

腰椎融合术前相邻节段退变对术后中长期临床疗效的影响

孙卓然, 周思宇, 郭 扬, 陈仲强, 李危石

(北京大学第三医院骨科 100191 北京市)

【摘要】目的:分析术前相邻节段退变(adjacent segment degeneration, ASD)对腰椎融合术后中长期预后的影响, 比较术前邻近节段椎管狭窄的程度与椎间盘退变的程度对相邻节段病变(adjacent segment disease, ASDis)的影响。**方法:**回顾性研究 2002 年 1 月~2010 年 12 月在我院因腰椎管狭窄症行后路减压、椎弓根螺钉固定和植骨融合术的 59 例患者(男 27 例, 女 32 例), 年龄 38~80 岁, 平均 63.0±9.6 岁。所有患者均融合至 S1, 平均随访时间为 80.7±7.4 个月(72~96 个月)。收集患者体重指数(BMI)、术前及末次随访时 Oswestry 功能障碍指数(ODI)、日本骨科协会(JOA)评分、视觉模拟评分(VAS)。影像学资料包括术前及末次随访时的腰椎 MRI、腰椎正侧伸屈位 X 线。用 MRI 与 X 线片判定术后 ASD 情况, 观察指标包括相邻节段椎间盘 Pfirman 分级、椎管狭窄程度、节段不稳定、椎间隙高度、椎体前后缘骨赘等。应用椎管内脑脊液闭塞程度与 Pfirman 分级评价术前邻近节段退变的程度。若在随访期内出现下肢神经症状加重或腰痛加重, 结合影像学表现诊断为 ASDis。以末次随访是否出现 ASDis 分组, 比较组间影响因素差异。应用 Logistic 回归分析, 分析影响末次随访时 ASDis 的危险因素。**结果:**末次随访时共 38 例患者(38/59, 64.4%)出现影像学上 ASD, 其中 9 例患者(9/59, 15.3%)诊断为 ASDis。共 40 例患者(40/59, 67.8%)术前相邻节段椎管无明显狭窄, 评为 0 级, 其中 2 例末次随访时出现 ASDis; 共 19 例患者(19/59, 32.2%)术前相邻节段椎管存在轻度狭窄, 评为 1 级, 其中 7 例末次随访时出现 ASDis。术前不同相邻节段椎管形态的患者 ASDis 发生率存在显著差异($P=0.003$)。Logistic 回归分析表明, 术前相邻节段椎管的狭窄程度与融合节段长短为影响 ASDis 的危险因素。**结论:**对于术前相邻节段退变程度的评估, 应重视相邻节段椎管狭窄程度的评估, 椎管狭窄和长节段固定融合显著增加术后中长期相邻节段病变的风险。

【关键词】 相邻节段病变; 术前退变; 椎管狭窄程度; 椎间盘退变

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【Abstract】 Objectives: To analyze the effect of pre-existing adjacent segment degeneration (ASD) on the long-term prognosis after lumbar fusion, and to compare the effect of canal stenosis and the degree of intervertebral disc degeneration on adjacent segment disease(ASDis). **Methods:** By retrieving the medical records from January 2002 to December 2010 in our hospital with the inclusion criteria of lumbosacral fusion and at least five years follow-up, 59 patients (27 males, 32 females; mean age, 63.0±9.6 years) were enrolled, with 80.7±7.4 months(72-96 months) follow-up. Preoperative and final follow-up radiographs and MRI images were evaluated. BMI, preoperative and final follow-up ODI, JOA, VAS scores were collected. Final follow-up adjacent segment degeneration was evaluated on MRI and radiographs. Observation indexes included Pfirman's grades of adjacent discs, spinal stenosis, instability of segments, height of intervertebral space, osteophytes of anterior and posterior margins of vertebral bodies. The degree of pre-existing adjacent segment degeneration was evaluated by obliteration of anterior cerebrospinal fluid space and Pfirman's grades. If neurological symp

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第一作者简介:男(1986-),主治医师,研究方向:脊柱外科

