

强直性脊柱炎胸腰椎后凸畸形截骨矫形术后 近端交界性后凸的危险因素与临床意义

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【摘要】目的:探讨强直性脊柱炎(ankylosing spondylitis, AS)胸腰椎后凸畸形矫形术后发生近端交界性后凸(proximal junctional kyphosis, PJK)的危险因素及表现形式。**方法:**回顾性分析 2002 年 1 月~2015 年 12 月接受矫形手术且随访大于 2 年的 133 例 AS 胸腰椎后凸畸形患者, 男性 118 例, 女性 15 例, 年龄 35.1 ± 9.8 岁(18~63 岁)。收集患者临床资料, 包括年龄、性别、体重指数、截骨方式和椎体融合节段。术前、术后及每次随访拍摄全脊柱正侧位片, 并测量矢状面平衡(sagittal vertical axis, SVA)、胸椎后凸角(thoracic kyphosis, TK)、腰椎前凸角(lumbar lordosis, LL)、骶骨倾斜角(sacral slope, SS)、骨盆倾斜度(pelvic tilt, PT)、骨盆投射角(pelvic incidence, PI)和近端交界角(proximal junctional angle, PJA)。根据 PJA 将患者分为 PJK 组和非 PJK 组, 利用卡方检验及 t 检验对比两组间临床资料及影像学参数。**结果:**133 例患者平均随访 3.6 ± 2.2 年(2.0~15.0 年), 11 例发生 PJK, 平均在术后随访 3.7 年(0.3~15.0 年)发生, PJA 从术前 $5.5^\circ \pm 9.7^\circ$ 进展至 $21.2^\circ \pm 9.5^\circ$ 。PJK 组手术年龄低于非 PJK 组 ($P < 0.01$), PJK 组行 SPO 人数比例高于非 PJK 组 ($P < 0.01$)。PJK 组术前 PJA 和 SVA 均低于非 PJK 组 ($P < 0.05$)。两组间 TK、LL、SS、PT 和 PI 均无显著性差异 ($P > 0.05$)。11 例 PJK 患者中, 有 3 种 PJK 表现形式, 包括假关节(2 例)、压缩性骨折(3 例)和 AS 胸椎后凸畸形的自然进展(6 例)。末次随访时, 1 例假关节 PJK 患者自发性愈合, 1 例 AS 胸椎后凸畸形自然进展的 PJK 患者行翻修手术, 其余患者均予以随访观察。**结论:**AS 术后 PJK 表现形式包括假关节、压缩性骨折和 AS 胸椎后凸畸形的自然进展。初次手术年龄、手术方式、术前 PJA 及 SVA 影响 PJK 的发生。

【关键词】强直性脊柱炎; 胸腰椎后凸畸形; 近端交界性后凸; 经椎弓根椎体截骨术; Smith-Petersen 截骨术

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【Abstract】 Objectives: To investigate the risk factors and clinical features of proximal junctional kyphosis (PJK) after osteotomy in thoracolumbar kyphosis secondary to ankylosing spondylitis(AS). **Methods:** A retrospective review of 133 AS patients with thoracolumbar kyphosis who underwent correction surgery between January 2002 and December 2015 with a minimum of 2-year follow-up performed, including 118 males and 15 females. The mean age was 35.1 ± 9.8 years(range, 18-63 years). Clinical data and radiographic parameters were assessed for the risk factors of PJK. Clinical data included age, sex, body mass index, types of osteotomy and fusion levels. Radiographic parameters were measured preoperatively, postoperatively and at each follow-up including sagittal vertical axis(SVA), thoracolumbar kyphosis(TK), lumbar lordosis(LL), sacral slope(SS), pelvic tilt(PT) and proximal junctional angle(PJA). Patients were divided into PJK group and no PJK group according to the change in PJA. Comparison of clinical and radiographic data were performed between the 2 groups using Student's t -test and Chi-square test. **Results:** Among the 133 patients with an average of $3.6 \pm$

