临床论著

单侧双通道内镜下经椎间孔腰椎椎间融合术治疗腰椎退行性疾病的早期疗效分析

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【摘要】目的:评估单侧双通道内镜下经椎间孔腰椎椎间融合术(unilateral biportal endoscopic transforaminal lumbar interbody fusion,UBE-TLIF/BETLIF)治疗腰椎退行性疾病的早期临床疗效。**方法**:选取 2019 年 3 月~2021 年 5 月行 BETLIF 治疗的腰椎退行性疾病患者共 60 例,其中Ⅰ度退行性腰椎滑脱 33 例(L3/4 1 例,L4/5 27 例,L5/S1 5 例),Ⅰ度退行性腰椎滑脱伴峡部裂 6 例(L3/4 1 例,L4/5 3 例,L5/S1 2 例),腰椎间盘突出症伴节段不稳 15 例(L4/5 14 例,L5/S1 1 例),腰椎椎管狭窄症伴腰椎不稳 5 例(L3/4 1 例,L4/5 4 例),单纯腰椎不稳 1 例(L4/5 1 例);男 14 例,女 46 例,年龄 38~70 岁(56±8 岁),体质指数(body mass index,BMI)25.2±3.0kg/m^2。统计手术时间、术后引流量、下地时间、术后住院时间及并发症;统计患者术前和术后 1 周、1 个月、3 个月及 6 个月的腿痛和腰背痛视觉模拟评分(visual analogue scale,VAS)、术前及术后 1、3、6 个月 Oswestry 功能障碍指数(Oswestry disability index,ODI)和术后 6 个月改良 Macnab 标准。计算术后 6 个月腿痛 VAS、腰背痛 VAS、ODI 改善率;采用单因素重复测量方差分析比较腿痛/腰背痛 VAS 评分和 ODI 在术前及术后各时间点是否有统计学差异,采用配对样本 t 检验比较术后 6 个月腿痛 VAS 与腰背痛 VAS 改善率差异;两名脊柱外科医生根据 Bridwell 椎间融合分级标准在 X 线/CT 上统计术后 6 个月手术节段融合情况。**结果**:60 例患者平均手术时间为 145.9±12.6min;术后留置引流管 35 例(58.3%),平均引流量为 56.40ml;术后下地时间为 2.9±1.0d;术后住院时间为 7.8±2.7d。术中硬脊膜撕裂 2 例,术后切口皮下水肿 3 例。患者术后 1 周及 1、3、6 个月的腿痛、腰背痛 VAS 评分均明显小于术前(P<0.05);术后 6 个月腿痛 VAS 改善率为(65.6±7.1)%,腰背痛 VAS 改善率为(62.3±7.2)%,腿痛比腰背痛改善更佳(P<0.05)。术后 1、3、6 个月的 ODI 均明显小于术前(P<0.05),术后 6 个月 ODI改善率为(60.9±4.7)%。术后 6 个月复查 X 线/CT 结果显示节段发生融合 26 例(43.4%),有融合趋势但尚未完全融合 29 例(48.3%),未发生融合 5 例(8.3%)。术后 6 个月改良 Macnab 标准评估为优 55 例(91.7%),良 5 例(8.3%)。**结论**:BETLIF 是一种安全、有效的腰椎椎间融合术,治疗腰椎退行性疾病能够获得良好的早期临床疗效。

【关键词】腰椎退行性疾病;腰椎椎间融合术;内镜手术;单侧双通道
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【Abstract】Objectives: To evaluate the early clinical efficacy of unilateral biportal endoscopic transforaminal lumbar interbody fusion(UBE-TLIF/BETLIF) in the treatment of lumbar degenerative diseases. **Methods:** 60 patients with lumbar degenerative diseases who underwent BETLIF surgery from March 2019 to May 2021 were selected, including 33 cases of grade Ⅰ degenerative lumbar spondylolisthesis (L3/4 1 case, L4/5 27 cases, L5/S1 5 cases), 6 cases of grade Ⅰ degenerative lumbar spondylolisthesis with isthmus fissure(L3/4 1 case, L4/5 3 cases, L5/S1 2 cases), 15 cases of disc herniation with segmental instability (L4/5 14 cases, L5/S1 1 case), 5 cases of lumbar spinal stenosis with segmental instability(L3/4 1 case, L4/5 4 cases), and 1

