临床论著

脊柱侧凸矫形术后严重冠状面失衡再次手术翻修的疗效及并发症

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【摘要】目的:观察脊柱侧凸矫形术后发生严重冠状面失衡进行再次手术翻修的效果及并发症。**方法**:回顾性分析我院 2013 年 1 月~2021 年 8 月手术治疗的 7 例脊柱侧凸矫形术后严重冠状面失衡患者的临床资料,其中男性 3 例,女性 4 例;本次手术年龄 21.3±7.5 岁(14~32 岁)。随访 16.3±4.2 个月(12~25 个月)。统计初次手术年龄、既往手术次数、本次手术时间、出血量和固定节段。在本次手术前、术后即刻及末次随访时在全脊柱正侧位 X 线片上测量主胸弯及腰弯 Cobb 角、最下固定椎倾斜角、冠状面平衡距离(coronal balance distance,CBD)、冠状面骨盆倾斜角等,计算 CBD 的矫正率。术前、术后即刻及末次随访时使用 SF-36 量表评估患者生活质量。记录本次手术后各类并发症发生及转归情况。**结果**:初次手术年龄 8.86±4.14 岁(3~15 岁);手术次数 5.29±3.55 次(2~13 次);本次手术时间为 346.14±64.65min,术中出血量 1342.86±687.65ml;6 例患者行不对称性 PSO 截骨,1 例患者行多节段 Ponte 截骨、延长内固定融合节段。术前 CBD 为 77.23±33.28mm,术后即刻为 36.11±15.14mm,较术前改善(P<0.05),矫正率为(53±3)%,末次随访为 35.91±14.45mm,与术后即刻相比无明显差异(P>0.05)。主胸弯、最下固定椎倾斜角及冠状位骨盆倾斜角术后即刻均较术前明显减少(P<0.05),末次随访与术后即刻无显著性差异(P>0.05)。术前腰弯 21.29°±17.77°,术后即刻 30.14°±8.86°,较术前有统计学差异(P<0.05),末次随访腰弯 30.14°±8.13°,与术后无显著性差异(P>0.05);术前 SF-36 综合评分 27.29±1.98 分,术后即刻 36.86±2.27 分(P<0.05),末次随访时 50.14±3.24 分(P<0.05)。5 例患者术后出现胸腔积液、脑脊液漏、下肢神经痛等并发症,均在住院期间完全治愈。**结论**:脊柱侧凸矫形术后出现严重冠状面失衡的患者,再次翻修截骨手术可取得较好的矫正效果并提高生活质量,但手术风险大,围手术期需密切关注并发症。

【关键词】脊柱侧凸;冠状面失衡;翻修手术;不对称截骨
doi:10.3969/j.issn.1004-406X.2023.03.06
中图分类号:R682.3,R619,R687.3 **文献标识码**:A **文章编号**:1004-406X(2023)-03-0228-08

Effects and complications of revision surgery for severe coronal imbalance after scoliosis correction/ WANG Jiaxu, WU Jigong, CHEN Zhiming, et al//Chinese Journal of Spine and Spinal Cord, 2023, 33 (3): 228-235

【Abstract】Objectives: To observe the effects and complications of revision for severe coronal imbalance after scoliosis correction surgery. **Methods:** A retrospective analysis was performed on the clinical data of 7 patients with severe coronal imbalance after scoliosis correction surgery who underwent reoperation and revision at our hospital from January 2013 to August 2021, including 3 males and 4 females, aged 21.3±7.5 years (14-32 years). The follow-up period was 16.3±4.2 months, ranging from 12 to 25 months. The age of the first operation, number of previous operations, operative time of this revision surgery, amount of intraoperative blood loss, osteotomy method, and fixed segment were collected. The Cobb angles of the main thoracic and lumbar curves, tilt angle of the lowest instrumented vertebra, coronal balance distance(CBD), and coronal pelvic tilt angle were measured on the anteroposterior and lateral full-spine X-rays preoperatively, immediately postoperatively, and at the last follow-up, and the correction rate of CBD was calculated. The 36-Item Short Form Health Survey(SF-36) was used to score all the patients before operation, immediately after opera-

