar spine confirmed instability of the L4–5 disc space, and the posterior disc height (PDH) at the L2–3 level was 6.3 mm. The range of motion at the L2–3 level was 14.2° , showing instability ($>11^\circ$) in the L2–3 motion segment (Figure 2). T2- and T1-weighted sagittal MRI of the lumbar region showed lumbar canal stenosis at the L2–3, L4–5, and L5–S1 levels. T2-weighted axial images

showed marked stenosis at the L2–3, L4–5, and L5–S1 levels (Figure 3). The patient was finally diagnosed with lumbar disc herniation (L2–3, L4–5, and L5–S1), lumbar spinal stenosis, and lumbar spondylolisthesis (L4–5).

Preoperative L3 nerve root blockade was performed to confirm whether the L2–3 level was the responsible segment. The radiating pain in the front aspect of both thighs

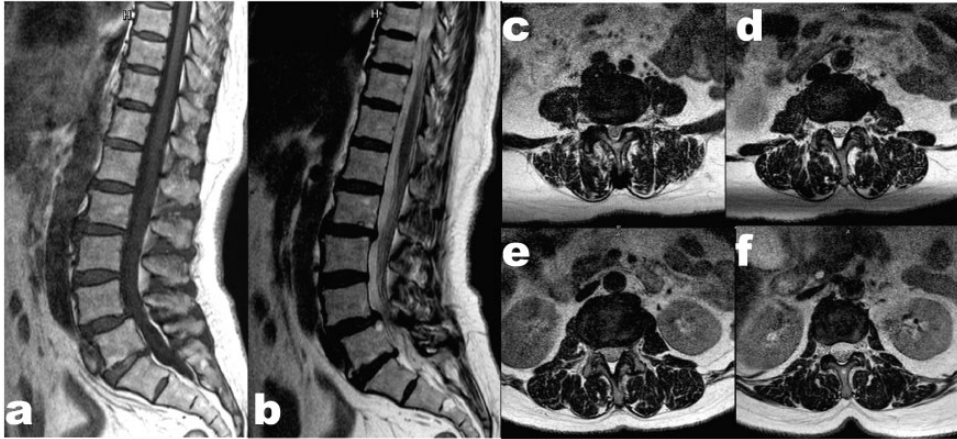


Figure 3. Preoperative magnetic resonance imaging (MRI). (a, b) T2- and T1-weighted sagittal MRI of the lumbar region showed lumbar canal stenosis at the L2–3, L4–5, and L5–S1 levels. (c–f) T2-weighted axial images showed marked stenosis at the L2–3, L4–5, and L5–S1 levels. The width of the L3–4 lumbar canal was acceptable. (a): T1-weighted MRI. (b) T2-weighted MRI. (c) L2–3 level. (d) L3–4 level. (e) L4–5 level. (f) L5–S1 level.

was relieved after the L3 nerve root blockade; i.e., the L2–3 level was verified as the responsible segment requiring treatment.

After obtaining an accurate diagnosis, the patient underwent PLIF with decompression at the L4–5 and L5–S1 segments, internal fixation with a pedicle screw system, and fusion with a bone graft. To ensure a satisfying outcome of decompression, we destructed the lamina and facet joint, which necessitated destruction of the posterior column integrity at the L5–S1 level. Thus, we performed fixation and fusion at the L5–S1 level. At the L2–3 segment, we implanted the IntraSPINE device without decompression.

Preoperatively, the visual analog scale (VAS) score for lower back pain was 7 points and that for both lower limbs was 8 points. Postoperatively, the VAS score for lower back pain was 3 points and that for both lower limbs was 2 points. The patient was encouraged to exercise her lower back muscles on the bed after the drainage tube was removed 2 days postoperatively. When her muscle strength had

recovered, the patient was requested to stand and walk with the help of a brace 5 days postoperatively. Three months after the operation, the patient's back pain, radiating pain of both lower limbs, and neurogenic claudication symptoms had completely disappeared. The hypesthesia of the front aspect of both thighs, posterolateral aspect of both shanks, and both soles was also relieved to some degree.

Postoperative X-ray and computed tomography examinations revealed that the pedicle screw system used for internal fixation was in the pedicle area and that the location of the IntraSPINE device was suitable. As shown in Figure 4(e), the anterior part of the IntraSPINE was attached to the ligamentum flavum, which effectively enlarged the interlaminar space. The PDH at the L2–3 level was 7.1 mm (Figure 4).

