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· 专题报道 ·

成人脊柱侧凸矫形术后近端交界性后凸的影响因素分析

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[摘要] **目的**　测量成人脊柱侧凸患者脊柱矢状位参数和骨盆参数，探讨矫形术后发生近端交界性后凸（PJK）的主要因素。**方法**　回顾性分析2014年1月至2016年9月于我院接受手术治疗的45例成人脊柱侧凸患者的病例资料。根据近端交界角（PJA）是否＞20°将患者分为PJK组和非PJK组。在脊柱正侧位X线片上测量两组患者术前、术后1周和末次随访时的胸椎后凸角（TK）、胸腰椎后凸角（TLK）、腰椎前凸角（LL）、矢状面躯干偏移（SVA）、骨盆投射角（PI）、骨盆倾斜角（PT）和骶骨倾斜角（SS）。采用logistic多元回归分析探讨成人脊柱侧凸矫形术后发生PJK的主要影响因素。**结果**　PJK组19例、非PJK组26例。两组患者在性别、年龄、随访时间、上端固定椎位置、下端固定椎位置方面差异均无统计学意义（P均＞0.05）。PJK组患者末次随访时LL、末次随访时SVA、术前PT、末次随访时PT均大于非PJK组，术前SS、末次随访时SS均小于非PJK组，差异均有统计学意义（P均＜0.05），其他参数在两组间差异均无统计学意义（P均＞0.05）。Logistic多元回归分析显示，术前TK、末次随访时TK、末次随访时LL、末次随访时PT、术前SS是成人脊柱侧凸矫形术后发生PJK的主要影响因素（P均＜0.05）。**结论**　术前TK、末次随访时TK、末次随访时LL、末次随访时PT、术前SS是成人脊柱侧凸患者矫形术后发生PJK的主要影响因素。

[关键词] 近端交界性后凸；成人脊柱侧凸；脊柱矢状位参数；骨盆参数
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Influencing factors of proximal junctional kyphosis in adult scoliosis patients after surgery

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[Abstract] **Objective**　To measure the spinal sagittal parameters and pelvic parameters of adult scoliosis patients, and to explore the influencing factors of proximal junctional kyphosis (PJK) after surgery. **Methods**　The clinical data of 45 adult scoliosis patients, who underwent surgical treatment in our hospital from Jan. 2014 to Sep. 2016, were retrospectively analyzed. The participants were divided into PJK group and non-PJK group according to whether proximal junctional angle (PJA) was ＞20°. Before operation, at 1 week after operation and at the last follow-up, the thoracic kyphosis (TK), thoracolumbar kyphosis (TLK), lumbar lordosis (LL), sagittal vertical axis (SVA), pelvic incidence (PI), pelvic tilt (PT) and sacral slope (SS) were measured and analyzed on the anteroposterior and lateral X-ray films of the spine. The main influencing factors of PJK in adult scoliosis patients after surgery were analyzed using logistic multivariate regression analysis. **Results**　Nineteen patients were enrolled in the PJK group and 26 in the non-PJK group. There were no significant differences in the gender, age, follow-up time, upper instrumented vertebra or lower instrumented vertebra between the two groups (all P＞0.05). Compared with the non-PJK group, the LL, SVA and PT at the last follow-up, and PT before operation were significantly larger in the PJK group, and the SS before operation and at the last follow-up were significantly lower (all P＜0.05). However, there were no significant differences in the other parameters between the two groups (all P＞0.05). Logistic multivariate regression analysis showed that TK and SS before operation, and TK, LL and PT at the last follow-up were the main influencing factors of PJK. **Conclusion**　TK and SS before operation, and TK, LL and PT at the last follow-up are the main influencing factors of PJK.

[Key words] proximal junctional kyphosis; adult scoliosis; spinal sagittal parameters; pelvic parameters
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成人脊柱侧凸是骨骼成熟后发生的脊柱畸形，通常需要手术矫正，目的是矫正矢状面和冠状面的平衡，阻止侧凸进一步发展，改善患者的生活质量。随着后路矫形器械的广泛应用，矫形术后近端交界性后凸（proximal junctional kyphosis，PJK）成为矫形术后常见的并发症之一[1-3]，也是目前的研究热点之一。