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2.2 years(range, 2 to 15 years) follow-up, PJK was observed in 11 patients, at a mean of 3.7 ± 4.1 years(range, 0.3 to 15 years) with PJA increased from $5.5^\circ \pm 9.7^\circ$ preoperatively to $21.2^\circ \pm 9.5^\circ$ at the time of PJK. Compared with the no PJK group, PJK group showed lower age ($P < 0.01$) and higher proportion of patients undergoing SPO($P < 0.01$). Preoperative PJA and SVA were greater in the no PJK group($P < 0.05$). There were no significant differences in TK, LL, SS, PT and PI between the two groups($P > 0.05$). There were 3 types of PJK, including pseudoarthrosis($n=2$), compression fracture($n=3$) and progressing thoracic kyphosis due to the natural history of AS($n=6$). At final follow-up, spontaneous fusion of pseudoarthrosis was found in 1 of the 2 patients with PJK of pseudoarthrosis, and the other was lost follow-up. Revision surgery was performed in 1 of the patients with PJK of progressing thoracic kyphosis due to the natural history of AS. **Conclusions:** PJK could be presented in the characteristics of pseudoarthrosis, compression fracture and progressing thoracic kyphosis due to the natural history of AS. The age at initial surgery and types of osteotomy were the risk factors of PJK. The patients with lower preoperative PJA and SVA were found to have a higher risk of PJK.

[Key words] Ankylosing spondylitis; Thoracolumbar kyphosis; Proximal junctional kyphosis; Pedicle subtraction osteotomy; Smith-Petersen osteotomy

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强直性脊柱炎(ankylosing spondylitis, AS)是一种慢性炎症性疾病,由于脊柱韧带、纤维环和椎间关节骨化,造成脊柱进行性强直^[1]。随着炎症活动及异位骨化的不断进展,脊柱后凸畸形逐渐加重^[2]。晚期 AS 患者会出现严重的矢状面失平衡,导致腰背痛和躯干前倾甚至步态异常,明显影响患者日常活动^[3,4];同时可导致不同程度的心理障碍^[5,6]。对于此类患者,截骨矫形手术往往是最后的治疗方式^[7]。

截骨矫形手术可以有效重建 AS 胸腰椎后凸畸形患者的脊柱矢状面序列,从而改善患者生活质量^[8]。矫形手术在取得显著临床疗效的同时,不可避免地存在一些手术并发症,如:神经损伤和深部感染等^[9]。而内固定相关并发症鲜有报道,近端交界性后凸(proximal junctional kyphosis, PJK)通常由脊柱后路融合术近端内固定交界区应力改变引起^[10]。PJK 是多因素共同作用的结果,在成人脊柱畸形中,危险因素包括高体重指数(body mass index, BMI)、高龄、融合至骶骨、脊柱畸形过度矫正等。其临床转归尚存在争议,部分学者认为 PJK 仅仅是一种特定的影像学改变,并不影响患者生活质量,而有些研究发现 PJK 的发生和发展会导致患者疼痛、脊柱畸形持续进展和脊柱结构不稳继发神经损伤^[11-13]。AS 患者因为炎症引起的异位骨化、脊柱僵直,其 PJK 发生机理可能不同于其他脊柱畸形疾病。但目前 AS 患者矫形术后 PJK 的研究尚未见报道。本研究通过回顾性分析因 AS 胸腰椎后凸畸形行截骨矫形术患者的临床和影像

学资料,探讨术后 PJK 的相关危险因素、表现形式及预防措施。

1 资料与方法

1.1 一般资料

回顾性分析 2002 年 1 月~2015 年 12 月在我院接受截骨矫形手术的 AS 胸腰椎后凸畸形患者。纳入标准:(1)符合 1984 年纽约修订 AS 诊断标准^[14];(2)初次手术年龄 ≥ 18 岁;(3)影像学资料完整(有术前、术后及每次随访的站立位全脊柱正侧位 X 线片);(4)随访 ≥ 2 年。排除标准:(1)脊柱骨折;(2)脊柱手术史。符合上述标准的 133 例 AS 患者被纳入本研究,男性 118 例,女性 15 例,手术时年龄 18~63 岁,平均 35.1 ± 9.8 岁。其中有 123 例患者行经椎弓根椎体截骨术(pedicle subtraction osteotomy, PSO),10 例患者接受 Smith-Petersen 截骨术(Smith-Petersen osteotomy, SPO)。所有患者融合节段均 ≥ 5 个。