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case of simple lumbar instability (L4/5 1 case). There were 14 males and 46 females, aged from 38 to 70 years old, averaged 56±8 years; with a mean body mass index(BMI) of 25.2±3.0kg/m^2. The operative time, postoperative drainage, ambulation time, postoperative length of hospital stay and complications were recorded. The visual analogue scale(VAS) of leg and low back pain was collected before operation, at postoperative 1 week, and 1, 3, and 6 months; Oswestry disability index(ODI) was collected before operation, at postoperative 1, 3, and 6 months; the modified Macnab criteria grade was recorded at the 6th month after operation. The improvement rate of VAS scores of leg pain and low back pain and ODI 6-month postoperatively were calculated. The VAS score of leg pain/low back pain and ODI before and after operation were analysed according to the one-way repeated measures ANOVA for statistical difference, the differences of improvements between postoperative 6-month VAS score of leg pain and low back pain 6-month postoperatively were compared by paired sample *t*-test. According to Bridwell interbody fusion grading system, the surgical segmental fusion was evaluated on X-ray/CT images at 6-month after operation by two spinal surgeons. **Results:** The average operative time was 145.9±12.6min. 35 cases out of 60(58.3%) had indwelling drainage tubes after operation, with an average drainage volume of 56.40ml. The average ambulation time was 2.9±1.0d, and the average postoperative hospital stay was 7.8 ±2.7d. The surgical complications included intraoperative dural tear in 2 cases and postoperative subcutaneous edema in 3 cases. The VAS scores of leg and low back pain at 1 week and 1, 3 and 6 months after operation were significantly lower than those before operation (P<0.05). The improvement rate of the VAS scores of leg pain and low back pain 6-month postoperatively were (65.6±7.1)% and (62.3±7.2)% respectively, with leg pain VAS better improved than low back pain VAS (P<0.05). The ODI at 1, 3 and 6 months after operation were significantly lower than those before operation(P<0.05), and the improvement rate of the ODI 6-month postoperatively were (60.9±4.7)%. The X-ray/CT at 6 months after operation revealed that 26 cases(43.4%) had segmental fusion, 29 cases(48.3%) had fusion trends but not fused, and 5 cases(8.3%) showed no segmental fusion at all. According to modified Macnab criteria, 55 patients were excellent(91.7%) and 5 patients were good(8.3%) at 6-month after operation. **Conclusions:** As a safe and effective lumbar interbody fusion technique, BETLIF has great early clinical efficacy for the treatment of lumbar degenerative diseases.

【Key words】 Lumbar degenerative diseases; Lumbar interbody fusion; Endoscopic surgery; Unilateral biportal

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人口老龄化导致腰椎滑脱、腰椎不稳等腰椎退行性病变的发生率逐年增加[1]。腰椎椎间融合术是治疗腰椎退行性疾病的有效手术方式[2]。腰椎椎间融合术的术式多样，包括开放术式如前路腰椎椎间融合术、外侧腰椎椎间融合术、后路腰椎椎间融合术、经椎间孔腰椎椎间融合术(transforaminal lumbar interbody fusion,TLIF)[3~6],及微创的镜下术式如微创经椎间孔腰椎椎间融合术(minimally invasive surgery transforaminal lumbar interbody fusion,MIS-TLIF)[7] 和单孔镜下经椎间孔腰椎椎间融合术 (endoscopic transforaminal lumbar interbody fusion,Endo-TLIF)[8,9]。近些年来,追求手术微创、提高生活质量渐渐成为医疗的关键目标,这对组织损伤小、早期恢复快的微创脊柱外科 (minimally invasive spine surgery,MISS)的发展提出了迫切需求。单侧双通道内镜下经椎间孔腰椎椎间融合术 (unilateral biportal endoscopic transforaminal lumbar interbody fusion, UBE-TLIF/BETLIF)是在单侧双通道内镜(unilateral biportal endoscopic,UBE)技术下进行的椎间融合术。单侧双通道由 Heo 等在 2017 年提出[10],前身为 1996 年 DeAntoni 等[11]提出的“经椎板间腰椎硬膜外内镜技术”，术者使用两个独立通道,能在较小损伤椎旁肌肉的条件下治疗腰椎间盘突出等疾病。在此技术基础上的 BETLIF 手术是一种新兴起的、具有良好临床疗效的手术方式。国外已有学者报道了采用 BETLIF 治疗腰椎退行性疾病的病例,获得良好的临床疗效[10,12,13]。目前国内对 BETLIF 的术后疗效报道较少，且对该技术早期应用开展的安全性和可行性缺乏系统的评估。本研究分析腰椎退行性疾病患者 BETLIF 术后 6 个月的随访信息，初步了解 BETLIF 治疗各种腰