Fourteen months after the operation, follow-up X-ray examination showed that the location of the IntraSPINE in the L2–3 segment had not moved and that the PDH at the L2–3 level was 7.0 mm. The range of motion at the L2–3 level was 7.1°, which

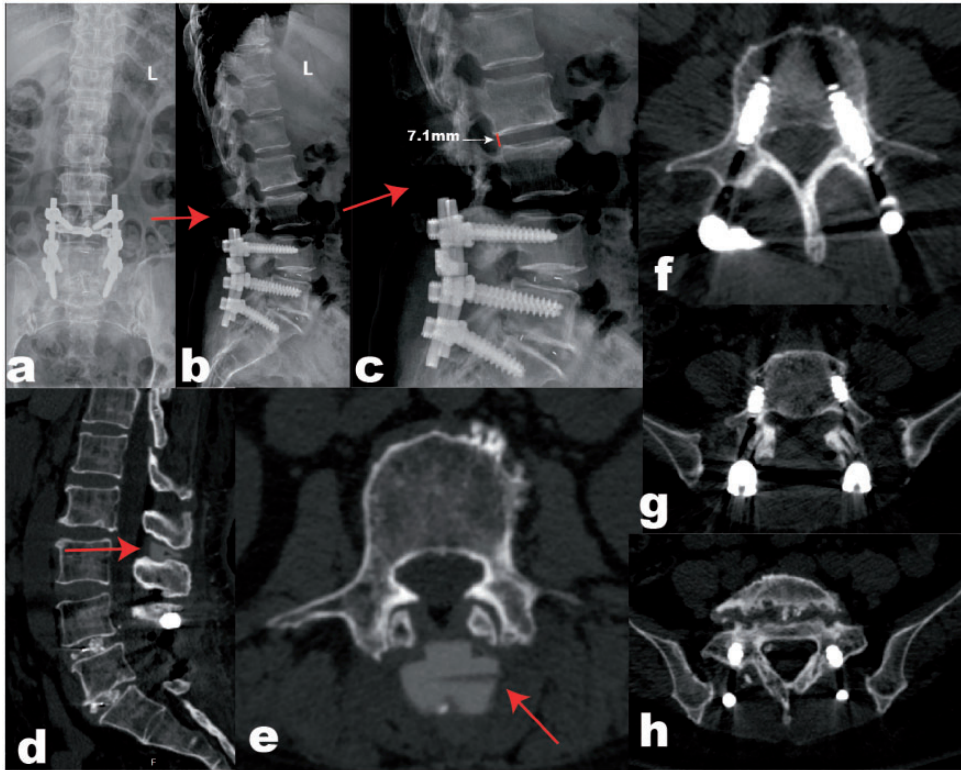


Figure 4. Postoperative (a–c) X-ray and (d–h) computed tomography (CT) examinations revealed that the pedicle screw system used for internal fixation was in the pedicle area, that the location of the IntraSPINE was suitable, and the posterior disc height at the L2–3 level was 7.1 mm. The red arrow indicates the location of the IntraSPINE. (a) Frontal X-ray views. (b). Lateral X-ray views. (c) The posterior disc height at the L2–3 level was 7.1 mm. (d) Sagittal CT. (e) Axial CT at the L2–3 level showed that the location of the IntraSPINE was suitable. (f) L4 vertebral body. (g) L5 vertebral body. (h) S1 vertebral body.

indicated instability ($>11^\circ$) before the operation. MRI showed disc degeneration at the L2–3 level without obvious aggravation (Figure 5).

Discussion

The unique occurrence of noncontiguous disc degeneration or SLDD of the lumbar spine, which is characterized by healthy/normal discs between degenerated discs on MRI, has been previously described.⁷ The reported prevalence of SLDD is 8.1% and 20.0% in the overall population and among individuals with multilevel disc

degeneration, respectively.¹² Certainly, PLIF is the optimal solution for the treatment of SLDD.