1994 年，Lowe 和 Kasten[4]在对休门病后凸矫形术后随访过程中首次详细描述了 PJK。2005 年，Glattes 等[5]将 PJK 定义为术后近端交界区后凸角＞10°，且与术前相比增加 10°以上。2013 年，Bridwell 等[6]提出以交界区矢状位 Cobb 角＞20°作为标准能更好地描述 PJK。2015 年，国际脊柱侧凸研究学会（Scoliosis Research Society，SRS）将 PJK 的诊断标准修正为近端交界角（proximal junctional angle，PJA）＞20°[7]。随着 PJK 的进展，PJK 导致的邻近节段疼痛、内固定失败、椎体滑脱甚至骨折给患者及其家庭带来了巨大的痛苦和经济负担。本研究回顾性分析成人脊柱侧凸患者的胸椎后凸角（thoracic kyphosis，TK）、胸腰椎后凸角（thoracolumbar kyphosis，TLK）、腰椎前凸角（lumbar lordosis，LL）、矢状面躯干偏移（sagittal vertical axis，SVA）、骨盆投射角（pelvic incidence，PI）、骨盆倾斜角（pelvic tilt，PT）和骶骨倾斜角（sacral slope，SS）与术后 PJK 的关系，探讨成人脊柱侧凸患者术后发生 PJK 的危险因素。

1　资料和方法

1.1　*纳入标准*　收集并分析我院 2014 年 1 月至 2016 年 9 月行后路椎弓根螺钉内固定手术的成人脊柱侧凸患者的病例资料。纳入标准：（1）成人脊柱侧凸；（2）年龄＞50 岁；（3）有手术指征且行后路椎弓根螺钉内固定并进行植骨融合；（4）有站立位脊柱全长 X 线片；（5）随访至少 2 年。排除特发性脊柱侧凸、感染、肿瘤或既往有脊柱手术史的患者。根据 PJA 是否＞20°将患者分为 PJK 组和非 PJK 组。本研究通过我院伦理委员会审批。

1.2　*数据采集*　收集人口统计学资料，包括年龄、性别。统计随访时间、上端固定椎（upper instrumented vertebra，UIV）位置、下端固定椎（lower instrumented vertebra，LIV）位置。分别于术前、术后 1 周和末次随访时测量 TK（T_5 椎体上终板与 T_{12} 椎体下终板之间的 Cobb 角）、TLK（T_{10} 椎体上终板与 L_2 椎体下终板之间的 Cobb 角）、LL（L_1 椎体上终板与 S_1 椎体上终板之间的 Cobb 角）、SVA（C_7 椎体中点矢状铅垂线与 S_1 椎体后上角的水平距离）、PT（铅垂线与股骨头中心连线中点和骶骨终板中点连线之间的夹角）、PI（股骨头中心连线中点和骶骨终板中点的连线与骶骨终板垂线之间的夹角）、SS（水平线与骶骨终板切线间夹角）。

1.3　*统计学处理*　用 SPSS 19.0 软件进行数据处理。呈正态分布的计量资料以 $\bar{x}\pm s$ 表示，两组间比较采用独立样本 t 检验；呈偏态分布的计量资料以中位数（下四分位数，上四分位数）表示，两组间比较采用 Mann whitney U 检验；计数资料以例数和百分数表示，两组间比较采用 χ^2 检验。采用 logistic 多元回归分析探讨成人脊柱侧凸矫形术后发生 PJK 的主要影响因素。检验水准（α）为 0.05。

2　结　果

2.1　*两组患者各参数的比较*　纳入成人脊柱侧凸患者 45 例，男 22 例、女 23 例，平均年龄为（57.07±5.81）岁，平均随访时间为（3.84±0.90）年。19 例患者并发 PJK，男 9 例、女 10 例，平均年龄为（58.05±6.26）岁，平均随访时间为（3.84±1.01）年，UIV 为 T_9 者 6 例、T_{10} 者 5 例、T_{11} 者 3 例、T_{12} 者 5 例，LIV 为 L_4 者 12 例、L_5 者 2 例、S_1 者 5 例；26 例患者无 PJK，男 13 例、女 13 例，平均年龄为（56.35±5.47）岁，平均随访时间为（3.85±0.83）年，UIV 为 T_9 者 8 例、T_{10} 者 3 例、T_{11} 者 8 例、T_{12} 者 4 例、L_1 者 3 例，LIV 为 L_4 者 14 例、L_5 者 6 例、S_1 者 6 例。两组患者在性别、年龄、随访时间、上端固定椎位置、下端固定椎位置方面差异均无统计学意义（P 均＞0.05）。PJK 组患者末次随访时 LL、末次随访时 SVA、术前 PT、末次随访时 PT 均大于非 PJK 组，术前 SS、末次随访时 SS 均小于非 PJK 组，差异均有统计学意义（P 均＜0.05），其他参数在两组间差异均无统计学意义（P 均＞0.05）。见表 1。