椎退行性疾病的早期临床疗效。

1 资料与方法

1.1 纳入及排除标准

纳入标准:(1)轻度腰椎滑脱(≤Ⅱ度)伴或不伴峡部裂;(2)单纯腰椎不稳(Frymoyer 标准:腰椎过伸过屈位邻近椎体移位超过 3mm 或角度变化超过 15°)[14];(3)腰椎管狭窄伴不稳;(4)腰椎间盘突出伴不稳。排除标准:(1)重度腰椎滑脱(>Ⅱ度);(2)融合节段≥2;(3)可能降低脊柱置入物安全性和有效性的疾病(骨质疏松、肿瘤、感染等)。

1.2 一般资料

纳入我院 2019 年 3 月~2021 年 5 月接受 BETLIF 的患者,排除失访及并发其他疾病影响随访的患者,共 60 例,其中Ⅰ度退行性腰椎滑脱 33 例(L3/4 1 例,L4/5 27 例,L5/S1 5 例),Ⅰ度退行性腰椎滑脱伴峡部裂 6 例(L3/4 1 例,L4/5 3 例,L5/S1 2 例),腰椎间盘突出症伴节段不稳 15 例(L4/5 14 例,L5/S1 1 例),腰椎椎管狭窄症伴腰椎不稳 5 例(L3/4 1 例,L4/5 4 例),单纯腰椎不稳 1 例(L4/5 1 例);男 14 例,女 46 例,年龄 38~70 岁(56±8 岁),体质指数(body mass index,BMI)25.2±3.0kg/m^2。患者术前均有腰背部疼痛及下肢疼痛麻木;手术均由同一主刀医生完成。

1.3 手术方法

1.3.1 手术器械 30°关节镜、显像系统、磨钻、逐级扩张套管、等离子射频;脊柱开放手术器械包括骨刀、骨膜剥离子、神经剥离子、枪钳、髓核钳、刮匙和神经拉钩等。

1.3.2 麻醉、体位与术前定位 患者采取气管插管全身麻醉后,俯卧于手术床,双侧上肢外展上举放置于支臂板上,双侧腋下放置腋垫,圆柱形体位垫垫高躯干部两侧,使腹部悬空;双侧髋关节、膝关节呈屈曲位。折叠手术床使目标椎间隙与地面垂直,C 型臂 X 线机正侧位透视确定目标椎间隙、目标椎间隙上下椎弓根体表投影点、棘突中线及椎弓根内缘线等标志并在皮肤标记(图 1a、b)。

1.3.3 切口及内镜下减压 常规消毒铺巾后铺放防水膜(图 1c)。以椎弓根体表投影点为中心做斜型“八”字切口,优势手侧为操作通道(约 2cm),非优势手侧为观察通道(约 0.5~1cm)(图 1d)。分级扩张软组织形成观察通道及操作通道,观察通道置入内镜,操作通道置入半套管(图 1e),打开灌注系统,冲洗至视野清晰,形成初始工作空间。使