However, complications of PLIF have been reported, such as massive trauma, excessive bleeding, and extensive posterior column destruction of the spine.¹³ Fan et al.¹⁴ reported that PLIF requires a much higher load to maintain lumbar stability than do non-fusion techniques, thus increasing the incidence of ASD. Cheh et al.¹⁵ considered that the length of fusion is a significant risk factor for the development of ASD, and the risk of fusion up to the L1–3 level was higher than that at L4 and L5 in their 5-year

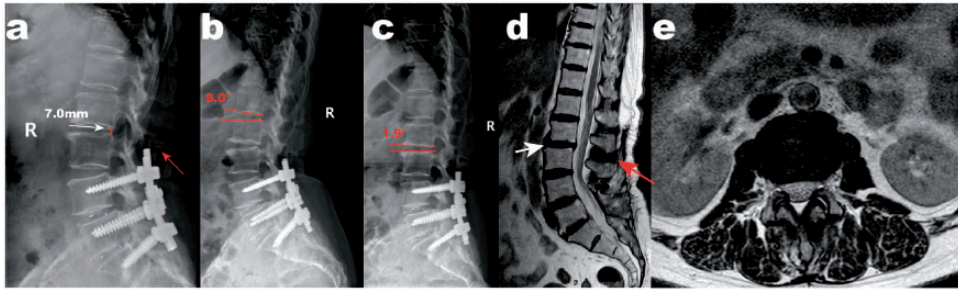


Figure 5. (a–c) Follow-up X-ray examination 14 months after the operation showed that the location of the IntraSPINE at the L2–3 segment had not moved, and magnetic resonance imaging showed disc degeneration at the L2–3 level without obvious aggravation. (a) Lateral X-ray views. The posterior disc height at the L2–3 level was 7.0 mm. (b, c) The range of motion at the L2–3 level was 7.1° ($9.0^\circ - 1.9^\circ = 7.1^\circ$). (d) T2-weighted sagittal images. (e) T2-weighted axial images at the L2–3 level.

follow-up study. Moreover, long-segment fusion also increases the risk of more severe trauma, more bleeding, more extensive posterior column destruction of the spine, and complications related to instrumentation.¹⁶ Zheng et al.¹⁷ indicated that the number of levels fused seemed to be the most significant factor predicting the hospital stay, operative time, intraoperative blood loss, and requirement for transfusion.

Interspinous spacers are typically representative of non-fusion techniques and include the Wallis, Coflex, X-Stop, and other similar devices.^{10,18} These are used as alternatives to PLIF in treating degenerative lumbar spinal disease.¹⁹ Interspinous spacers unload the facet joints, enlarge the interspinous space, and reduce the intradiscal pressure in extension by distracting the spinous processes.²⁰ However, complications of interspinous spacers have been described, including incorrect positioning, intraoperative spinous process fracture, spinous process fatigue fracture, supraspinous ligament rupture, and difficult implantation at the L5–S1 level.^{21,22}

In contrast to interspinous spacers, the IntraSPINE is a new kind of interlaminar device²³ that can significantly improve the functional status in patients with chronic low back pain.²⁴ The compression ratio of

the anterior and posterior parts of the IntraSPINE is different; i.e., the anterior part is full of medical silica gel, while the posterior part is hollow inside. Enlargement of the lamina space is mainly facilitated by the anterior part of the IntraSPINE, which is closer to the ligamentum flavum. The posterior part of the IntraSPINE mainly affects dynamic stability and is located in the interspinous space. A small-sample study showed that the IntraSPINE was able to reduce the workload on adjacent levels compared with interspinous spacers.²⁵ Sixty-seven patients were treated with the IntraSPINE in a 3-year follow-up study performed by Darwono,²⁶ and the result indicated that the IntraSPINE was close to the axis of instantaneous rotation of the spinal motion segment; that is, the IntraSPINE seemed to stabilize the segmental instability, maintain the sagittal balance, and restore the physiologic movement of the spinal motion segment. Moreover, the results of using the IntraSPINE for treatment of degenerative disc disease at the L5–S1 segment were encouraging in a study by Caspar et al.²⁷ Guizzardi and Morichi²⁸ verified the efficacy of the IntraSPINE in stopping or reversing the progressive cascade associated with disc degeneration. Another study corroborated

that the IntraSPINE was an excellent alternative treatment for patients with chronic low back pain due to Baastrup's disease.²⁹ According to the designer's original intentions, the combination of the IntraSPINE and lumbar spinal fusion is feasible for the treatment of degenerative lumbar disease.¹¹ However, this has not been supported by related clinical reports.