1.2 影像学指标与临床资料

影像学参数均通过 Surgimap 软件(Version: 1.1.2.293)在站立位全脊柱侧位 X 线片上测量,包括:矢状面平衡(sagittal vertical axis, SVA):C7 铅垂线与骶骨后上缘之间的水平距离,正值代表 C7 铅垂线落在骶骨后上缘前方,负值代表 C7 铅垂线落在骶骨后上缘后方;胸椎后凸角(thoracic kyphosis, TK):T4 椎体上终板与 T12 椎体下终板形成的夹角,正值代表后凸,负值代表前凸;腰椎前凸角(lumbar lordosis, LL):L1 椎体上终板与 S1

上终板形成的夹角,正值代表后凸,负值代表前凸;骶骨倾斜角(sacral slope,SS):S1 上终板与水平线之间的夹角;骨盆倾斜角(pelvic tilt,PT):股骨头中心和 S1 上终板中点连线与铅垂线之间的夹角;骨盆投射角(pelvic incidence,PI):股骨头中心和 S1 上终板中点连线与 S1 上终板垂线之间的夹角;近端交界角(proximal junctional angle, PJA):最上端固定椎(upper instrumented vertebra,UIV)的下终板与 UIV+2 的上终板之间的夹角,正值代表后凸,负值代表前凸。近端交界区(proximal junction region,PJR):UIV 下终板与 UIV+2 上终板之间的区域。

患者临床资料包括年龄、性别、BMI、截骨方式和椎体融合节段。PJK 定义为 PJA $\geq 10^\circ$ 且与术前测量值相比增加 $\geq 10^\circ$ [15]。根据患者是否发生 PJK 分为 PJK 组和非 PJK 组。

1.3 统计学方法

统计分析应用 SPSS 13.0 软件。应用 t 检验比较连续变量(影像学参数,年龄,随访时间,体重指数和融合节段)在 PJK 组和非 PJK 组之间的差异;应用卡方检验分析两组分类变量(性别和手术方式)之间的差异。数据用 $\bar{x}\pm s$ 表示,双侧 $P<0.05$ 为差异具有统计学意义。

2 结果

本研究 133 例患者平均随访 3.6 ± 2.2 年(2.0~15.0 年),其中 11 例(8.3%)患者发生 PJK,PJK 组患者初次手术年龄低于非 PJK 组($P<0.01$),PJK 组行 SPO 手术的人数百分比高于非 PJK 组($P<0.01$)(表 1)。11 例患者平均在术后 3.7 ± 4.1 年(0.3~15.0 年)发生 PJK,PJA 从术前 $5.5^\circ\pm 9.7^\circ$ ($-11^\circ\sim 26^\circ$)进展至 $21.2^\circ\pm 9.5^\circ$ ($10^\circ\sim 37^\circ$),末次随访时 PJA 为 $21.0^\circ\pm 8.9^\circ$ ($10^\circ\sim 37^\circ$)。

对比两组患者影像学参数发现,PJK 组术前 PJA 和 SVA 均低于非 PJK 组($P<0.05$),术后 PJK 组 PJA 仍低于非 PJK 组($P<0.01$)。末次随访时,PJK 组 PJA 大于非 PJK 组($P<0.05$),两组之间 SVA 无统计学差异(表 2)。

11 例 PJK 患者中,发现 3 种 PJK 的表现形式,包括 PJR 内发生假关节(2 例,图 1)、压缩性骨折(3 例,图 2)和 AS 胸椎后凸的自然进展(6 例,图 3)。末次随访时,假关节 PJK 患者中,1 例在术后 8.0 年随访时假关节自发性愈合,另 1 例

表 1 PJK 组与非 PJK 组临床资料比较

Table 1 Comparison of clinical data between PJK group and no PJK group

	PJK 组 (n=11) PJK group	非 PJK 组 (n=122) No PJK group	P 值 P value
性别(女/男) Sex (F/M)	3/8	12/110	0.110
年龄(岁) Age (y)	25.4 $\pm$ 5.7	40.0 $\pm$ 9.7	0.000
随访时间(年) Follow-up period (y)	5.3 $\pm$ 3.8	3.5 $\pm$ 2.0	0.155
体重指数(kg/m ²) Body mass index	22.7 $\pm$ 2.6	22.6 $\pm$ 4.2	0.913
手术方式(SPO/PSO) Types of osteotomy	5/6	5/117	0.000
融合节段 Fusion levels	8.6 $\pm$ 2.6	8.4 $\pm$ 2.0	0.765