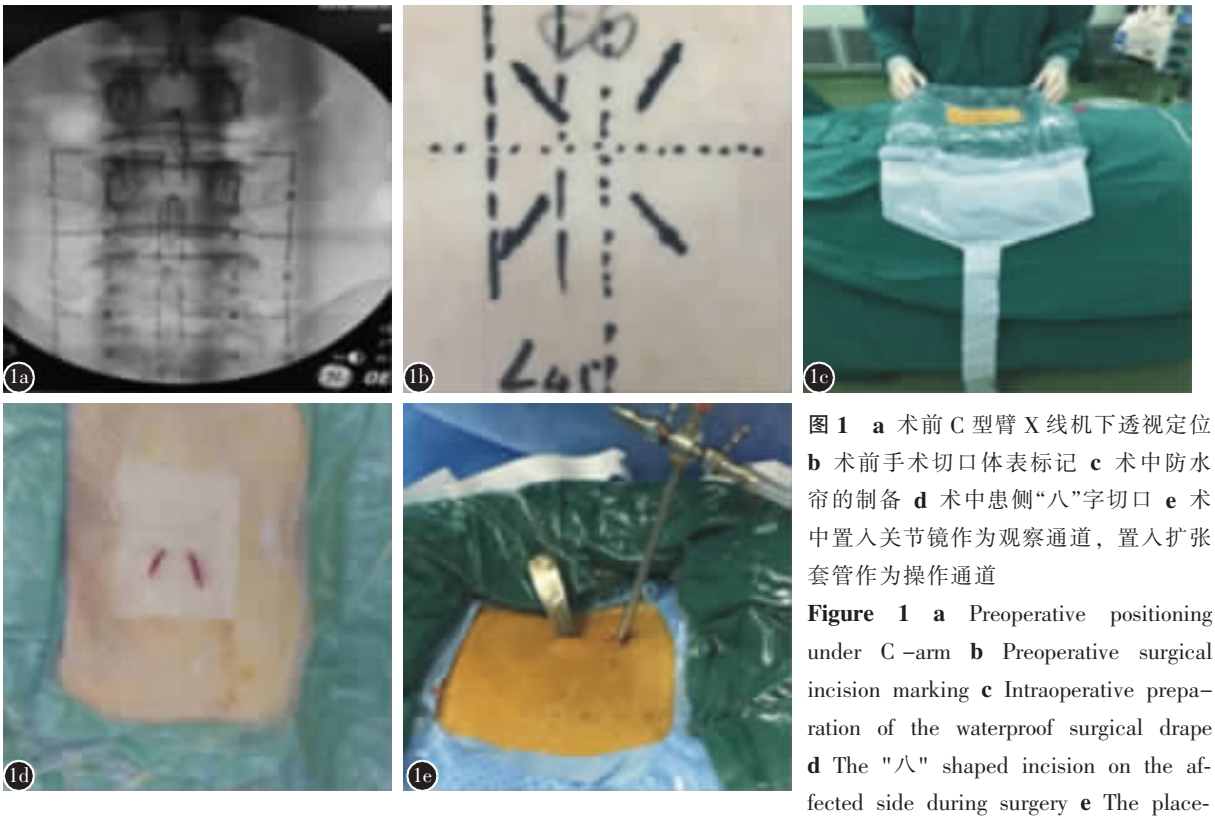

图 1 **a** 术前 C 型臂 X 线机下透视定位 **b** 术前手术切口体表标记 **c** 术中防水帘的制备 **d** 术中患侧“八”字切口 **e** 术中置入关节镜作为观察通道,置入扩张套管作为操作通道

Figure 1 **a** Preoperative positioning under C-arm **b** Preoperative surgical incision marking **c** Intraoperative preparation of the waterproof surgical drape **d** The "八" shaped incision on the affected side during surgery **e** The placement of arthroscopy as viewing portal and expansion sleeve as working portal

用等离子射频以关节突关节为中心分离软组织(图 2a),显露头端椎板下缘、关节突关节及尾端椎板上缘(图 2b)。再次透视明确责任节段后使用骨刀进行下关节突分段截骨，切除部分椎板和下关节突关节(图 2c),应用椎板咬骨钳和骨刀去除部分上关节突及周围椎板(图 2d);显露椎间盘,充分暴露操作侧行走根和(或)出口根。

1.3.4 椎间盘及终板处理 助手使用神经拉钩牵开并保护好暴露的神经根，使用尖刀切开纤维环(图 3a);7 号铰刀绞碎髓核及纤维环 (图 3b);椎间刮匙刮除髓核及部分软骨终板(图 3c);直视下剥离软骨终板以显示软骨下骨(图 3d)。

1.3.5 cage 放置与椎弓根螺钉固定 终板处理完全后将自体骨与同种异体骨混合并置入椎间隙(图 3e)，直视下将 cage 置入椎间隙并推至前缘(图 3f)。在双侧各置入 2 枚椎弓根螺钉,完成钉棒固定(图 3g)。对于需要对侧减压的患者,应用椎板咬骨钳及磨钻去除棘突基底部及对侧部分椎板,直视下切除黄韧带,减压硬膜囊,显露并松解对侧神经根(图 2e),结束后再次探查硬膜囊及双侧神经根确保减压充分;减压完成的标志:①硬膜囊、神经根恢复正常的形态和路径;②硬膜囊、神经根周围间隙明确分离;③牵拉神经根张力变低。对于滑脱较难复位或椎间隙过窄的患者，则可先对侧置钉辅助椎体复位及椎间隙撑开，再行手术侧减压、放置 cage 等操作。确认无活动性出血后完成缝皮操作(图 3h),术后按需引流。