电话:(010)82267368 E-mail:puh3_szzr@outlook.com

通讯作者:李危石 E-mail:wslee72@163.com

toms of lower extremities or low back pain were aggravated during the follow-up period, the adjacent segment disease(ASDis) were diagnosed. Influencing factors were compared between ASDis group and no ASDis group. Logistic regression analysis was used to analyze the risk factors of adjacent segment disease in final follow-up. **Results:** In the final follow-up, ASD were found in 38 cases(38/59, 64.4%), and 9 patients(9/59, 15.3%) were diagnosed ASDis. Forty patients (40/59, 67.8%) who had no obvious pre-existing stenosis at adjacent segments were rated as grade 0, 2 patients had ASDis at final follow-up. Nineteen patients(19/59, 32.2%) had mild pre-existing stenosis at adjacent segments, which were rated as grade 1, 7 patients had ASDis at final follow-up. The incidence of ASDis was significantly different between the two groups ($P=0.003$). Logistic regression analysis showed that the degree of pre-existing canal stenosis and length of fusion segments were risk factors for adjacent segment lesions. **Conclusions:** Compared with the degeneration of intervertebral disc, more attention should be paid to the evaluation of the degree of adjacent spinal canal stenosis, especially for the presence of mild spinal canal stenosis, which will significantly increase the risk of long-term adjacent segment disease.

[Key words] Adjacent segment disease; Pre-existing degeneration; Degree of canal stenosis; Disc degeneration

[Author's address] Orthopedics Department, Peking University Third Hospital, Beijing, 100191, China

在过往 10~20 年间,腰椎融合术呈现不断增长的趋势。尽管腰椎固定融合手术可以取得肯定的远期临床疗效^[1],但融合术后,融合节段相邻节段出现的退变(adjacent segment degeneration, ASD)始终困扰着研究者,对其病因和处理始终存在争议^[2,3]。ASD 为一种影像学改变,表现为手术相邻节段的椎间盘信号降低、椎间隙狭窄、新骨赘形成或原有骨赘增加等改变,有文献指出发病率为 11%~100%^[4]。当相邻节段退变在术后随访期进一步引起下肢放射性疼痛、间歇性跛行等神经症状或腰痛显著加重,就会形成相邻节段病变(adjacent segment disease, ASDis),严重影响手术的预后和患者的生活质量,甚至需要再次翻修手术治疗,而翻修手术往往难以取得与初次手术相同的临床疗效。

研究发现术前已经存在的拟融合节段的相邻节段退变是影响术后相邻节段退变加重的危险因素^[2]。但术前如何准确评价责任节段的相邻节段退变的程度,并且不同程度的退变对远期预后有何影响,目前尚无共识。笔者对远期随访的腰椎融合术后患者进行回顾性分析,比较术前相邻节段不同退变程度对远期预后的影响,分析术前何种程度的相邻节段退变会增加 ASDis 的风险。

1 资料与方法

1.1 一般资料

本研究资料为 2002 年 1 月~2010 年 12 月在我院因腰椎管狭窄症行后路减压、椎弓根螺钉固

定和植骨融合术的患者。纳入标准:(1)均融合至 S1,且融合节段数 ≤ 4 ;(2)至少完成 5 年以上随访;(3)无假关节形成;(4)术前无退变性腰椎侧凸畸形。共 59 例患者纳入研究(男性 27 例,女性 32 例),其中 5 例行 L5~S1 减压固定融合术,32 例行 L4~S1 减压固定融合术,16 例行 L3~S1 减压固定融合术,6 例行 L2~S1 减压固定融合术。所有患者末次随访时间为术后 80.7 ± 7.4 个月(72~96 个月),末次随访时年龄为 63.0 ± 9.6 岁(38~80 岁)。影像学资料包括术前及末次随访时的腰椎 MRI、腰椎正侧伸屈位 X 线片。收集患者体重指数(body mass index, BMI)、术前及末次随访时 Oswestry 功能障碍指数(Oswestry disability index, ODI)、日本骨科学会(Japanese Orthopedic Association, JOA)功能评分、腰痛及腿痛视觉模拟评分(visual analogue scale, VAS)。

