

腰椎后路单节段固定融合术后邻近节段 关节突关节退变的随访观察

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【摘要】目的:分析单节段后路腰椎固定融合(PLIF)术后邻近节段关节突关节(facet joint, FJ)退变的影像学特征,探讨 PLIF 对融合邻近节段 FJ 退变的影响。**方法:**选取 2005 年 1 月~2014 年 1 月采用单节段 PLIF 或单纯髓核摘除术治疗的患者共 84 例,其中 PLIF 组(A 组)44 例,手术邻近节段共 140 个关节突关节;髓核摘除组(B 组)40 例,手术邻近节段共 122 个关节突关节。观察两组患者手术前后病变邻近节段 FJ 的 CT 和 MRI 影像学特征及退变发生率,依据 Weishaupt 分级系统对 FJ 进行分级,采用行平均分差检验,对两组患者手术前后病变邻近节段 FJ 的退变程度进行组内和组间比较。**结果:**两组患者的性别比、年龄、随访时间及手术节段差异均无统计学意义($P>0.05$)。FJ 退变常见的影像学表现为骨赘形成、关节间隙狭窄、软骨下骨的侵蚀、软骨下囊肿、关节突关节对位不良、关节突关节空气征、关节突关节积液、关节突再塑形以及关节突关节融合。A 组术前关节间隙狭窄、软骨下骨的侵蚀发生率分别为 52.9%、31.4%,术后为 75.7%、62.1%;B 组术前关节间隙狭窄、软骨下骨的侵蚀发生率分别为 51.6%、30.3%,术后为 63.9%、50%。两组患者关节间隙狭窄、软骨下骨的侵蚀术前发生率无统计学差异;术后两组发生率均较术前显著性增加($P<0.05$),且两组间比较差异有统计学意义($P<0.05$)。按照 Weishaupt 分级, A 组 140 个关节突关节中,术前 0 级 3 个,1 级 95 个,2 级 34 个,3 级 8 个,退变发生率为 97.9%;术后 0 级 1 个,1 级 49 个,2 级 59 个,3 级 31 个,退变发生率为 99.3%;B 组 122 个关节突关节中,术前 0 级 4 个,1 级 82 个,2 级 30 个,3 级 6 个,退变发生率为 96.7%;术后 0 级 2 个,1 级 60 个,2 级 39 个,3 级 21 个,退变发生率为 98.4%,两组手术前后退变发生率差异均无统计学意义($P>0.05$)。采用行平均分差检验,两组患者组内手术前后对比,术后退变程度加重,与术前比较均有统计学差异($P<0.05$);两组间比较, A 组术前 FJ 退变程度与 B 组术前无统计学差异($P>0.05$);但 A 组术后 FJ 退变程度评分较 B 组术后评分高,差异有统计学意义($P<0.05$)。**结论:**腰椎后路单节段固定融合术可能会加速邻近节段关节突关节的退变,以关节间隙狭窄和软骨下骨的侵蚀最为常见。

【关键词】腰椎;脊柱融合术;邻近节段退变;关节突关节;随访研究

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Adjacent facet joint degeneration after posterior single-level lumbar fusion: a mid-term follow-up/
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【Abstract】 Objectives: To analyze the degenerative imaging features of adjacent facet joints after posterior single-level lumbar interbody fusion(PLIF), and to discuss the effect of PLIF on the degeneration of adjacent facet joints. **Methods:** From January 2005 to January 2014, 84 patients who underwent single-level PLIF (group A) or mere discectomy(group B) were collected. There were 44 patients with 140 adjacent facet joints in group A and 40 patients with 122 adjacent facet joints in group B. The degenerative imaging features and the incidence of adjacent facet joint were investigated on CT and MRI before and after surgery. The degenerative degree of facet joint was evaluated by Weishaupt grading system, analyzed by Cochran-Mantel-Haenszel statistics and compared within and between groups. **Results:** There was no statistical difference in sex ratio,