1.3.6 术后处理 术后严格卧床 3d，常规卧床 14d,后可佩戴腰围适当下地行走锻炼。术后 3 个月内以卧床休息为主,期间行直腿抬高、小燕飞等腰背肌锻炼;可佩戴腰围下地活动,注意避免弯腰及体力劳动。

1.4 观察及评价指标

统计围术期参数如手术时间、术后引流量、术后下地时间、术后住院时间、并发症等;统计患者术前和术后 1 周及 1、3、6 个月的腿痛和腰背痛视觉模拟评分(visual analogue scale,VAS),术前及术后 1、3、6 个月 Oswestry 功能障碍指数(Oswestry disability index,ODI)。VAS 评分改善率(%)=(术前评分−术后 6 个月评分)/术前评分×

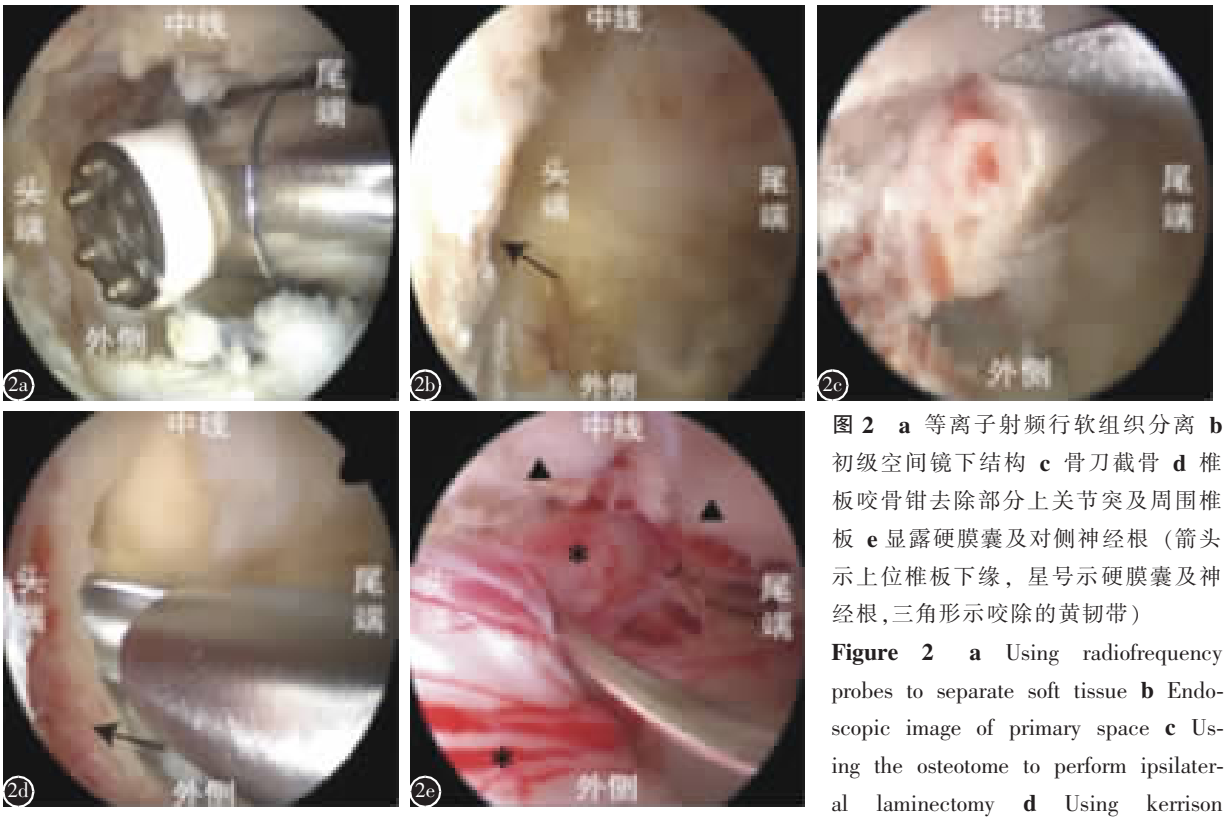

图 2 **a** 等离子射频行软组织分离 **b** 初级空间镜下结构 **c** 骨刀截骨 **d** 椎板咬骨钳去除部分上关节突及周围椎板 **e** 显露硬膜囊及对侧神经根 (箭头示上位椎板下缘，星号示硬膜囊及神经根,三角形示咬除的黄韧带)