1.2 手术方法

所有患者腰椎管狭窄症诊断明确,所有患者手术均在全麻下进行,采用经典的后路腰椎固定融合术,后路腰椎椎弓根螺钉内固定、椎板切除减压,术中注意保护头侧相邻节段关节突及关节囊,融合方式采用椎体间、横突间、后外侧植骨融合。

1.3 影像学评价

依据 Lee 等^[5]的腰椎管狭窄程度的 MRI 影像学分级,将患者术前融合节段的相邻节段椎管狭窄程度进行分级(图 1)。同时应用评价椎间盘退变程度的费尔曼(Pfirrmann)分级^[6],将患者术前融合阶段的相邻节段椎间盘退变程度进行分级(图

2)。

X线评估相邻节段退变的标准为:(1)伸屈位邻近节段椎体前后滑移超过 3mm,或者椎体活动角度 $>10^{\circ}$;(2)终板硬化,退变性侧凸;(3)椎间隙高度丢失超过 10%;(4)新骨赘形成或原有骨赘增加 3mm 以上。

末次随访时,只要出现相邻节段椎管狭窄程度、椎间盘退变程度加重,或出现 X 线上符合相邻节段退变标准的改变,均诊断为 ASD。同时,若再次出现下肢神经症状、腰痛显著加重,结合影像上退变表现,则诊断为 ASDis。

1.4 统计学方法

应用 SPSS 17.0 软件对测量结果进行统计学处理,记录末次随访时 ASD 和 ASDis 情况;以末次随访是否出现 ASDis 分组,比较每组间年龄、性别、BMI、吸烟、糖尿病、融合节段数、术前相邻节段椎管形态、术前相邻椎间盘费尔曼分级、术前及末次随访临床评分进行比较(独立样本 t 检验, Fisher 精确检验)。应用 Logistic 回归分析,分析影响末次随访时 ASDis 的独立危险因素。 $P<0.05$ 为有统计学意义。

2 结果

末次随访时,共 38 例患者(38/59,64.4%)出现影像学上 ASDis,其中 9 例患者(9/59,15.3%)在术后随访中再次出现下肢神经症状加重或腰痛加重,诊断为 ASDis,且均为相邻节段再次出现明显中央管狭窄,且均保守治疗,未进行翻修手术。4 例患者术前相邻节段椎间盘费尔曼分级为 2 级(6.8%),31 例为 3 级(52.5%),23 例为 4 级(39.0%),1 例为 5 级(1.7%)。共 40 例患者(40/59,67.8%)术前相邻节段椎管无明显狭窄,评为 0 级,共 19 例患者(19/59,32.2%)术前相邻节段椎管存在轻度狭窄,评为 1 级。其中术前相邻节段为椎管形态为 0 级的患者中,2 例末次随访时出现 ASDis。术前椎管形态为 1 级的患者中,7 例末次随访时出现 ASDis(图 3)。

以末次随访是否出现 ASDis 分组,组间年龄、性别、BMI、吸烟、糖尿病、融合节段数、术前相邻节段椎管形态、术前相邻椎间盘费尔曼分级、术前及末次随访临床评分比较情况见表 1。组间年龄、性别分布、是否吸烟、糖尿病状态、BMI、术前相邻椎间盘费尔曼分级没有显著差异($P>0.05$),但