表 1　成人脊柱侧凸矩形术后 PJK 与非 PJK 患者基本资料、脊柱矢状位参数及骨盆参数的比较

Tab 1　Comparison of general characteristics and spinal sagittal parameters and pelvic parameters between PJK and non-PJK groups

Variable	PJK group N=19	Non-PJK group N=26	Statistic	P value
General characteristic				
Male/female n	9/10	13/13	χ^2=0.030	0.862
Age (year), $\bar{x}\pm s$	58.05±6.26	56.35±5.47	t=−0.973	0.336
Follow-up time t/year, $\bar{x}\pm s$	3.84±1.01	3.85±0.83	t=0.015	0.988
UIV (T_9/T_{10}/T_{11}/T_{12}/L_1) n	6/5/3/5/0	8/3/8/4/3	χ^2=−1.087	0.338
LIV (L_4/L_5/S_1) n	12/2/5	14/6/6	χ^2=−2.646	0.118
Spinal sagittal parameter				
TK before operation θ/(°), M (Q_L, Q_U)	18.00 (13.00, 23.00)	23 (15.00, 29.25)	U=−1.648	0.099
TK at 1 week after operation θ/(°), $\bar{x}\pm s$	20.53±9.03	24.77±8.91	t=−1.570	0.124
TK at the last follow-up θ/(°), $\bar{x}\pm s$	26.89±9.15	26.77±8.89	t=0.046	0.963
TLK before operation θ/(°), M (Q_L, Q_U)	12.00 (6.00, 17.50)	10.00 (9.00, 12.00)	U=−1.072	0.284
TLK at 1 week after operation θ/(°), M (Q_L, Q_U)	10.00 (4.00, 14.00)	11.50 (8.25, 13.00)	U=−0.784	0.443
TLK at the last follow-up θ/(°), $\bar{x}\pm s$	10.53±8.54	9.07±3.41	t=0.081	0.424
LL before operation θ/(°), $\bar{x}\pm s$	31.21±6.52	34.12±7.62	t=1.341	0.187
LL at 1 week after operation θ/(°), $\bar{x}\pm s$	36.26±5.77	35.92±5.57	t=−0.199	0.843
LL at the last follow-up θ/(°), $\bar{x}\pm s$	37.79±5.21	32.15±10.39	t=−2.069	0.036
SVA before operation l/mm, M (Q_L, Q_U)	8.00 (5.60, 16.00)	13.50 (10.25, 19.00)	U=−1.703	0.089
SVA at 1 week after operation l/mm, M (Q_L, Q_U)	13.00 (9.00, 18.50)	12.00 (11.25, 16.00)	U=−0.046	0.963
SVA at the last follow-up l/mm, M (Q_L, Q_U)	18.00 (13.50, 23.50)	12.00 (12.00, 16.00)	U=−2.131	0.033
Pelvic parameter θ/(°), $\bar{x}\pm s$				
PT before operation	20.11±6.81	14.08±4.19	t=3.667	0.001
PT at 1 week after operation	16.95±4.97	15.50±4.56	t=1.012	0.317
PT at the last follow-up	24.32±6.96	18.35±5.62	t=3.181	0.003
PI before operation	41.26±7.27	42.19±3.48	t=−0.570	0.572
PI at 1 week after operation	41.11±6.47	42.04±3.32	t=−0.632	0.531
PI at the last follow-up	42.00±6.92	42.31±3.45	t=−0.196	0.845
SS before operation	21.16±6.06	28.12±4.26	t=−4.531	<0.01
SS at 1 week after operation	24.16±5.32	26.54±3.33	t=−1.846	0.072
SS at the last follow-up	17.68±6.46	23.96±2.00	t=−3.859	<0.01

PJK: Proximal junctional kyphosis; UIV: Upper instrumented vertebra; LIV: Lower instrumented vertebra; TK: Thoracic kyphosis; TLK: Thoracolumbar kyphosis; LL: Lumbar lordosis; SVA: Sagittal vertical axis; PT: Pelvic tilt; PI: Pelvic incidence; SS: Sacral slope; M (Q_L, Q_U): Median (lower quartile, upper quartile)