Figure 2 **a** Using radiofrequency probes to separate soft tissue **b** Endoscopic image of primary space **c** Using the osteotome to perform ipsilateral laminectomy **d** Using kerrison punch to remove partial superior facet and surrounding lamina **e** Exposure of the dural sac and contralateral nerve root (The arrow indicating the lower edge of the upper lamina, the asterisk indicating the dural sac and nerve root, and the triangle indicating the removed ligamentum flavum)

100%;ODI 改善率（%）=(术前-术后 6 个月)/术前×100%。术后 6 个月复查 X 线片/CT，依据 Bridewell 椎间融合分级标准 [15] 进行融合情况评价，具体标准：Ⅰ级，存在融合重塑和及骨小梁；Ⅱ级，cage 位置良好，未融合重塑，顶部与底部没有透亮区；Ⅲ级，cage 位置良好，顶部和底部存在透亮区；Ⅳ级，融合缺失，cage 塌陷。由两名脊柱外科医生进行评估：当两人同时评价为Ⅰ级时，定义为节段发生融合；当一人评价为Ⅰ级，另一人为Ⅱ级或两人评价为Ⅱ级时，定义为节段有融合趋势但尚未完全融合；当有一人评价为Ⅲ级时定义为节段未发生融合；当有一人评价为Ⅳ级时定义为节段需随访及干预。术后 6 个月采用改良 Macnab 标准评估临床疗效。

1.5 统计学方法

使用 SPSS 26.0 软件进行统计分析。统计数

图 3 **a** 尖刀破坏纤维环 **b** 铰刀破坏髓核及纤维环 **c** 髓核钳及椎间刮匙摘除髓核及纤维环 **d** 剥离子进行终板处理(白三角示上终板) **e** 混合骨植入椎间隙（黑三角示下终板） **f** 直视下敲入 cage **g** 术中完成螺钉固定的透视影像 **h** 术后切口的缝合，四个切口均控制在 0.5~2.5cm

Figure 3 **a** Using the Indian knife to destroy the annulus **b** Using the disc reamer to destroy the nucleus pulposus and annulus **c** Using pulposus forceps and curette to remove the nucleus pulposus and annulus **d** Using the scraper for endplate processing(the white triangle indicating the superior endplate) **e** Implantation of autologous bone and allogeneic bone (the black triangle indicating the inferior endplate) **f** Knocking the cage into the intervertebral space **g** The fluoroscopic image of the pedicle screws fixation during surgery **h** The suture of the operative incisions, all four incisions were controlled at 0.5–2.5cm

据符合正态分布，结果以 $\bar{x}\pm s$ 形式表示。采用单因素重复测量方差分析比较腿痛/腰背痛 VAS 评分和 ODI 在术前及术后各时间点是否有统计学差异，采用配对样本 t 检验比较术后 6 个月腿痛 VAS 与腰背痛 VAS 改善率差异。检验水准 α 值为双侧 0.05。

2 结果

平均手术时间为 145.9±12.6min（镜下时间 98.7±12.2min，其他时间 47.2±4.0min）；60 例患者术后留置引流管 35 例（58.3%），平均引流量 56.40ml。术后下地时间为 2.9±1.0d；术后住院时间为 7.8±2.7d。手术并发症：术中硬脊膜撕裂 2 例，术后切口皮下水肿 3 例。2 例术中硬脊膜撕裂均小于 1cm，未予缝合，均予明胶海绵覆盖，术后采取平卧位及抗感染治疗，患者均无特殊不适主诉及后续并发症；切口皮下水肿未予特别处理。

术前及术后的腰腿痛 VAS 评分见表 1，单因素重复测量方差分析示患者术后 1 周及 1、3、6 个月的腿痛及腰背痛 VAS 评分均明显小于术前（P<0.05），且各随访时间点评分较上次随访均显著下降（P<0.05）。术后 6 个月腿痛 VAS 改善率为（65.6±7.1）%，腰背痛 VAS 改善率为（62.3±7.2）%，通过配对样本 t 检验得出术后 6 个月腿痛与腰背痛 VAS 改善程度存在统计学差异，腿痛比腰背痛改善更佳（P<0.05）。患者术前及术后的 ODI 见表 1，单因素重复测量方差分析示患者术后 1、3、6 个月的 ODI 均明显小于术前（P<0.05），且各随访时间点评分较上次随访均显著下降（P<0.05）。术后 6 个月 ODI 改善率为（60.9±4.7）%。