基金项目:国家自然科学基金(编号:82172518)
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tion, and at final follow-up to assess their improvements in the quality of life. The complications of this re-operation and their outcomes were recorded. **Results:** The age of the first operation of the patients was 8.86±4.14 years (3-15 years), the number of previous operations was 5.29±3.55(2-13), the operative time of this revision was 346.14±64.65min, and the intraoperative blood loss was 1342.86±687.65ml. Asymmetric pedical subtraction osteotomy (PSO) was performed in 6 patients, and multi-segment Ponte osteotomy with internal fixation fusion segment extended was performed in the remaining 1 patient. The CBD was improved to 36.11±15.14mm immediately after surgery from the preoperative 77.23±33.28mm significantly (P<0.05), with a correction rate of (53±3)%, and it was 35.91±14.45mm at final follow-up, with no significant difference from that immediately after surgery(P>0.05). The main thoracic curve, the lowest instrumented vertebra inclination angle, and the coronal pelvic inclination angle were significantly reduced immediately after surgery (P<0.05), and no significant differences were found between those at final follow-up and immediately after surgery, respectively (P>0.05). The lumbar curve was 21.29°±17.77° at preoperation and 30.14°±8.86° at immediately after surgery, the changes were significantly different(P<0.05), and it was 30.14°±8.13° at the last follow-up, not significantly changed from that after surgery (P>0.05). The SF-36 comprehensive score before surgery was 27.29±1.98 points, which improved to 36.86±2.27 points immediately after surgery (P<0.05) and 50.14±3.24 points at final follow-up(P<0.05). Five patients developed postoperative complications such as pleural effusion, cerebrospinal fluid leakage, and lower extremity neuralgia, all of which were completely cured during hospitalization. **Conclusions:** Revision osteotomy can obtain good correction for patients with severe coronal imbalance after multiple operations for scoliosis, but the surgical risk is high, and perioperative complications need to be closely monitored.

【Key words】 Scoliosis; Coronal imbalance; Revision surgery; Asymmetric osteotomy

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脊柱侧凸畸形严重或快速进展期的患者,需要矫正融合手术干预。然而,此类手术并发症发生率较高,常见的有脊柱冠状面失衡等[1]。脊柱冠状面失衡是指冠状面平衡距离 (coronal balance distance,CBD)(C7 铅垂线相对于骶骨中线平移)超过 2cm。既往报道后路脊柱融合术后 2 年脊柱冠状面失衡率高达 41%[2]。有研究[3]指出,脊柱冠状面失衡的发生与患者术后生活质量密切相关。冠状面失衡的患者多存在行走不便、端坐困难、背部僵硬等不适。多数患者术后 6 个月内可自发代偿纠正[4]。对于 2 年以上仍存在冠状面失平衡加重, 或 CBD>4cm 的患者, 严重影响患者生活质量,需要再次手术[5]。但再手术难度大、风险高,针对脊柱侧凸术后冠状面失衡再手术治疗的报道不多。本研究回顾分析我院 2013 年 1 月~2021 年 8 月手术治疗脊柱侧凸术后严重冠状面失衡患者的临床资料,探讨手术疗效及并发症。

1 资料与方法

1.1 纳入与排除标准

纳入标准:(1)既往多次行脊柱畸形矫正植骨融合手术;(2)术后 2 年出现严重脊柱冠状面失衡(CBD>4cm);(3)因冠状面失衡再手术;(4)末次手术随访超过 12 个月, 具备完整影像及随访资料。排除标准:(1)合并椎体骨折、肿瘤、感染的患者;(2)退变性脊柱侧凸术后再手术。

1.2 一般资料

根据纳入排除标准,2013 年 1 月~2021 年 8 月期间再次手术翻修治疗的脊柱侧凸术后严重冠状面失衡患者共 7 例。男 3 例,女 4 例。本次手术年龄为 14~32 岁(21.3±7.5)岁。初次诊断先天性脊柱侧凸(半椎体、椎体分节不良)6 例,神经肌肉型脊柱侧凸 1 例。