表 2 PJK 组与非 PJK 组影像学参数比较

Table 2 Comparison of radiographic parameters between PJK group and no PJK group

	PJK 组 (n=11) PJK group	非 PJK 组 (n=122) No PJK group	P 值 P value
近端交界角($^\circ$) PJA			
术前 Pre-operation	5.5 $\pm$ 9.7	13.7 $\pm$ 6.2	0.020
术后 Po-operation	7.4 $\pm$ 8.0	13.6 $\pm$ 6.2	0.001
末次随访 Final follow-up	21.0 $\pm$ 8.9	14.2 $\pm$ 5.9	0.030
矢状面平衡(mm)SVA			
术前 Pre-operation	122.9 $\pm$ 83.5	178.0 $\pm$ 69.0	0.014
术后 Po-operation	18.6 $\pm$ 30.5	44.8 $\pm$ 46.1	0.068
末次随访 Final follow-up	35.7 $\pm$ 42.9	48.2 $\pm$ 47.8	0.405
胸椎后凸角($^\circ$) TK			
术前 Pre-operation	37.5 $\pm$ 32.9	49.1 $\pm$ 16.9	0.270
术后 Po-operation	44.5 $\pm$ 24.8	48.8 $\pm$ 15.6	0.580
末次随访 Final follow-up	58.4 $\pm$ 28.9	49.8 $\pm$ 15.3	0.355
腰椎前凸角($^\circ$) LL			
术前 Pre-operation	-5.6 $\pm$ 27.7	0.4 $\pm$ 21.3	0.381
术后 Po-operation	-47.2 $\pm$ 18.2	-47.1 $\pm$ 14.9	0.992
末次随访 Final follow-up	-43.4 $\pm$ 19.4	-43.5 $\pm$ 13.2	0.969
骶骨倾斜角($^\circ$) SS			
术前 Pre-operation	9.8 $\pm$ 13.3	7.9 $\pm$ 11.5	0.606
术后 Po-operation	28.6 $\pm$ 11.1	24.2 $\pm$ 9.7	0.152
末次随访 Final follow-up	25.5 $\pm$ 13.1	21.5 $\pm$ 8.9	0.177
骨盆倾斜角($^\circ$) PT			
术前 Pre-operation	34.4 $\pm$ 12.5	37.8 $\pm$ 10.7	0.321
术后 Po-operation	16.7 $\pm$ 10.1	21.5 $\pm$ 10.0	0.135
末次随访 Final follow-up	19.1 $\pm$ 8.9	24.8 $\pm$ 9.4	0.055
骨盆投射角($^\circ$) PI			
术前 Pre-operation	34.4 $\pm$ 12.5	37.8 $\pm$ 10.7	0.321
术后 Po-operation	45.4 $\pm$ 9.9	45.7 $\pm$ 10.8	0.918
末次随访 Final follow-up	44.5 $\pm$ 10.8	46.3 $\pm$ 10.9	0.613

失访;6 例 AS 胸椎后凸自然进展的 PJK 患者在术后平均 4.0 年 (2.0~8.0 年) 随访时,TK 由术后 $58.0^{\circ} \pm 23.9^{\circ}$ ($21.0^{\circ} \sim 78^{\circ}$) 进展至 $77.7^{\circ} \pm 22.7^{\circ}$ ($48^{\circ} \sim 100^{\circ}$) (表 3), 其中 1 例行翻修手术。11 例 PJK 患者均无明显疼痛或神经损伤等临床症状。

3 讨论

PJK 是脊柱畸形后路长节段矫形融合术后的常见并发症,有学者认为 PJK 的发生是为了适应术后脊柱矢状面序列的改变,以维持躯干平衡^[16]。既往文献中,PJK 在成人脊柱畸形术后的发生率为 26%~39%^[13,17],危险因素包括高龄、骨质疏松、短节段融合和脊柱畸形矫正过大^[18]。PJK 的表现形式有近端交界区骨折,内固定拔出或融合失败和椎间盘及韧带破坏^[19]。

本研究结果显示,PJK 在 AS 中发生率为 8.3%,明显低于成人脊柱畸形患者。研究^[20]表明,脊柱后方韧带在 PJK 的发生中起重要作用,其缺损或退变可显著增加 UIV 上方椎间盘压力,促使 PJK 的发生。AS 患者脊柱后方韧带及小关节的骨化或许可以减弱椎间盘的作用力,此外,前纵韧带