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age, follow-up time or surgical segment between the two groups($P>0.05$). The common radiographic appearances of facet joint degeneration were osteophyte formation, joint-space narrowing, subchondral erosion, subchondral cyst, joint malalignment, joint-space vacuum phenomenon, joint effusion, joint remodeling and joint fusion. The preoperative incidence of joint-space narrowing and subchondral erosion in group A was 52.9% and 31.4%, and increased to 75.7% and 62.1% postoperatively; that was 51.6% and 30.3% in group B preoperatively, and increased to 63.9% and 50% postoperatively. The incidence of joint-space narrowing and subchondral erosion between the two groups had no significant difference preoperatively ($P>0.05$), but it increased and had a significant difference between the two groups($P<0.05$). According to Weishaupt grading system, among 140 joint facet joints in group A, 3 were of grade 0, 95 were of grade 1, 34 were of grade 2, 8 were of grade 3, with a degenerative incidence of 97.9% before surgery. While after surgery, 1 was of grade 0, 49 were of grade 1, 59 were of grade 2, 31 were of grade 3, with a degenerative incidence of 99.3%. Among 122 joint facet joints in group B, 4 were of grade 0, 82 were of grade 1, 30 were of grade 2, 6 were of grade 3, with a degenerative incidence of 96.7% before surgery. While after surgery, 2 were of grade 0, 60 were of grade 1, 39 were of grade 2, 21 were of grade 3, with a degenerative incidence of 98.4%. There was no significant difference of degenerative incidence before and after surgery in the two groups ($P>0.05$). Analyzed by Cochran-Mantel-Haenszel statistics, the degenerative degree of facet joint in the two groups aggravated after surgery, with a significant difference compared with that before surgery. The preoperative degenerative degree of facet joint had no significant difference between the two groups($P>0.05$), while the postoperative degenerative degree had a significant difference ($P<0.05$), with more severe degenerative degree in patients of group A. **Conclusions:** The adjacent facet joint degeneration may accelerate after posterior single-level lumbar fusion, which most commonly shows as joint-space narrowing and subchondral erosion.

[Key words] Lumbar; Spinal fusion; Adjacent segment degeneration; Facet joint; Follow-up study

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腰椎后路减压椎间融合术应用于腰椎退行性疾病的治疗取得了良好的效果,但腰椎融合术后邻近节段退行性变或加剧已存在的脊柱退行性变的问题也越来越多地引起学者们的关注^[1-3]。尽管其确切的机制目前尚未完全明确,但多数学者认为腰椎融合术后邻近节段活动度异常增大、椎间盘内压力增高以及关节突负荷增大等是导致邻近节段退变的主要原因^[4]。近年来针对腰椎融合术后邻近节段退变的研究多聚焦于椎间盘的退变,而对关节突关节(facet joint,FJ)的退变缺乏足够的研究。本研究通过观察 2005 年 1 月~2014 年 1 月在我院行腰椎后路椎间融合术 (posterior lumbar interbody fusion,PLIF) 和后路单纯髓核摘除术患者的影像学资料,分析单节段 PLIF 与单纯髓核摘除术后邻近节段 FJ 退变的影像学特征,探讨 PLIF 对融合邻近节段 FJ 退变的影响。

1 资料和方法

1.1 一般资料

患者纳入研究的标准:采用后路椎管减压单节段椎间融合椎弓根螺钉固定术或后路椎管减压

单节段髓核摘除术患者,术前及术后末次随访具有完整的腰椎 CT 及 MRI 检查资料,并且随访时间 ≥ 36 个月。融合固定组(A组)共 44 例患者(140 个关节突关节)获得随访,髓核摘除组(B组)共 40 例患者(122 个关节突关节)获得随访。两组患者的年龄、性别、随访时间、手术节段见表 1,差异无统计学意义。

表 1 两组患者一般资料比较

Table 1 Comparison of two groups of patients with general information

	A组(n=44) Group A	B组(n=40) Group B	P值 P value
男/女 Male/Female	22/22	18/22	>0.05
年龄(岁) Age(year)	53.4 $\pm$ 4.9 28~80	56.8 $\pm$ 5.3 22~85	>0.05
随访时间(月) Follow-up time(month)	44.9 $\pm$ 5.1 36~62	48.3 $\pm$ 4.6 37~70	>0.05
手术节段(例数) Surgical segment(n)			>0.05
L1/2	1	0	
L3/4	0	1	
L4/5	25	20	
L5/S1	18	19	