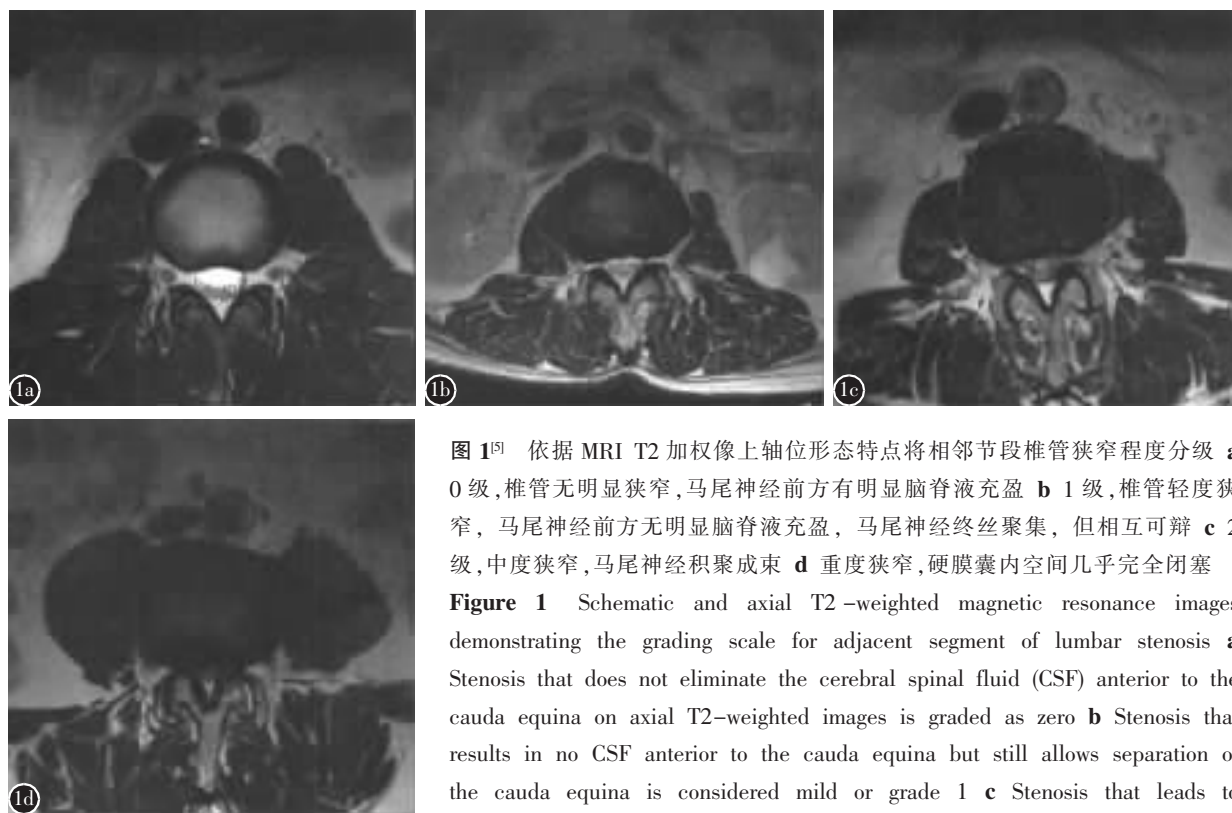


图 1^[5] 依据 MRI T2 加权像上轴位形态特点将相邻节段椎管狭窄程度分级 **a** 0 级,椎管无明显狭窄,马尾神经前方有明显脑脊液充盈 **b** 1 级,椎管轻度狭窄,马尾神经前方无明显脑脊液充盈,马尾神经终丝聚集,但相互可辨 **c** 2 级,中度狭窄,马尾神经积聚成束 **d** 重度狭窄,硬膜囊内空间几乎完全闭塞

Figure 1 Schematic and axial T2-weighted magnetic resonance images demonstrating the grading scale for adjacent segment of lumbar stenosis **a** Stenosis that does not eliminate the cerebral spinal fluid (CSF) anterior to the cauda equina on axial T2-weighted images is graded as zero **b** Stenosis that results in no CSF anterior to the cauda equina but still allows separation of the cauda equina is considered mild or grade 1 **c** Stenosis that leads to some cauda equina bunching is considered moderate or grade 2 **d** Stenosis that leads to no space between the elements of the cauda equina is considered severe or grade 3