的骨化很大程度地减少了椎体前方压缩性骨折的发生,因此,AS 患者韧带及关节的骨化可能是 PJK 低发生率的原因。

对比两组临床资料发现,AS 患者年龄和手术方式为 PJK 发生的危险因素。在成人脊柱畸形矫形术后,PJK 多见于高龄患者,与其椎间盘和椎旁软组织退变有关^[21]。而本研究中,低龄患者为 PJK 高发人群。既往研究^[22]显示,AS 患者脊柱韧带骨化程度与年龄显著相关,对于年轻患者,韧带不完全骨化反而使其易于发生 PJK。有研究^[23]发现,短节段融合至下胸椎比长节段融合至上胸椎更容易发生 PJK。本研究 10 例 SPO 手术患者中,5 例发生 PJK;本组 PSO 患者手术融合节段为 8~9 个,而 SPO 患者融合节段只有 5~6 个,UIV 的选取也常在下胸椎。因此,SPO 术后 PJK 发生率较高的原因可能为融合节段较短,且 UIV 位于下胸椎。

通过分析影像学参数,两组患者术前 LL 无差异,但 PJK 组术前 PJA 和 SVA 均显著低于非 PJK 组,提示 PJK 组胸椎局部节段后凸程度低于非 PJK 组,甚至 PJK 组术前 PJR 为前凸状态。既往文献报道,腰椎退变性后凸矫形术后,术前胸椎

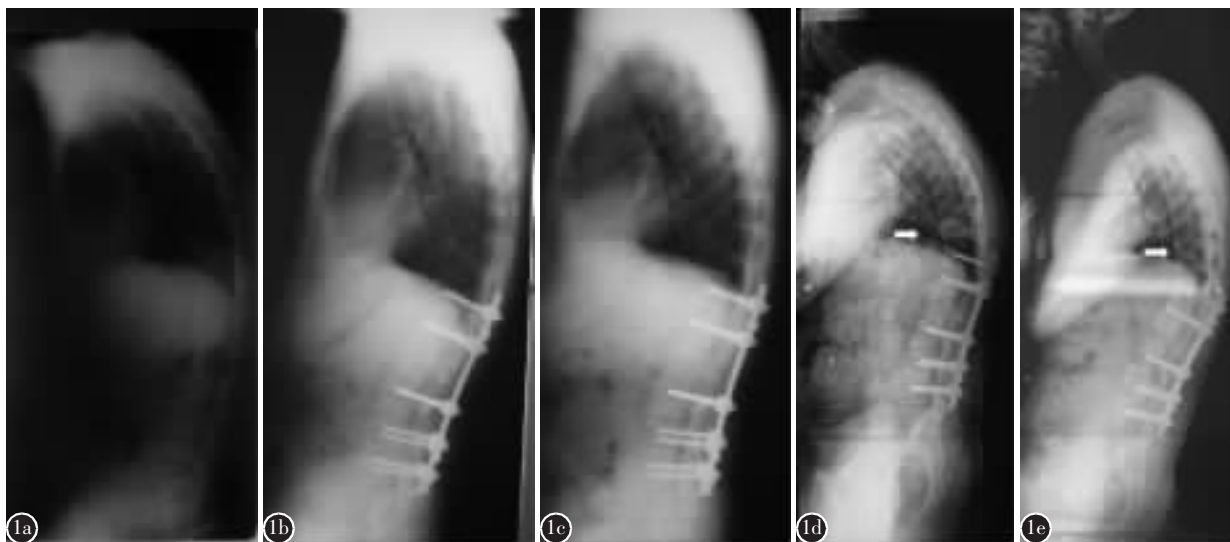


图 1 患者男,25 岁,AS 胸腰椎后凸畸形行 SPOs a 术前 LL 为 -6° ,PJA 为 10° ,SVA 为 101mm b 术后 LL 为 -19° ,PJA 为 15° ,SVA 为 0mm c 术后 1 年 PJA 为 18° ,SVA 为 23mm d 术后 5.3 年出现 PJK,UIV+1/UIV+2 开成假关节(箭头),PJA 为 32° ,SVA 为 107mm e 术后 8.8 年,假关节愈合(箭头),PJA 降低至 27° ,SVA 为 34mm