1.3 观察指标

统计所有患者初次手术年龄、既往手术次数、本次手术时间、出血量、截骨级别、固定节段,末次手术后各类并发症发生及转归情况。本次手术前、手术后及末次随访时采用 SF-36 评分量表评估患者的生活质量。

本次手术前、术后即刻及末次随访时拍摄站立位全脊柱正侧位 X 线片,测量冠状位主胸弯及腰弯 Cobb 角、最下固定椎倾斜角(站立位 X 线片

上最下固定椎上终板与水平线的夹角，或与髂嵴连线最高点的夹角）、CBD、冠状位骨盆倾斜角等。计算 CBD 矫正率=(术前 CBD−术后 CBD)/术前 CBD×100%。

1.4 手术方法

依据冠状面失衡程度、主胸弯、腰弯、骨盆倾斜度及最下固定椎倾斜度等制定手术方案，术中采取 SRS 2 级（多节段 Ponte）截骨及延长内固定；腰段顶椎区域附近不对称 3 级（PSO）截骨进行再手术[6]，有助于纠正侧弯及冠状面失衡[7]。所有手术由同一组医生完成。

患者全身麻醉后，取俯卧位于俯卧垫上，腹部悬空，全程躯体感觉诱发电位（somatosensory evoked potential，SEP）及躯体运动诱发电位（motor evoked potential，MEP）监测。沿原手术切口瘢痕行纵向皮肤切口。探寻椎板骨性结构进行软组织剥离。根据术前 CT，探查并替换松动的椎弓根螺钉，对影像检查显示融合较好的患者，原有上下固定端椎不变，不延长内固定。6 例患者术前影像资料显示长节段胸腰椎融合，胸弯>腰弯、腰弯僵硬、腰椎曲度<20°，取腰段凸侧顶椎区域进行 SRS 3 级不对称性 PSO 截骨，用超声骨刀在截骨水平完整地切除椎板，显露出硬脑膜及神经根，切断横突，沿截骨侧进行经椎弓根截骨。上切线应平行于截骨椎的上终板，必要时切除邻近的椎间盘结构至上位椎体的下终板，下切线平行于截骨椎的下终板。用超声骨刀切除椎体侧壁及前壁，完成不对称性截骨。量取合适长度的纵向连接棒，适当折弯后，于凸侧进行合拢，凹侧反向撑开，减少骨盆倾斜，及最下固定椎较髂骨连线的成角，纠正冠状面失衡。1 例 T12 半椎体切除术后患者腰段未完全融合，腰椎曲度>20°，腰弯大于胸弯。按术前规划截骨节段，切除棘突、棘上韧带、棘间韧带及双侧上下关节突、黄韧带，显露硬脊膜，直至椎体间具备活动度。采取 SRS 2 级（多节段 Ponte）截骨，并延长内固定为 T8~L5，将钛合金或钴铬钼合金棒裁剪成合适长度，并用多米诺连接器纵向连接（多椎弓根螺钉同时作用进行平移或提拉矫形，避免单个椎弓根螺钉松动），合拢截骨断端至骨性贴合。根据术前规划，SRS 2 级截骨患者缩小腰弯，不对称 Ponte 截骨患者增大腰弯，实现最下固定椎相对髂骨最高点连线的水平化，改善冠状面失衡。术后患者佩戴支具 3~6 个月，双下肢不等长患者垫脚垫。

1.5 统计学分析

采用 SPSS 22.0 软件对数据进行统计学分析，计量资料数据以均数±标准差表示。手术前、术后及末次随访时的影像学参数及 SF−36 评分，采用配对 t 检验，P<0.05 为显著性差异。

2 结果

7 例患者中双下肢不等长 5 例，骨盆倾斜 5 例，最下固定锥倾斜 6 例；4 例本次手术前出现内固定松动，1 例患者取出内固定后冠状面失衡逐渐加重。患者的一般资料见表 1。

初次手术年龄为 3~15 岁（8.9±4.1 岁）；手术次数 2~13 次（5.29±3.55 次）；本次手术时间 346.14±64.65min，术中出血量 1342.86±687.65ml。