1.2 研究方法

所有患者术前和术后末次随访时均有完整腰椎 CT 及 MRI 检查,根据影像学资料共观察 A 组 140 个 (T12/L1 2 个、L2/3 2 个、L3/4 50 个、L4/5 36 个、L5/S1 50 个)、B 组 122 个 (L2/3 2 个、L3/4 40 个、L4/5 40 个、L5/S1 40 个)FJ 的影像学特征及退变的发生率。将关节突关节退变按 Weishaupt 标准^[9]分为 4 级:0 级,关节间隙正常(2mm);1 级,关节间隙变窄(<2mm),伴或不伴有关节突肥大,伴或不伴有轻微骨赘形成;2 级,关节间隙变窄(<2mm),中度关节突肥大,伴或不伴有中度骨赘形成,少量软骨下骨侵蚀;3 级,关节间隙变窄(<2mm),重度关节突肥大,伴或不伴有巨大骨赘形成,严重软骨下骨侵蚀,伴有或不伴有软骨下囊肿。0 级为正常,1~3 级为退变,退变的发生率为 1~3 级 FJ 数量/FJ 总数。由 1 名骨科医生和 1 名影像科医生分别独立进行观察评估,若结果不一致,与第 3 名医生共同讨论后得出一致结果。依据 Weishaupt 分级结果,对比手术前后 FJ 退变的情况。

1.3 统计方法

应用 SAS 9.4 统计软件进行分析,对计数资料采用卡方检验,理论频数 ≤ 5 时,采用 Fisher 精确概率检验法;对两组患者手术前后 Weishaupt 分级的单项有序资料采用行平均分差检验。 $P < 0.05$ 表示差异具有统计学意义。

2 结果

2.1 FJ 退变的影像学特征

CT 及 MRI 上 FJ 退变常见的影像学表现为骨赘形成、关节间隙狭窄、软骨下骨的侵蚀、软骨下囊肿、关节突关节对位不良、关节突关节空气征、关节突关节积液、关节突再塑形、关节突关节融合(图 1)。两组患者手术邻近节段 FJ 退变的影像学特征分布见表 2。其中 A 组术前关节间隙狭窄、软骨下骨的侵蚀发生率分别为 52.9%、31.4%,术后为 75.7%、62.1%;B 组术前关节间隙狭窄、软骨下骨的侵蚀发生率分别为 51.6%、30.3%,术后为 63.9%、50%。两组患者关节间隙狭窄、软骨下骨的侵蚀术前发生率无统计学差异 ($P > 0.05$),术后两组发生率与术前比较均明显增高,且 A 组较 B 组高,差异均有统计学意义 ($P < 0.05$)。其余各影像学表现,两组手术前后对比均无统计学差异

($P > 0.05$)。

2.2 手术邻近节段 FJ 退变情况

两组患者手术前后手术邻近节段 FJ 退变情况见表 3、4。按照 Weishaupt 分级,A 组手术邻近节段 140 个关节突关节中,术前 0 级 3 个,1 级 95 个,2 级 34 个,3 级 8 个,退变发生率为 97.9%;术后 0 级 1 个,1 级 49 个,2 级 59 个,3 级 31 个,退变发生率为 99.3%,手术前后退变发生率差异无统计学意义 ($P > 0.05$)。髓核摘除组(B 组)手术邻近节段 122 个关节突关节中,术前 0 级 4 个,1 级 82 个,2 级 30 个,3 级 6 个,退变发生率为 96.7%;术后 0 级 2 个,1 级 60 个,2 级 39 个,3 级 21 个,退变发生率为 98.4%,手术前后退变发生率差异无统计学意义 ($P > 0.05$);A 组中 FJ 由 0 级退变为 1 级 2 个,1 级退变为 2 级 38 个,1 级退变为 3 级 10 个,2 级退变为 3 级 13 个;B 组中 FJ 由 0 级退变为 1 级 1 个,0 级退变为 2 级 1 个,1 级退变为 2 级 18 个,1 级退变为 3 级 5 个,2 级退变为 3 级 10 个。采用行平均分差检验分别对 A 组、B 组手术前后 FJ 退变程度进行评估,两组患者术后退变程度较术前均明显加重,差异均有统计学意义 ($P < 0.0001$);A 组术前 FJ 退变程度与 B 组术前比较差异无统计学意义;但 A 组术后 FJ 退变程度更为严重,与 B 组术后比较有统计学差异。

3 讨论

随着腰椎融合术的广泛应用,术后邻近节段退变导致邻椎病的问题也愈显突出。邻近节段退变包括:脊柱不稳、椎体滑脱、椎管狭窄、椎间盘突出、椎体压缩性骨折、关节突肥大和骨关节炎等。腰椎融合术后邻近节段退变发生的确切机制目前尚未完全明确,但多数学者认为包括年龄、性别、内固定方式、融合节段的长短、骨质疏松情况、术后脊柱矢状面及冠状面的平衡、术前存在的退变、手术对相邻椎间小关节的破坏等多方面因素均可能影响邻近节段退变^[6-8]。邻近节段退变常常导致患者出现再发的腰痛与功能障碍,严重时需要再次行手术治疗。目前学者对腰椎融合术后邻近节段退变研究的关注点多集中于椎间盘的退变、椎间隙高度的丢失、脊柱的失稳等方面,对 FJ 的退变缺乏深入的研究。