In our case, protrusion of the intervertebral discs was found at the L2–3, L4–5, and L5–S1 levels. However, the width of the lumbar vertebral canal at the L3–4 level was acceptable; that is, decompression of the L3–4 segment was unnecessary. If we had performed lumbar spinal fusion of the L2–S1 segments, the patient would have undergone massive trauma, excessive bleeding, and extensive posterior column destruction of the spine. The risk of ASD would also have been increased. We considered the topping-off technique as another alternative procedure that has been shown to be conducive to alleviating ASD.³⁰ However, the patient's lumbar activity would have been limited if pedicle screws had been inserted bilaterally at L3–S1 for internal fixation, and this might have seriously affected her quality of life and increased the economic cost of surgery. Additionally, as previously described, L3–S1 fusion might have increased the risk of ASD and postoperative complications, potentially necessitating a second surgery.

By the 14-month postoperative follow-up, the patient's back pain and neurogenic claudication symptoms had wholly disappeared, and the hypesthesia of both lower limbs had become relieved to some degree. The location of the IntraSPINE at the L2–3 segment did not move, the PDH at the L2–3 level recovered, and the local vertebral instability at the L2–3 level was resolved based on the postoperative and follow-up imaging examinations. That is, the results of our attempt are encouraging. However, these results should be confirmed by studies

with larger cohorts and more extended postoperative follow-up periods.

Limitations

This case report describes an attempt to verify the feasibility of the combination of the IntraSPINE and PLIF technique in treating SLDD. Although the outcome of this case is encouraging, a randomized controlled trial is necessary.

Conclusion

The IntraSPINE combined with PLIF can be a feasible procedure for the treatment of SLDD. Combination with lumbar spinal fusion may be one indication for the IntraSPINE. The IntraSPINE device can maintain the stability of the lumbar spine and preserve the motion of the spine to prevent the occurrence of ASD with minimal trauma and bleeding.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

Ethics approval and consent to participate

The case report only involved objective retrospective descriptions; therefore, ethics approval is not applicable. The patient provided informed consent for the use of her physical and imaging data.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

1. Kim KT, Lee SH, Lee YH, et al. Clinical outcomes of 3 fusion methods through the posterior approach in the lumbar spine.

- Spine (Phila Pa 1976)* 2006; 31: 1351–1357; discussion 8.
2. Fleege C, Rickert M and Rauschmann M. [The PLIF and TLIF techniques. Indication, technique, advantages, and disadvantages]. *Orthopade* 2015; 44: 114–123.
 3. Di Martino A, Quattrocchi CC, Scarciolla L, et al. Estimating the risk for symptomatic adjacent segment degeneration after lumbar fusion: analysis from a cohort of patients undergoing revision surgery. *Eur Spine J* 2014; 23: 693–698.
 4. Schmier JK, Halevi M, Maislin G, et al. Comparative cost effectiveness of Coflex(R) interlaminar stabilization versus instrumented posterolateral lumbar fusion for the treatment of lumbar spinal stenosis and spondylolisthesis. *Clinicoecon Outcomes Res* 2014; 6: 125–131.
 5. Senteler M, Weisse B, Snedeker JG, et al. Pelvic incidence-lumbar lordosis mismatch results in increased segmental joint loads in the unfused and fused lumbar spine. *Eur Spine J* 2014; 23: 1384–1393.
 6. Rawall S, Mohan K and Nene A. Posterior approach in thoracolumbar tuberculosis: a clinical and radiological review of 67 operated cases. *Musculoskelet Surg* 2013; 97: 67–75.
 7. Hsu K, Zucherman J, Shea W, et al. High lumbar disc degeneration. Incidence and etiology. *Spine (Phila Pa 1976)* 1990; 15: 679–682.
 8. Cheung KM, Samartzis D, Karppinen J, et al. Are “patterns” of lumbar disc degeneration associated with low back pain? New insights based on skipped level disc pathology. *Spine (Phila Pa 1976)* 2012; 37: E430–E438.
 9. Tachibana N, Kawamura N, Kobayashi D, et al. Preventive effect of dynamic stabilization against adjacent segment degeneration after posterior lumbar interbody fusion. *Spine (Phila Pa 1976)* 2017; 42: 25–32.
 10. Wu H, Pang Q and 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: 1562–1573.
 11. Guizzardi G. Looking at the future of motion preservation surgery in the lumbar spine with the experience of the past. *Global Spine J* 2017; 6: s-0036-1582979-s-0036.
 12. Cheung KM, Samartzis D, Karppinen J, et al. Intervertebral disc degeneration: new insights based on “skipped” level disc pathology. *Arthritis Rheum* 2010; 62: 2392–2400.
 13. Liao Y, Ye R, Tang Q, et al. [Application of ultrasonic osteotome in the posterior lumbar interbody fusion surgery by unilateral fenestration and bilateral decompression in the treatment of degenerative lumbar spinal stenosis]. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi* 2019; 33: 416–422.
 14. Fan Y, Zhou S, Xie T, et al. Topping-off surgery vs posterior lumbar interbody fusion for degenerative lumbar disease: a finite element analysis. *J Orthop Surg Res* 2019; 14: 476.
 15. Cheh G, Bridwell KH, Lenke LG, et al. Adjacent segment disease following lumbar/thoracolumbar fusion with pedicle screw instrumentation: a minimum 5-year follow-up. *Spine (Phila Pa 1976)* 2007; 32: 2253–2257.
 16. Cho KJ, Suk SI, Park SR, et al. Complications in posterior fusion and instrumentation for degenerative lumbar scoliosis. *Spine (Phila Pa 1976)* 2007; 32: 2232–2237.
 17. Zheng F, Cammisa FP Jr, Sandhu HS, et al. Factors predicting hospital stay, operative time, blood loss, and transfusion in patients undergoing revision posterior lumbar spine decompression, fusion, and segmental instrumentation. *Spine (Phila Pa 1976)* 2002; 27: 818–824.
 18. Kulduk A, Altun NS and Senkoylu A. Biomechanical comparison of effects of the Dynesys and Coflex dynamic stabilization systems on range of motion and loading characteristics in the lumbar spine: a finite element study. *Int J Med Robot* 2015; 11: 400–405.
 19. Gu H, Chang Y, Zeng S, et al. Wallis interspinous spacer for treatment of primary lumbar disc herniation: three-year results of a randomized controlled trial. *World Neurosurg* 2018; 120: e1331–e1336.