7 例患者中 5 例（71.4%）患者术后出现不同程度并发症。胸腔积液 4 例（<500ml）：采取无创呼吸机辅助呼吸、补充白蛋白联合利尿药等综合措施，治疗后胸腔积液消失；硬脊膜损伤 3 例，术中即刻修补，术后头低脚高位，引流管术后 3 日内拔出，并盐袋加压切口，复查皮下超声未见积液，切口愈合良好；下肢神经痛 3 例，予以甘露醇、小剂量激素、营养神经及高压氧等治疗 3 月后好转。所有患者并发症在出院时完全治愈。

随访 12~25 个月（16.3±4.2）个月。所有患者术后即刻冠状面失衡较术前均有所改善（P<0.05），矫正率为（53±3）%，末次随访与术后即刻比较无明显差异（P>0.05）；主胸弯、最下固定椎倾斜角及冠状位骨盆倾斜角，均明显好转（P<0.05），末次随访与术后即刻无显著性差异（P>0.05）。腰弯矫正术前明显改变（P<0.05），末次随访与术后即刻无明显差异（P>0.05）（表 2）。末次随访 X 线片及 CT 显示脊柱已融合，无内固定失败或再翻修，典型病例见图 1、2。

3 讨论

脊柱整体平衡是脊柱畸形矫正手术的主要目标之一，术后冠状面失衡常有报道[8,9]。多数研究认为 CBD<2cm 为轻微冠状面失衡，可逐渐恢复，对患者预后影响较小[10,11]。能够通过自身矫正或代偿来维持平衡状态，但自发纠正的机制尚无报道[12]。脊柱融合术后出现严重冠状面失衡的患者，往往自我评价/治疗满意度低，需再次手术[13]。

表 1 患者一般资料

Table 1 General information of patients

序号 Number	性别 Gender	年龄 Age	初次手术年龄 Age of primary operation	既往手术次数 Number of previous operations	CIB可能原因 Possible reason of CIB	截骨方式 Method of osteotomy	固定节段 Fixed segment	椎管内畸形 Intraspinal deformity	并发症 Complication
1	女 Female	14	9	5	①②③	L1 PSO	T2–L4	Ⅰ Ⅱ	无 None
2	女 Female	32	3	13	①④	L2 PSO	T2–L4	无 None	ABC
3	男 Male	29	11	5	①②③④	L3 PSO	L1–L5	Ⅱ Ⅲ Ⅳ Ⅴ	AB
4	男 Male	18	6	4	①②	L2 PSO	T3–L5	Ⅰ Ⅳ Ⅴ Ⅵ	ABCD
5	女 Female	15	6	4	①②③④	L3 PSO	T2–L5	Ⅰ	CD
6	女 Female	26	15	4	①②③④	L1 PSO	T4–L5	Ⅱ Ⅴ Ⅵ Ⅷ	C
7	男 Male	15	12	2	④⑤⑥	Ponte	T8–L5	无 None	无 None

注:CIB,冠状位失衡;①骨盆倾斜;②最下固定椎切斜;③内固定松动;④双下肢不等长;⑤未融合;⑥L5 椎体倾斜 Ⅰ 脊髓空洞;Ⅱ 脊髓纵裂;Ⅲ 半椎体畸形;Ⅳ 骨嵴切除术后;Ⅴ 脊髓拴系切除术后;Ⅵ 脊髓低位;Ⅶ 小脑疝;A 下肢疼痛、麻木;B 脑脊液漏;C 胸腔积液;D 肋骨切除

Note: CIB, coronal imbalance; ①Pelvic tilt; ②Inclination of the lowest instrumented vertebra; ③Loosening of the internal fixation; ④Unequal in legs length; ⑤Unfused; ⑥Vertebrae L5 tilted; Ⅰ, Syringomyelia; Ⅱ, Diastomyelia; Ⅲ, Hemivertebra; Ⅳ, Post-osteocristaectomy; Ⅴ, Post-teatulectomy; Ⅵ Low spinal cord, diastomyelia; Ⅶ Subtonsillar hernia; A, Limb numbness and pain; B, Cerebrospinal fluid leakage; C, Cerebrospinal fluid leakage; D, Rib excision

表 2 患者影像学参数及 SF–36 评分 ($\bar{x}\pm s$, n=7)