由于 FJ 对脊柱后侧提供负荷支持,在腰背部屈伸活动中能够限制腰椎的轴向旋转并阻止腰椎

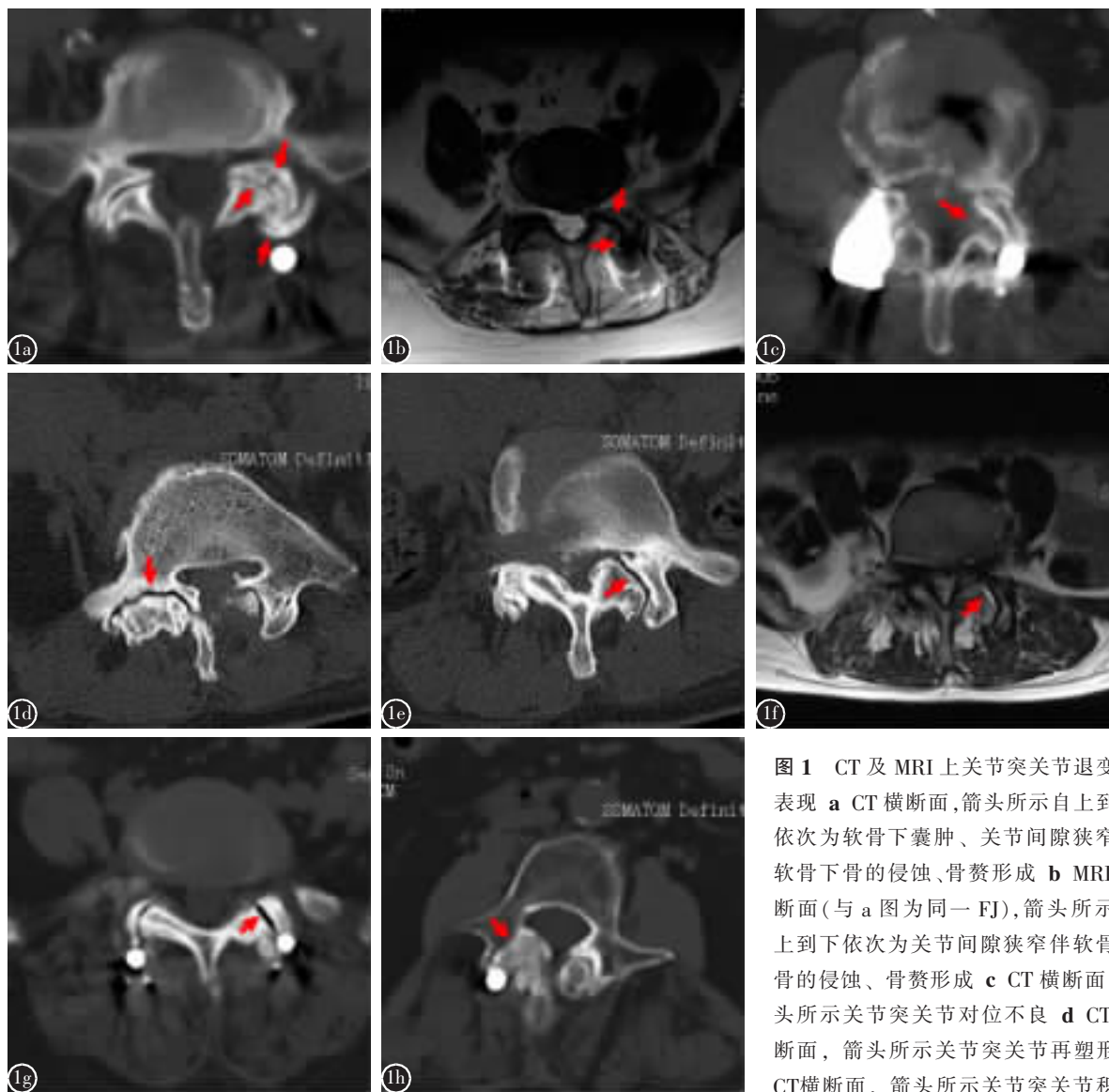


图 1 CT 及 MRI 上关节突关节退变的表现 a CT 横断面, 箭头所示自上到下依次为软骨下囊肿、关节间隙狭窄伴软骨下骨的侵蚀、骨赘形成 b MRI 横断面(与 a 图为同一 FJ), 箭头所示自上到下依次为关节间隙狭窄伴软骨下骨的侵蚀、骨赘形成 c CT 横断面, 箭头所示关节突关节对位不良 d CT 横断面, 箭头所示关节突关节再塑形 e CT 横断面, 箭头所示关节突关节积液