术后 6 个月 X 线片/CT 评价结果示节段发生融合 26 例（43.4%）（图 4），有融合趋势但尚未完全融合 29 例（48.3%），节段未发生融合 5 例（8.3%）。

术后 6 个月改良 Macnab 标准评定为优 55 例（91.7%），良 5 例（8.3%），随访患者反馈术后持续或间断的背部不适是影响生活的主要因素。

3 讨论

MISS 技术基于使用已知解剖空间、避免关键肌肉附着点破坏、减少扩张器强度、限制手术通道面积等原则，最大限度减少了范围内组织损伤[16]，广泛用于椎体退行性疾病的临床治疗中[17]。Foley 等[7]开发了 MIS-TLIF 以弥补开放 TLIF 的缺点。使用管状扩张器将手术视野聚焦至靶点上方通路进行减压，这种扩张器可以一定程度上减少对肌肉、血管和神经的牵拉，配合椎间融合器和经皮螺钉，为减少背部肌肉损伤提供了一种有益选择[16]。临床研究显示 MIS-TLIF 有较好的临床疗效及较高的融合率[18-20]。然而，MIS-TLIF 仍需切开肌肉来放置管状扩张器，存在影响肌肉血运的风险；且空气介质下视野不清晰及无法直视下处理终板也是其不足之处。因此，与现有的开放手术相比，MIS-TLIF 代表了一种渐进但不是革命性的进步[21]。

与 MIS-TLIF 相比，经皮内镜下腰椎椎间融合术通过软组织顺序扩张和极少的去骨操作进行手术，局麻是其一大特点[22,23]；近些年报道的 Endo-TLIF 具有创伤小、术后神经损伤发生率低等优势，报道显示了良好的临床疗效[24-26]。与传统 TLIF 相比，该术式不仅降低了手术风险及成本，取得了相同疗效，且避免了严重的硬膜外粘连等并发症[24]，完全符合脊柱手术微创理念。但椎间孔

表 1 不同时间点腿痛和腰背痛 VAS 评分及 ODI

Table 1 Leg pain and low back pain VAS scores and ODI at different time points

	术前 Preoperative	术后 1 周 1-week follow-up	术后 1 个月 1-month follow-up	术后 3 个月 3-month follow-up	术后 6 个月 6-month follow-up	改善率(%) Improvement rate
腿痛 VAS VAS(LP)	6.33±0.71	3.73±0.55①	3.12±0.50①②	2.33±0.48①②③	2.15±0.48①②③④	65.6±7.1
腰背痛 VAS VAS(LBP)	6.52±0.62	4.18±0.77①	3.37±0.66①②	3.00±0.58①②③	2.47±0.50①②③④	62.3±7.2⑤
ODI(%)	63.59±4.99	–	46.43±5.18①	32.83±4.43①③	24.92±4.19①③④	60.9±4.7

注：①与术前比较 P<0.05；②与术后 1 周比较P<0.05；③与术后 1 个月比较 P<0.05；④与术后 3 个月比较 P<0.05；⑤与术后 6 个月腿痛 VAS 改善率比较P<0.05

Note: ①Compared with preoperation, P<0.05; ②Compared with 1-week postoperatively, P<0.05; ③Compared with 1-month postoperatively, P<0.05; ④Compared with 3-month postoperatively, P<0.05; ⑤Compared with the improvement rate of VAS(LP) 6-month postoperatively, P<0.05

镜观察、操作通道一体化及所需的专业器械，加大了其操作、普及难度。

近年来，水介质下的单侧双通道内镜技术正逐渐被运用，Eum、Kim 及其他国外学者先后报道了应用 UBE 治疗腰椎椎管狭窄症患者取得了良好疗效[12,27~30]；国内学者介绍了 UBE 技术及报道了 UBE 治疗腰椎间盘突出症和腰椎椎椎管狭窄症良好的临床疗效[31~33]。不仅如此，针对腰骶部的各类椎间孔病变，其他术式面临着高髂嵴阻挡器械而影响手术操作等难题；使用 UBE 浮动操作界面，既使椎间孔区清晰可见，也可动态处理各种器械而不过多破坏小关节以避免医源性不稳的发生，这有助于术者进行更温和操作从而达到精准减压 [34]；30°关节镜的运用更能体现 UBE 对于腰骶部椎管内及椎间孔区减压的优势 [35,36]。Heo 和 Kim 报道了 BETLIF 治疗腰椎退行性疾病取得良好临床疗效 [10,13]。Heo 比较三种微创椎间融合术式，得出 MIS-TLIF 的优势在于治疗中央型腰椎