Figure 1 A male patient, 25 years old, was underwent SPOs for the thoracolumbar kyphosis secondary to AS a Preoperative LL was -6° , PJA and SVA was 10° and 101mm respectively b Postoperative LL was -19° , PJA and SVA was 15° and 0mm respectively c One year after surgery, PJA and SVA was 18° and 23mm respectively d 5.3 years after surgery, PJK was seen with UIV+1/UIV+2 pseudoarthrosis (arrow). The PJA and the SVA was 32° and 107mm respectively e 8.8 years after surgery, PJA was 27° with the spontaneous fusion of pseudoarthrosis(arrow) and the SVA was 34mm

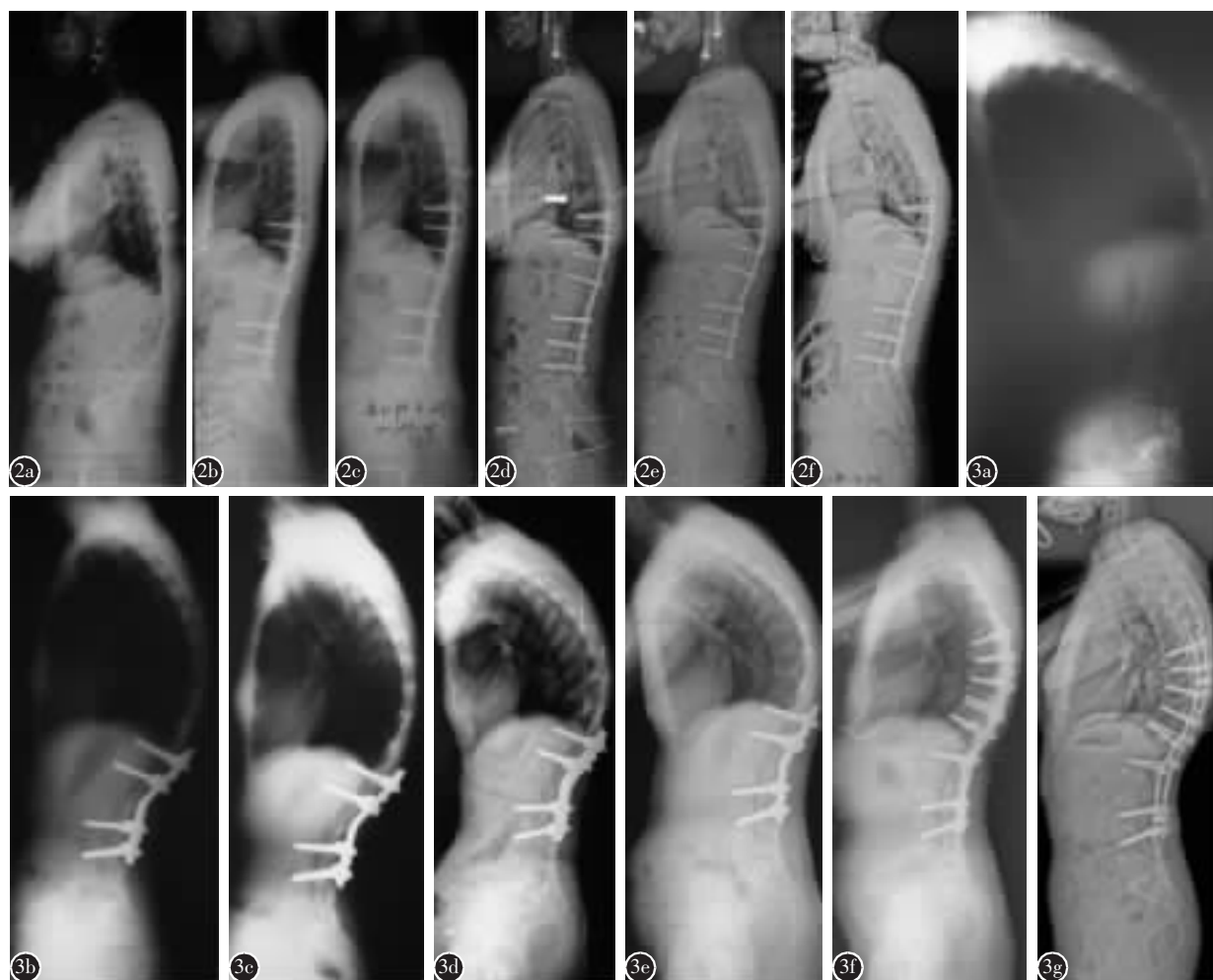


图 2 患者女, 28 岁, AS 胸腰椎后凸畸形行 L2 PSO **a** 术前 LL 为 7° , PJA 为 -2° , SVA 为 15.0mm **b** 术后 LL 为 -35° , PJA 为 4° , SVA 为 -43.3 mm **c** 术后 3 个月 PJA 为 7° , SVA 为 -3.9 mm **d** 术后 8 个月出现 PJK, UIV+1 椎体发生压缩性骨折(箭头), PJA 为 14° , SVA 为 8mm **e** 术后 1.5 年, PJA 进展为 15° , SVA 为 -9.8 mm **f** 术后 2 年, PJA 为 17° , SVA 为 33mm **图 3** 患者女, 31 岁, AS 胸腰椎后凸畸形行 SPOs **a** 术前 LL 为 -30° , TK 为 67° , PJA 为 21° , SVA 为 173mm **b** 术后 LL 为 -70° , TK 为 72° , PJA 为 23° , SVA 为 20mm **c** 术后 1.5 年出现 PJK, TK 为 85° , PJA 为 33° , SVA 为 26mm **d** 术后 6.5 年, TK 为 88° , PJA 为 34° , SVA 为 102mm **e** 术后 8 年, TK 为 100° , PJA 为 40° , SVA 为 140mm **f** 术后 8 年行翻修手术, TK 为 45° , PJA 为 15° , SVA 为 60mm **g** 翻修术后 4 年, TK 为 50° , PJA 为 18° , SVA 为 65mm