f MRI 横断面(与 e 图为同一 FJ), 箭头所示关节突关节积液 g CT 横断面, 箭头所示关节突关节空气征 h CT 横断面, 箭头所示关节突关节融合

Figure 1 CT and MRI features of facet joint degeneration a Axial CT imaging of FJ, from top to bottom as indicated by the arrows, subchondral cyst, joint-space narrowing with subchondral erosion, and osteophyte formation b Axial MRI imaging of FJ (the same facet joint showed in figure a), from top to bottom as indicated by the arrows, joint-space narrowing with subchondral erosion, and osteophyte formation c Axial CT imaging of FJ, joint malalignment as indicated by the arrow d Axial CT imaging of FJ, joint remodeling as indicated by the arrow e Axial CT imaging of FJ, joint effusion as indicated by the arrow f Axial MRI imaging of FJ (the same facet joint showed in figure e), joint effusion as indicated by the arrow g Axial CT imaging of FJ, joint-space vacuum phenomenon as indicated by the arrow h Axial CT imaging of FJ, joint fusion as indicated by the arrow

前移,在传导脊柱负荷中扮演重要角色。关节突关节的关节囊、软骨下骨和滑膜有丰富的神经支配,是腰痛潜在的病因。大量的放射学和骨科学者通过关节内和关节周围的证据证明,疼痛可起源于 FJ^[9]。在主诉背痛的患者中腰椎 FJ 疼痛的发生率

为 7%~75%^[10],在腰痛人群中 FJ 退变的发生率为 37.6%~43.3%^[11-13]。杨勇等^[14]的研究发现,腰椎 FJ 的影像学退变 Weishaupt 分级与腰痛患者疼痛及功能障碍评估之间均存在相关性,不同程度的腰椎 FJ 退变在腰痛患者中可能导致不同程度的腰

表 2 两组患者手术邻近节段 FJ 退变的影像学特征

Table 2 Degenerative imaging features of the adjacent facet joint of two groups

影像学表现 imaging features	A组(n=140) Group A		B组(n=122) Group B	
	术前 (例数) Preopera- tion(n)	术后 (例数) Postopera- tion(n)	术前 (例数) Preopera- tion(n)	术后 (例数) Postopera- tion(n)
骨赘形成 Osteophyte formation	121	130	103	110
关节间隙狭窄 Joint-space narrowing	74	106 ^①	63	78 ^{①②}
软骨下骨的侵蚀 Subchondral erosion	44	87 ^①	37	61 ^{①②}
软骨下囊肿 Subchondral cyst	3	8	3	4
关节对位不良 Joint malalignment	1	5	1	6
关节突空气征 Joint-space vacuum phenomenon	2	5	1	3
关节突积液 Joint effusion	0	2	1	2
关节突再塑形 Joint remodeling	1	1	1	1
关节突关节融合 Joint fusion	0	1	0	0

注:①与同组术前比较 $P<0.05$;②与 A 组术后比较 $P<0.05$ Note: ①Compared with preoperation of the same group, $P<0.05$; ②Compared with postoperation of group A, $P<0.05$

背痛、下肢痛及功能障碍。由此可见, FJ 退变是邻椎病的一个重要临床表现, 其作用不容小觑, FJ 的退变将影响患者术后功能的恢复。本研究中我们观察发现, 两组患者术前 FJ 的退变已广泛存在, 术后末次随访时两组退变发生率均有上升, 但差异无统计学意义; Weishaupt 分级对患者 FJ 退变程度定量分析发现, 两组患者术后退变程度较术前均明显加重。值得注意的是, 术前髓核摘除组患者退变程度评分与融合固定组相比差异无统计学意义, 但术后两组患者退变程度评分出现统计学差异, 这一结果提示病变节段的椎间融合内固定加速邻近节段 FJ 的退变。

FJ 退变发生的机制包括机械外力导致关节软骨负荷过重; 炎症等因素导致软骨内环境的调控机制受到破坏, 细胞外基质降解破坏; 关节滑膜破坏、供应关节的血管破坏。腰椎融合术改变了邻近节段的生物力学, 增加了小关节载荷, 关节软骨退变形成局部病灶, 导致关节间隙狭窄, 然后逐渐侵蚀软骨下骨。生物力学的改变能够促使关节囊