Table 2 Imaging parameters and SF–36 scores

	术前 Preoperative	术后即刻 Immediately postoperative	末次随访 Final follow–up
CBD(mm)	77.23±33.28	36.11±15.14①	35.91±14.45①
主胸弯(°) Major thoracic curve	52.86±27.37	37.29±27.60①	33.25±29.03①
腰弯(°) Lumbar curve	21.29±17.77	30.14±8.86	30.14±8.13
骨盆倾斜角(°) Angle of pelvic inclination	11.43±7.50	6.43±4.61①	5.25±4.40①
最下固定椎倾斜角(°) Inclination of LIV	6.14±4.60	2.71±3.09①	2.86±3.34①
SF–S6 评分 SF–36 scores	27.29±1.98	36.86±2.27①	50.14±3.24①

注:①与术前比较 P<0.05

Note: ①Compared with preoperation, P<0.05; LIV, lowest instrumented vertebra

Glassman等[14]认为 CBD>4cm 将严重影响患者身心健康及生活质量。Koller 等[15]也认为融合术后冠状面失衡显著影响临床治疗效果。然而,针对此类患者的手术治疗方案报道较少, 脊柱侧凸术后严重冠状面失衡(CBD>4cm)的治疗是个难点。

本研究中 7 例患者在融合手术后 2 年随访中,出现了冠状面失衡加重,未自发纠正,要求手术治疗。本组患者手术次数 2~13 次, 平均 5.29 次,体现了患者对于改善外观及生活质量的决心,以及本研究的重要性。但临床上此类患者相对较少,术后冠状面失衡加重的原因仍不明确。Anari 等[5]统计 954 例青少年特发性脊柱侧凸患者,发现 0.9%的患者术后 2 年出现了严重的冠状面失衡,认为胸椎柔韧性小于 20%是出现严重冠状面失衡的独立影响因素。Xu 等[16]认为先天性脊柱侧凸三柱截骨术后出现冠状面失衡的发生率为 20%, 术前 C 型弯、LIV 倾斜>23.58°及术后即刻 LIV 倾斜>12.38°是术后冠状面失衡的独立影响因素。其他影响因素包括患者年龄、性别、体重指数(body mass index,BMI)、病因、侧凸严重及僵硬程度、是否合并移行弯、是否为再手术、软组织状态及术前冠状面失衡、固定椎的选择、侧凸矫形程度、截骨技术及术者经验等[17~19]。

本研究中本次手术前 5 例存在骨盆倾斜,5 例双下肢不等长, 最下固定椎相对髂嵴最高点连线的倾斜角为 6.14°±4.60°;同时,5 患者内固定失败 (4 例松动,1 例取出后侧弯及脊柱冠状面失衡加重)。双下肢不等长、腰骶段倾斜伴有远端内固定失败, 可能是导致脊柱侧凸矫形术后再次出现冠状面失衡加重的原因,但仍需大样本研究。究其原因, 可能是既往手术未实现 L4~S1 水平化,僵硬的腰骶弯及胸弯,或未固定的腰骶椎角度增加,无法实现冠状位自发代偿, 易导致冠状面失衡加重。Lewis 等[20]也有相似报道,他认为成人脊柱畸形术后冠状面失平衡与术前最下固定椎倾斜度大有关。有学者甚至在腰骶椎进行 TLIF,以增大腰骶椎纠正度,减少腰骶代偿弯,从而改善冠状面失衡[21]。因此本组患者采取单纯在腰椎顶椎附近不对称截骨,或者延长最下固定锥的方式,尽可能减