图 4 患者女，49 岁，腰痛 10 年余，加重 4 年，伴有双下肢麻木 **a** 术前 X 线片示 L4 椎体滑脱(I 度) **b** 术前 MRI 矢状位示 L4/5 硬膜囊受压 **c** 术前 MRI 横断位示 L4/5 椎管狭窄 **d** 术中切除的下关节突 **e** 术中终板处理完成：去除软骨终板，显露骨性终板 **f** 术后三维 CT 示去除的骨性结构范围 **g** 术后 X 线片显示螺钉位置良好 **h** 术后 6 个月 CT 示 cage 位置良好，椎体间已有密度较高的骨性融合

Figure 4 A female patient, 49 years old, low back pain for more than ten years, aggravating for four years, accompanied by numbness of both lower limbs **a** Preoperative X-ray showed spondylolisthesis(grade Ⅰ) of L4 **b** Preoperative MRI sagittal plane showed compression of L4/5 dural sac **c** Preoperative MRI transverse plane showed stenosis of L4/5 **d** The inferior articular process removed during the surgery **e** The endplate processing was completed during the surgery: the cartilage endplate removed and the bony endplate exposed **f** The postoperative CT showed the range of the removed bony structure **g** The postoperative X-ray showed the screw was fixed well **h** The CT showed the cage was well positioned at 6 months after operation and high density bone fusion between vertebral bodies

管狭窄时比经皮内镜手术更有利于术后硬脊膜的扩张，而 BETLIF 在避免小关节破坏方面有更多优势；单通道或双通道内镜手术对减少术后即刻疼痛有更好的帮助[37]。

本研究结果证实了 BETLIF 对 60 例腰椎退行性疾病患者的腰腿痛具有良好疗效，腰痛和腿痛的改善与时间密切相关，且术后短期内患者腿痛改善更佳。术后 6 个月随访结果显示手术有着较佳融合率，但缺少与其他融合术式的对比，针对远期融合情况还需进一步随访。手术并发症包括术中硬脊膜撕裂及术后切口皮下水肿。切口皮下水肿多由灌注水压导致，无需处理；术中硬脊膜撕裂需适当降低灌注水压并尽快结束手术，避免类脊髓高压综合征的发生。BETLIF 可以通过经 Kambin 三角入路或椎板间入路（后外侧）进行椎间融合处理[8,38]，本研究采取后外侧入路，研究中腰椎滑脱纳入标准为轻度滑脱，因此术前体位、术中充分松解及钉棒提拉已能良好地复位滑脱椎体。BETLIF 完全经皮组织，因此不存在管道的牵拉压迫，经多裂肌间隙的通道形式最大程度上减少了手术对多裂肌的损伤，这对预防术后腰痛和维持术后腰椎稳定性十分重要[16]。术中在水介质下能清晰地充分减压；值得注意的是，由于控制性降压及灌注水压的影响，减压后硬脊膜搏动并不明显。终板处理是影响椎间融合手术预后的关键步骤，相对于 MIS-TLIF 无法直视终板和单通道内镜的单通道操作，BETLIF 对于终板处理等操作有较大优势：双通道操作模式对终板进行直视化处理，可调整内镜角度以观察上下终板处理情况，及时预防骨性终板损伤；可在直视下避开神经根置入 cage 并推至椎间隙前缘；这些操作为预防术后 cage 下沉、促进椎间融合、维持腰椎前凸和稳定性提供了良好保障。除此之外，我们认为 BETLIF 还存在其他优势：(1) 操作通道与观察通道的分离，能提供更立体的视野从而减少术野失真；(2)30°镜的应用使视野范围更广阔从而应付更多变的术中情况；(3)全程水流冲洗能提供清晰的术中视野及预防术后感染；(4)无管道及操作器械限制，可以使用开放手术器械进行手术。但双通道内镜下的双手操作存在一定学习曲线，容易面临丢失操作视野、不易找到正确节段等困难。

综上所述，BETLIF 具有视野清晰、操作灵活、减压充分、手术安全性高等优势，治疗腰椎退行性病变早期临床疗效良好。

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