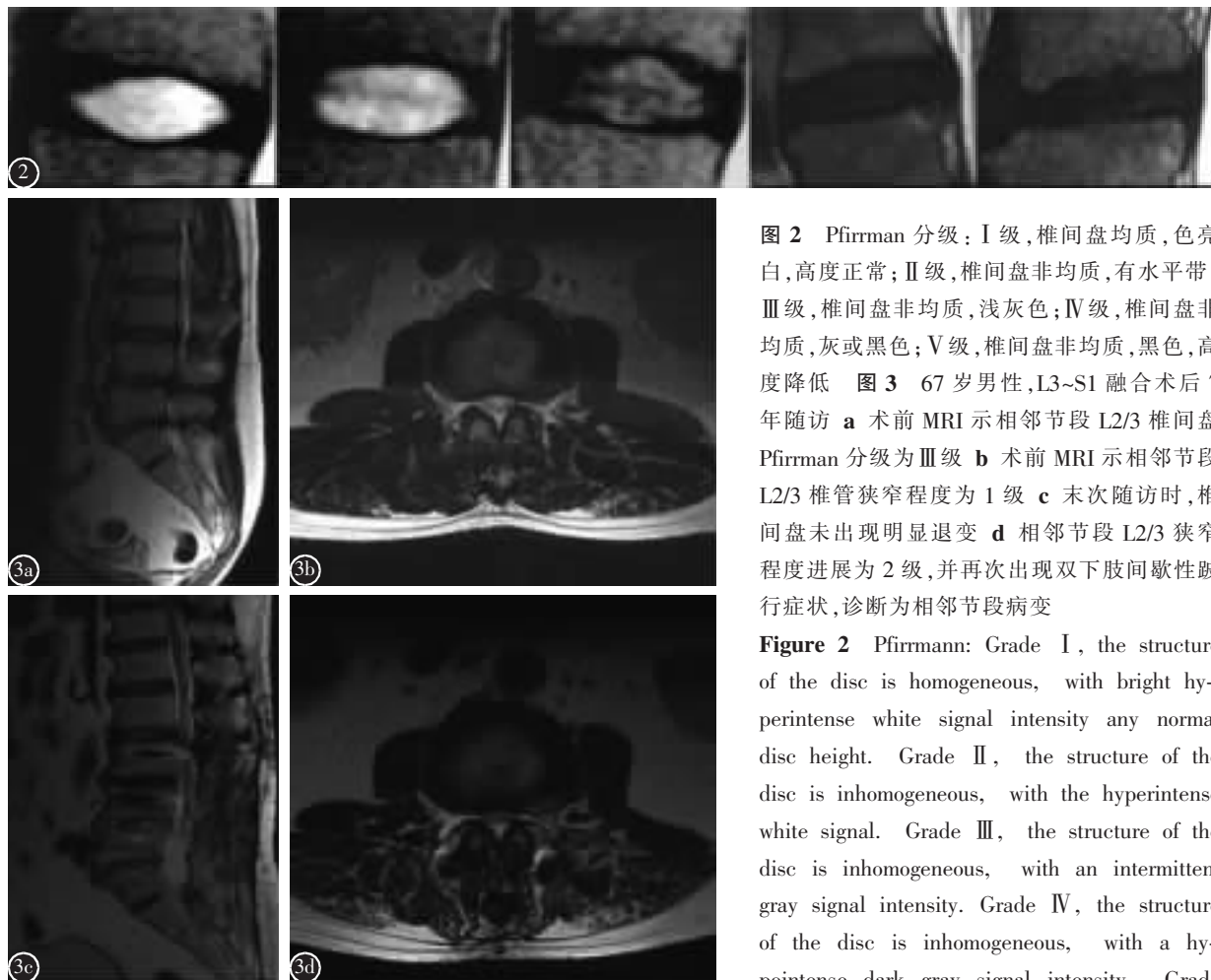


图 2 Pfirrmann 分级: I 级,椎间盘均质,色亮白,高度正常;II 级,椎间盘非均质,有水平带;III 级,椎间盘非均质,浅灰色;IV 级,椎间盘非均质,灰或黑色;V 级,椎间盘非均质,黑色,高度降低 **图 3** 67 岁男性, L3~S1 融合术后 7 年随访 **a** 术前 MRI 示相邻节段 L2/3 椎间盘 Pfirrmann 分级为 III 级 **b** 术前 MRI 示相邻节段 L2/3 椎管狭窄程度为 1 级 **c** 末次随访时,椎间盘未出现明显退变 **d** 相邻节段 L2/3 狭窄程度进展为 2 级,并再次出现双下肢间歇性跛行症状,诊断为相邻节段病变

Figure 2 Pfirrmann: Grade I, the structure of the disc is homogeneous, with bright hyperintense white signal intensity any normal disc height. Grade II, the structure of the disc is inhomogeneous, with the hyperintense white signal. Grade III, the structure of the disc is inhomogeneous, with an intermittent gray signal intensity. Grade IV, the structure of the disc is inhomogeneous, with a hypointense dark gray signal intensity. Grade V, the structure of the disc is inhomogeneous, with a hypointense black signal intensity