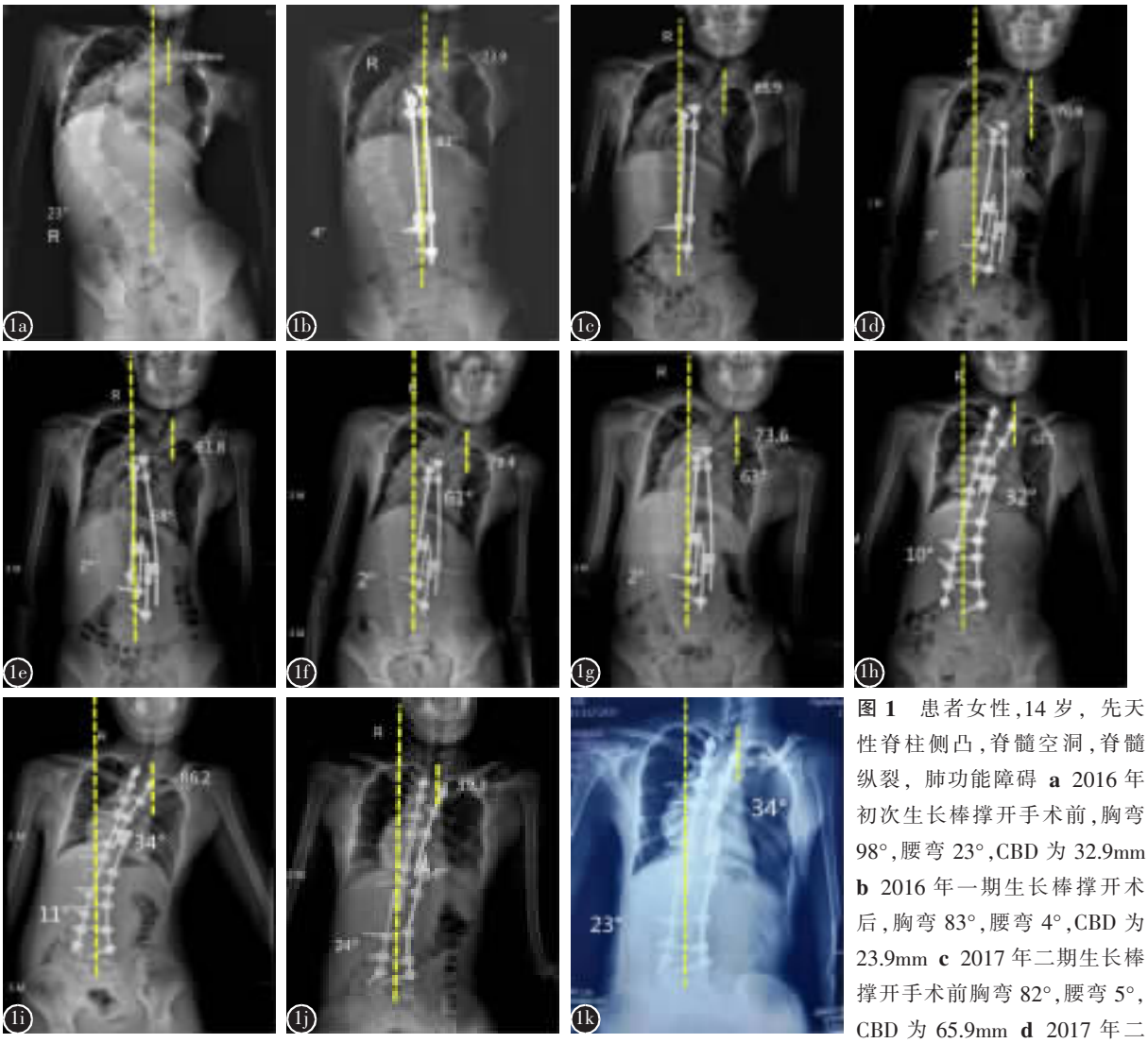

图 1 患者女性,14 岁, 先天性脊柱侧凸,脊髓空洞,脊髓纵裂, 肺功能障碍 **a** 2016 年初次生长棒撑开手术前,胸弯 98°,腰弯 23°,CBD 为 32.9mm **b** 2016 年一期生长棒撑开术后,胸弯 83°,腰弯 4°,CBD 为 23.9mm **c** 2017 年二期生长棒撑开手术前胸弯 82°,腰弯 5°,CBD 为 65.9mm **d** 2017 年二期生长棒撑开手术后胸弯 66°, 腰弯 3°,CBD 为 70.8mm **e** 2018 年三期生长棒术前胸弯 68°, 腰弯 2°,CBD 为 61.8mm **f** 2018 年三期生长棒撑开手术后胸弯 61°, 腰弯 2°,CBD 为 79.4mm **g** 2019 年, 植骨融合术前胸弯 63°, 腰弯 2°,CBD 为 73.6mm **h** 2019 年于我院行后路截骨矫形内固定植骨融合术(T2~L4,T9 PVCR)后,胸弯 32°,腰弯 10°,CBD 为 63.2mm **i** 2021 年,随访 2 年时胸弯 34°,腰弯 11°,CBD 为 86.2mm **j** 2021 年脊柱侧凸术后末次手术矫形内固定植骨融合术(T2~L4,L1 不对称 PSO), 多米诺连接器撑开, 胸弯 34°, 腰弯 24°,CBD 为 39.3mm **k** 2022 年末次手术后 13 个月随访胸弯 34°,腰弯 23°,CBD 为 40.4mm

Figure 1 A 14 years old female, diagnosed as congenital scoliosis, syringomyelia, longitudinal spasm, and pulmonary dysfunction **a** In 2016, before the first growth rod distraction surgery, thoracic curve was 98°, lumbar curve was 23°, CBD was 32.9mm **b** After the first stage growth rod operation in 2016, thoracic curve was 83°, lumbar curve was 4°, CBD was 23.9mm **c** In 2017, before the second grow rod distraction, thoracic curve was 82°, lumbar curve was 5°, CBD was 65.9mm **d** In 2017, thoracic curve was 66°, lumbar curve was 3°, CBD was 70.8mm after the second stage of growth rod operation **e** In 2018, preoperative thoracic curve was 68°, lumbar curve was 2°, CBD was 61.8mm for the third stage growth rod