表 3 A 组手术前后邻近节段 FJ 退变的 Weishaupt 分级

Table 3 Adjacent facet joint degeneration evaluated by Weishaupt grading system preoperation and postoperation of group A

术前分级 Preoperative grade	个数 (n)	术后分级(个) Postoperative grade (n)			
		0级 Grade 0	1级 Grade 1	2级 Grade 2	3级 Grade 3
0级 Grade 0	3	1	2	/	/
1级 Grade 1	95	/	47	38	10
2级 Grade 2	34	/	/	21	13
3级 Grade 3	8	/	/	/	8

表 4 B 组手术前后邻近节段 FJ 退变的 Weishaupt 分级

Table 4 Adjacent facet joint degeneration evaluated by Weishaupt grading system preoperation and postoperation of group B

术前分级 Preoperative grade	个数 (n)	术后分级(个) Postoperative grade(n)			
		0级 Grade 0	1级 Grade 1	2级 Grade 2	3级 Grade 3
0级 Grade 0	4	2	1	1	/
1级 Grade 1	82	/	59	18	5
2级 Grade 2	30	/	/	20	10
3级 Grade 3	6	/	/	/	6

附件纤维软骨化生形成骨赘、关节突的肥大。三关节(椎间盘和 2 个关节突关节)失稳可能导致退变性不稳定(包括退变性脊椎滑脱和脊柱侧凸)。我们在影像学上观察到 FJ 退变表现为骨赘形成、关节间隙狭窄、软骨下骨的侵蚀、软骨下囊肿、对位不良、关节空气征、关节积液、关节突再塑形以及关节突关节融合。统计分析发现关节间隙狭窄、软骨下骨的侵蚀在两组患者术前发生率无统计学差异, 术后发生率增高且两组间差异有统计学意义, 这可能与融合术后生物力学改变有关。相反, 影像学表现最常见的骨赘形成, 在手术后发生率并无明显增加, 这可能是由于本研究中患者术前骨赘形成已广泛存在, 现有的 Weishaupt 分级仅按照轻微、中度及巨大骨赘进行简单划分, 并未对关节突骨赘大小进行定量分析, 从而导致手术前后骨赘形成的发生率并无统计学差异。

关节突骨赘的形成主要集中在上关节突的侧

缘和下关节突的下极, 腰椎的轴向旋转可导致对侧关节囊的后侧部分伸缩, 而当后伸运动时, 下关节突下极和相应的上关节突相接触, 从而形成骨赘。术后邻近节段 FJ 软骨破坏多集中在关节面的边缘, 以下关节突的上下极、上关节突上极部位最为常见, 这与既往文献报道是一致的^[15]。因为这些部位在腰背部屈伸活动中受到较大的压力而出现软骨的磨损。软骨破坏与椎弓根螺钉的置入也密切相关。因 PLIF 术中置入椎弓根螺钉时术者会去除部分下关节突下极以寻找正确的进钉点, 破坏了上位关节突关节的稳定性, 从而导致后伸性不稳, 对头侧 FJ 的退变产生影响。若拧入的椎弓根螺钉位于关节突关节内, 将导致上关节突关节面的破坏, 术后活动可能会加速关节突关节面的退变并导致邻近节段的 FJ 出现永久性的改变。若同一椎体的两个椎弓根螺钉位置不对称, 只有一侧位于关节突关节内, 将导致关节对位不良, 甚至半脱位, 影响脊柱的稳定性。因此术中合理的置钉避免对关节突关节的侵扰应该引起重视。

软骨下囊肿、关节空气征、关节积液、再塑形以及自发性融合等发生率较低, 并非手术后所特有影像学表现, 亦可见于其他腰椎退变性疾病。而 PLIF 是否增加了邻近节段这些影像学表现的发生率, 仍需要大样本量数据进一步研究。

本研究中不论单纯髓核摘除组还是融合内固定组患者手术邻近节段 FJ 均发生不同程度的退变, 但融合内固定组患者退变程度更为严重, 提示腰椎后路单节段固定融合术可能加速邻近节段关节突关节的退变, 以关节间隙狭窄和软骨下骨的侵蚀最为常见。但是本研究由于样本量偏小, 随访时间偏短, 存在一定的不足, 腰椎融合术后邻近节段 FJ 的退变原因仍需要进一步研究。

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