Figure 2 A 28-year-old woman with thoracolumbar kyphosis secondary to AS was underwent PSO **a** Preoperative LL was 7° , the PJA and the SVA was -2° and 15.0mm respectively **b** Postoperative LL was -35° , the PJA and the SVA was 4° and -43.3 mm respectively **c** 3 months after surgery, the PJA and the SVA was 7° and -3.9 mm respectively **d** 8 months after surgery, the PJK was found with the compression fracture at UIV+1 (arrow). The PJA and the SVA was 14° and 8mm respectively **e** 1.5 years after surgery, the PJA and the SVA was 15° and -9.8 mm respectively **f** 2 years after surgery, the PJA and the SVA was 17° and 33mm respectively **Figure 3** A 31-year-old woman was underwent SPOs for the AS-related thoracolumbar kyphosis **a** Preoperative LL and TK was -30° and 67° , the PJA and the SVA was 21° and 173mm respectively **b** Postoperative LL and TK was -70° and 72° , the PJA and SVA was 23° and 20mm respectively **c** 1.5 years after SPOs, PJK was seen with a TK of 85° , the PJA and SVA was 33° and 26mm respectively **d** 6.5 years after surgery, TK was 88° , the PJA and SVA was 34° and 102mm respectively **e** 8 years after surgery, TK was 100° , the PJA and SVA was 40° and 140mm respectively **f** Revision surgery of PSO at T12 was performed 8 years postoperatively. TK was 45° , the PJA and SVA was 15° and 60mm respectively **g** 4 years after revision surgery, TK was 50° , the PJA and SVA was 18° and 65mm respectively

表 3 三种不同 PJK 表现形式患者的影像学参数
Table 3 Radiographic parameters among the patients with 3 different modes of PJK