2.2　成人脊柱侧凸矫形术后发生 PJK 的影响因素　Logistic 多元回归分析显示，术前 TK、末次随访时 TK、末次随访时 LL、末次随访时 PT、术前 SS 是成人脊柱侧凸矫形术后发生 PJK 的主要影响因素（P 均<0.05）。见表 2。

表 2　Logistic 回归分析成人脊柱侧凸矫形术后发生 PJK 的影响因素

Tab 2　Influencing factors of PJK in adult scoliosis patients after surgery using logistic regression analysis

Variable	B	Standard error	β	t value	P value
Constant	0.146	0.334	0.857	0.437	0.665
SS before operation	−0.031	0.008	−0.376	−3.748	0.001
LL at the last follow-up	−0.013	0.005	−0.230	−2.343	0.024
PT at the last follow-up	0.019	0.007	0.258	2.604	0.013
TK before operation	−0.043	0.010	−0.888	−4.388	<0.01
TK at the last follow-up	0.039	0.012	0.690	3.346	0.002

PJK: Proximal junctional kyphosis; SS: Sacral slope; LL: Lumbar lordosis; PT: Pelvic tilt; TK: Thoracic kyphosis; B: Regression coefficient; β: Standardized regression coefficient

3 讨 论

本研究单因素分析显示，成人脊柱侧凸患者矫形术后并发 PJK 组及无 PJK 组末次随访时 LL、末次随访时 SVA 差异均有统计学意义（P 均＜0.05）。既往研究发现随访 LL、随访 SVA 与 PJK 的发生有明显的相关性，患者的 PJK 越严重，则身体越会前倾，而引起脊柱矢状位的失平衡，导致 SVA 的改变[8-9]。

本研究结果亦显示，成人脊柱侧凸患者矫形术后并发 PJK 组与无 PJK 组术前 PT、末次随访时 PT、术前 SS、末次随访时 SS 的差异均有统计学意义（P 均＜0.05），与 Nicholls 等[10]的研究结果一致。矫形术后并发 PJK 的成人脊柱侧凸患者骨盆旋转的同时伴有 PT 增大和 SS 减小，从而弥补骨盆旋转的影响。然而，术前、术后和末次随访时 PI 在成人脊柱侧凸患者矫形术后并发 PJK 组与无 PJK 组差异均无统计学意义（P 均＞0.05），这与 Lonner 等[11]的研究结果一致，进一步证实了 PI 在成年后保持不变，PI 不是矢状位的补偿机制。

Park 等[12]通过多因素分析发现 UIV 位于胸腰段是 PJK 的危险因素，Lafage 等[13]也发现 UIV 位于胸腰段的患者术后 PJK 发生率显著增高。因为胸腰段为应力交界区，承接着相对固定的胸椎和活动度较大的腰椎，容易发生交界性后凸，因此在临床工作中，我们也认为不应在胸腰椎交接区选择 UIV。但本研究结果显示，成人脊柱侧凸患者矫形术后并发 PJK 组与无 PJK 组在 UIV 的选择方面差异无统计学意义（P＞0.05），可能原因是本研究纳入病例多数选择胸腰段为 UIV。

Logistic 回归分析显示，术前 TK、末次随访时 TK、末次随访时 LL、末次随访时 PT、术前 SS 是成人脊柱侧凸患者矫形术后发生 PJK 的主要影响因素。一方面，TK 与 LL 在矢状位保持平衡，如果 TK 过大，势必造成 UIV 近端的应力增加，导致术后 PJK 的风险增加[14]；其次 LL 过大可能导致骨盆矢状位前倾，PJK 代偿以恢复矢状位平衡。另一方面，后凸畸形的过度矫正也有可能导致腰椎前凸减少，与 PI 不相匹配，这种不匹配导致 PJK 的风险增加[14]。骨盆参数 PT 和 SS 决定骨盆的位置，术前的 SS 相对固定，这样 PT 决定骨盆的倾斜，随着骨盆位置的改变而变化，在侧凸矫形术后能通过骨盆的倾斜代偿脊柱矢状位的平衡[15]。因此，在成人脊柱侧凸矫形术中应综合考量脊柱矢状位参数和骨盆参数，防止 PJK 的发生。

本研究仍有如下不足：（1）样本量小，随访时间短；（2）由于 PJK 还可能与骨质疏松、手术过程中棘突韧带保留程度有关[16-18]，而本研究未纳入骨质疏松、术中后方复合体保留程度等相关因素。因此，今后仍需开展大规模、多中心、随访时间较长的临床研究。

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