Figure 3 Male with sixty-seven years old, 7 years follow-up after L3-S1 fusion **a** Preoperative MRI of L2/3 showed adjacent disc grade as III of Pfirrmann **b** Preoperative MRI of L2/3 showed stenosis grade as 1 **c** At final follow-up, there was no significant change of L2/3 disc degeneration **d** MRI showed L2/3 stenosis grade as 2, patient had recurrence of intermittent claudication, and was diagnosed as ASDis

ASDis 组术前相邻节段椎管形态存在显著差异 ($P < 0.05$), MRI 分级 1 级(椎管轻度狭窄, 马尾神经积聚, 前方无明显脑脊液充盈)的患者显著多于非 ASDis 组。两组间术前 ODI、JOA、VAS(腰)评分无显著差异, 末次随访时, ASDis 组临床功能评分显著差于非 ASDis 组 (ODI、JOA, $P < 0.05$), ASDis 组腰痛更明显 ($P < 0.05$), ASDis 组 VAS(腿)评分高于非 ASDis 组, 但尚未达到显著性差异 ($P = 0.11$)。

Logistic 回归分析表明, 术前相邻节段椎管的狭窄程度与融合节段长短为影响 ASDis 的独立危险因素(表 2)。

3 讨论

在过往 20 余年的时间内, 腰椎融合术后相邻节段退变现象在越来越多的研究中得到证实。无论是动物实验^[7,8], 还是在体的模拟实验^[9-11], 都从生物力学角度验证了脊柱融合术后分布于相邻节段的应力会显著增加, 提示 ASD 更多与融合因素本身相关。一些研究^[12-15]同时采用了 X 线与 MRI 对腰椎融合术后进行 5 年以上远期随访, ASD 发生率在 36%~84%, ASDis 发生率在 0~24%, 由此可见, 腰椎融合术后影像学上的相邻节段退变是普遍存在的现象, 而临床医生更多关注的是与患者预后密切相关的相邻节段病变。尽管形成 ASDis 的病因始终存在争议, 目前大多数研究认