	假关节 (n=2) Pseu- doarthrosis	压缩性骨折 (n=3) Compres- sion fracture	AS 自然进展 (n=6) Natural history of AS
近端交界角(°) PJA			
术前 Pre-operation	11.5±2.1	-6.0±4.6	8.8±8.8
术后 Po-operation	12.0±1.4	-1.3±4.2	11.5±7.1
末次随访 Final follow-up	28.5±2.1	12.0±4.4	23.0±8.6
矢状面平衡(mm) SVA			
术前 Pre-operation	87.0±19.8	159.7±136.0	116.5±71.2
术后 Po-operation	28.5±40.3	23.2±23.6	13.0±34.9
末次随访 Final follow-up	17.0±24.0	44.3±42.2	37.7±51.7
胸椎后凸角(°) TK			
术前 Pre-operation	43.0±0	-1.7±17.8	55.2±27.1
术后 Po-operation	44.5±2.1	17.3±1.5	58.0±23.9
末次随访 Final follow-up	49.0±8.5	26.0±9.2	77.7±22.7
腰椎前凸角(°) LL			
术前 Pre-operation	-6.0±8.5	23.0±14.2	-19.8±26.5
术后 Po-operation	-36.0±14.1	-31.0±4.0	-59.0±15.5
末次随访 Final follow-up	-45.5±27.6	-20.7±9.3	-54.0±11.0
骶骨倾斜角(°) SS			
术前 Pre-operation	-6.0±0	5.7±10.0	17.2±11.8
术后 Po-operation	19.0±18.4	22.0±3.6	35.2±7.7
末次随访 Final follow-up	20.5±20.5	14.0±7.2	32.8±9.3
骨盆倾斜角(°) PT			
术前 Pre-operation	55.0±9.9	27.3±7.2	31.0±7.6
术后 Po-operation	29.0±9.9	16.3±4.9	12.8±9.9
末次随访 Final follow-up	28.0±11.3	20.0±3.6	15.7±9.1
骨盆投射角(°) PI			
术前 Pre-operation	49.0±9.9	33.0±4.4	48.2±10.3
术后 Po-operation	48.0±8.5	38.3±7.0	48.0±11.0
末次随访 Final follow-up	48.5±9.2	34.0±3.6	48.5±10.9

后凸角度代偿性减小的患者术后会发生适应性的增加以维持躯干矢状面平衡^[24]。AS 患者的脊柱僵硬,腰椎 PSO 术后,胸椎序列的适应性改变多集中于 PJR,尤其是 PJR 后凸程度小的患者,更易发生 PJK 以维持脊柱矢状面平衡。因此,对于此类患者,设计手术方案时,可延长融合节段跨过此区域并重建胸椎后凸,以防止 PJK 的发生。

本研究共发现 3 种 PJK 的表现形式,包括假关节、压缩性骨折和 AS 胸椎后凸的自然进展。假关节是长病程 AS 的常见并发症^[25],一般由机械力和炎症共同作用导致,患者可通过顶椎区的假关节获得部分的畸形矫正^[26]。虽然 PJR 为内固定术后的应力集中区,但既往文献未见 PJR 发生假关

节的报道。假关节出现后,脊柱稳定性受到破坏,但 AS 患者具有极强的骨愈合能力,可予以制动保守观察。本组 2 例发现假关节后,1 例 2.5 年后自发性愈合,另 1 例失访。PJR 压缩性骨折是成人脊柱畸形 PJK 最常见的表现形式,由椎体前方受压力作用引起,且一般发生在术后 1 年内^[27],本研究 3 例(27.3%)压缩性骨折患者平均随访 2.9 年(0.7~5 年)时发生 PJK,显著长于既往文献。可能因为,AS 患者椎体前纵韧带骨化可增加椎体前方的力学强度从而延缓压缩性骨折的发生,AS 骨化程度对 PJK 的作用机制仍需进一步研究。

本研究最常见的 PJK 表现形式是 AS 胸椎后凸的自然进展(无特殊病理改变,如压缩性骨折或假关节),有 6 例,占 54.5%。既往文献分析退变性侧凸矫形术后发生 PJK 的原因为老年患者脊柱后凸随年龄增加的自然进展^[28]。成人脊柱畸形术后无症状 PJK 患者一般无需手术干预,只有伴随显著疼痛、矢状面畸形进展、PJR 椎体不稳定或存在神经损害等临床症状的患者需行翻修手术^[12]。本研究中,有 1 例 PJK 患者因胸椎后凸进展严重致矢状面失平衡(SVA, 140mm)行翻修手术,其余无症状 PJK 患者均予以密切随访。

本研究局限处在于:PJK 是一个动态变化的过程,2 年随访时间尚不能准确反映其在 AS 中的发生率。由于 PJK 发生人数较少,未能对 PJK 各种不同表现形式做单独的危险因素分析。在未来的研究中,将进一步扩大样本量及增加随访时长,以进一步分析 PJK 在 AS 中的发生率、表现形式及危险因素。

综上所述,AS 在 2 年随访时,PJK 的发生率为 8.3%,其表现形式有 3 种,包括假关节、压缩性骨折和 AS 胸椎后凸的自然进展。初次手术年龄及手术方式均可影响 PJK 的发生。此外,术前较小的 PJA 及 SVA 也可增加 PJK 的发生几率。

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