20. Gazzeri R, Galarza M and Alfieri A. Controversies about interspinous process devices in the treatment of degenerative lumbar spine diseases: past, present, and future. *Biomed Res Int* 2014; 2014: 975052.
21. Puzzilli F, Gazzeri R, Galarza M, et al. Interspinous spacer decompression (X-STOP) for lumbar spinal stenosis and degenerative disk disease: a multicenter study with a minimum 3-year follow-up. *Clin Neurol Neurosurg* 2014; 124: 166–174.
22. Davis R, Auerbach JD, Bae H, et al. Can low-grade spondylolisthesis be effectively treated by either coflex interlaminar stabilization or laminectomy and posterior spinal fusion? Two-year clinical and radiographic results from the randomized, prospective, multicenter US investigational device exemption trial. *J Neurosurg Spine* 2013; 19: 174–184.
23. Bhavani A. *Modern techniques in spinesurgery [M]*. Bhavani: Jaypee Brothers Medical Publishers, 2014, p. 416–431.
24. Bae J, Lee SM, Lee SH, et al. The likelihood of reaching substantial clinical benefit after an interlaminar dynamic spacer for chronic low back pain: a clinical and radiologic analysis of a prospective cohort. *World Neurosurg* 2017; 101: 589–598.
25. Carrabs G, Sessa G, Oliva G, et al. Intraspine interlaminar device: clinical, radiological, and safety results of a mini case series (10 cases). *Global Spine J* 2015; 5: s-0035-1554605-s-0035.
26. Darwono AB. The new dynamic interlaminar device for the treatment of early and late lumbar degenerative problems. *Global Spine J* 2017; 4: s-0034-1376703-s-0034.
27. Caspar A, Manuel CJ, Giancarlo G, et al. The Intraspine® in the treatment of L5-S1 degenerative disc disease. Preliminary report. *EC Orthopaedics* 2015; 2: 146–152.
28. Giancarlo G and Morichi R. Clinical results with IntraSPINE®. *EC Orthopaedics* 2015; 2: 101–106.
29. Mostofi K, Moghadam BG and Peyravi M. Interlaminar lumbar device implantation in treatment of Baastrup disease (kissing spine). *J Craniovertebr Junction Spine* 2018; 9: 83–86.
30. Li D, Hai Y, Meng X, et al. Topping-off surgery vs posterior lumbar interbody fusion for degenerative lumbar disease: a comparative study of clinical efficacy and adjacent segment degeneration. *J Orthop Surg Res* 2019; 14: 197.