为,ASDis 不是由单一病因所导致的,包括年龄、性别、术前邻近节段退行性改变、固定长度、融合

表 1 ASDis 组与非 ASDis 组数据比较

Table 1 The comparison of data between ASDis group and N-ASDis group

因素 Factors	ASDis组 (n=9) ASDis group	非 ASDis 组 (n=50) N-ASDis group
年龄(岁)/Age(Year)	66.44±7.99	62.40±9.79
性别(男/女) Sex(Male/Female)	6/3	21/29
吸烟(否/是) Smoking(No/Yes)	8/1	42/2
糖尿病(否/是) Diabetes(No/Yes)	7/2	44/6
融合节段数 Fusion length	3.00±0.71	2.28±0.76 ^①
体重指数/BMI	26.14±3.05	26.03±3.64
术前Pfirman分级 Pre-Pfirman's grade	3.6±0.5	3.3±0.6
术前椎管形态(0级/1级) Pre-existing stenosis grade	2/7	38/12 ^①
术前 ODI Preoperative ODI	50.89±24.42	52.18±23.33
术前 JOA Preoperative JOA	12.62±8.85	11.29±6.32
术前 VAS(腰) Preoperative VAS(Low back)	7.63±2.26	5.60±2.83 ^①
术前 VAS(腿) Preoperative VAS (Leg)	5.25±2.92	7.16±1.99 ^①
随访 ODI Follow-up ODI	36.44±21.07	18.16±17.08 ^①
随访 JOA Follow-up JOA	17.22±5.97	22.88±4.98 ^①
随访 VAS(腰) Follow-up VAS(Low back)	5.22±2.86	2.58±2.21 ^①
随访 VAS(腿) Follow-up VAS(Leg)	3.78±2.77	2.16±2.74

注:①与ASDis组比较 $P<0.05$

Note: ①Compared with ASDis group, $P<0.05$

表 2 ASDis 影响因素分析(Logistic 回归)

Table 2 Logistic regression analysis of influencing factors of ASDis

因素 Factors	比值比 OR	95%置信区间 95% CI	显著性 Significance
术前相邻节段椎管形态 Pre-existing stenosis grade	706.88	4.20~>500	0.01
年龄/Age	1.00	0.81~1.23	0.99
体重指数/BMI	0.83	0.57~1.20	0.31
吸烟/Smoking	364.55	0.35~>500	0.10
糖尿病/Diabetes	9.95	0.38~262.42	0.17
融合节段数 Fusion length	20.26	1.52~273.45	0.02
术前 Pfirman 分级 Pre-existing adjacent disc Pfirman's grade	10.60	0.65~174.18	0.10

方式、矢状位序列等在内的多种因素都可能参与了 ASDis 的病因^[6]。其中,术前相邻节段已经存在的退变因素会给手术策略的制定带来挑战。由于需要融合手术治疗的腰椎退变性疾病越来越多的为中老年人群,往往术前多个节段均存在不同程度的退变甚至椎间盘突出,而致病责任节段可能只是其中的某一个。单纯处理责任节段可局限手术范围,但是存在发生术后相邻节段退变加重的风险;如果在融合责任节段的基础上,将其相邻的存在退变的节段一并融合,虽然消除了此相邻节段术后发生退变的可能性,但是增加了融合节段数量,不仅加大了手术创伤,增加了医疗费用,而且增加融合节段后其相邻节段同样面临着因融合节段数量增加而带来的退变风险。所以,有必要深入研究术前相邻节段退变程度对远期预后的影响,以及如何判断相邻节段退变的程度。

Okuda 等^[7]对 87 例 L4/5 融合术后患者进行了 2 年的随访研究,发现术前 L3/4 椎间盘退变的程度与末次随访时 ASD 及 ASDis 无关。Throckmorton 等^[8]同样通过回顾性研究发现,邻近节段椎间盘退变的程度与临床症状无关。Lee 等^[15]对腰椎融合术后至少 1 年随访的患者进行回顾性研究,发现在 1069 例患者中,出现 ASDis 患者为 28 例(2.62%),应用费尔曼分级评价术前相邻节段椎间盘退变的程度并不是影响 ASDis 的危险因素(Logistic 回归, $P=0.17$),而应用小关节退变程度分级,发现小关节退变的程度是影响 ASDis 的危险因素($P<0.01$),而小关节退变程度加重正是导致椎管狭窄的因素。Anandjiwala 等^[19]对 74 例腰椎融合术患者进行了 5 年以上前瞻性随访研究,发现术前相邻节段椎间盘的退变是术后出现影像学上相邻节段退变的危险因素,但并没有发现术前相邻节段椎间盘退变的程度与末次随访时患者的临床症状相关。上述研究表明,术前椎间盘退变的程度与患者远期临床症状间无明显相关性,也并不是导致相邻节段病变的危险因素,这与本研究的结果是一致的,分析其原因可能为术后 ASDis 的发生与椎管狭窄导致的神经压迫关系密切,因此应评估术前相邻节段椎管的整体的退变情况,而非单纯分析椎间盘的退变程度,即术前相邻节段椎间盘的退变程度不能够完整代表术前邻近节段的退变状态。

Nakashima 等^[20]对 101 例腰椎融合术患者进

行了 10 年的随访研究,发现术前相邻节段椎间盘的退变并不是影响相邻节段病变的危险因素。该研究同时探讨了术前椎管狭窄的程度对相邻节段病变的影响,应用矢状位上椎管的有效径与椎管直径的比值判断椎管狭窄的程度^[21],并没有发现其与 ASDis 有关(Logistic 回归分析, $P=0.38$)。由于单纯从矢状位上无法准确判断椎管狭窄引起的马尾神经积聚、受压程度,故这可能是没有发现其与术后相邻节段病变存在相关性的原因。由于椎管狭窄引起的马尾神经积聚、受压是引起下肢神经症状的原因,本研究中,我们采用 Lee 等^[9]提出的 MRI 上椎管狭窄程度的分级。该分级系统简洁、直观,观察者内与观察者间信度高。并且 Park 等^[22]在 160 名人群中分析了验证了该分级系统与临床症状间存在显著相关性,尤其对于中老年患者,0 级几乎不会引起临床症状,2、3 级多数患者会出现症状。1 级的椎管狭窄程度与临床症状间的相关性尚存不确定性。Schizas 等^[23]同样依据硬膜囊内马尾神经与脑脊液的形态与分布将椎管狭窄程度进行分级,分为 A 级(A1-A4)、B 级、C 级、D 级。通过 95 例患者研究发现,C 级与 D 级患者更多需要手术治疗,而 A 级与 B 级患者很少需要手术治疗,即使存在症状,保守治疗也可取得较好的临床疗效,而该分级中的 A 级(A1-A4)、B 级与 Lee 分型中的 0 级、1 级相似,C 级、D 级与 Lee 分型中的 2 级、3 级相似。正是基于此,我们采用 Lee 分级系统,较 Schizas 分级更为简便,而术前的相邻节段椎管形态全部为 0 级与 1 级,其中 1 级与临床症状间的不确定性正是手术策略制定所面临的难题。通过 Logistic 回归分析,术前轻度的椎管狭窄造成马尾神经积聚,并且马尾终丝前方无明显脑脊液充盈状态下(分型 1 级),正是形成相邻节段病变的危险因素。因此,若术前相邻节段椎管处于上述状态,需要警惕远期相邻节段病变的发生,是否需要预防性融合或采用 Topping-off 技术来保护轻度退变的相邻节段,值得深入研究。

本研究发现融合节段数的增加,会显著增加 ASDis 的风险,一些研究^[24-26]同样得出了相似的结论。分析其原因,当融合至骶骨后,腰椎固定节段与骶骨共同组成无法运动的整体,使得在机体活动时,腰椎剩余的上相邻节段会通过更多的代偿运动以尽量维持生理性的活动范围。当融合至 S1 后,越长的融合节段,形成越长的杠杆力臂,会导

致近端相邻节段的应力分布明显增加^[27,28],尤其是患者只剩下了近端的相邻节段,使得应力更为集中^[29],加速了相邻节段的不稳定与退变进程,显著增加了相邻节段病变的风险。

通过本研究,我们首次将椎管内脑脊液闭塞程度应用于术前相邻节段椎管狭窄的评估。对于术前相邻节段存在轻度的椎管狭窄因素,即马尾神经积聚并且无明显脑脊液充盈时,会显著增加相邻节段病变的风险。相较于相邻椎间盘的退变,应重视相邻节段椎管整体狭窄程度的评估,警惕术后中长期 ASDis 的发生。

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(英文编审 孙浩林/贾丹彤)

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