operation **f** In 2018, thoracic curve was 61°, lumbar curve was 2°, CBD was 79.4mm after the third stage growth rod operation **g** In 2019, preoperative thoracic curve was 63°, lumbar curve was 2°, CBD was 73.6mm **h** Posterior osteotomy orthopedic internal fixation and bone graft fusion(T2–L4, T9 PVCR) was performed in our hospital in 2019, the postoperative thoracic curve was 32°, lumbar curve was 10°, CBD was 63.2mm **i** In 2021, at 2–year follow–up, thoracic curve was 34°, lumbar curve was 11°, CBD was 86.2mm **j** In 2021, orthopedic internal fixation and bone graft fusion (T2–L4, L1 asymmetric PSO with Dominos distraction) was performed after scoliosis. Dominos were spread, thoracic curve was 34°, lumbar curve was 24°, CBD was 39.3mm **k** In 2022, at 13–month follow–up after the last operation, thoracic curve was 34°, lumbar curve was 23°, CBD was 40.4mm

少对原有融合椎干扰破坏,减少手术创伤,在腰段凹侧采用多米诺支撑技术，骨盆倾斜角缩小至6.43°±4.61°，最下固定椎倾斜角缩小至 2.71°±3.09°，将腰骶椎相对于骨盆最高点连线水平化，使得冠状面失衡矫正率达 53%。通过积极纠正及控制骨盆倾斜和最下固定椎倾斜，对预防和改善术后冠状面失衡可取得良好效果。然而,盲目追求内固定延长并不能根本预防冠状面失衡。1 例患者,在本次手术前,已经固定至 S1 及双侧髂骨,但随访过程中,内固定松动,冠状面失衡依然加重,说明在不实现远端椎体水平化的情况下，即使固定至骶骨或髂骨,依然存在内固定失败、冠状面失衡加重的风险。此次术后,患者垫脚垫,尽可能维持最下固定椎及骨盆水平化,随访过程中,冠状面失衡无明显丢失。患者的生活质量也显著提高,SF-36 综合评分由术前平均 27.29±1.98 分，改善至术后 36.86±2.27 分,在末次随访时进一步改善至 50.14±3.24 分,临床效果明显。

不对称性截骨在成人退变性腰椎侧凸中展现较好的矢状面平衡矫正效果[22]。Toyone 等[23]分析 14 例接受不对称性 PSO 截骨的患者资料,腰椎侧凸平均减少 28°,前凸平均恢复 39°,表明通过凸

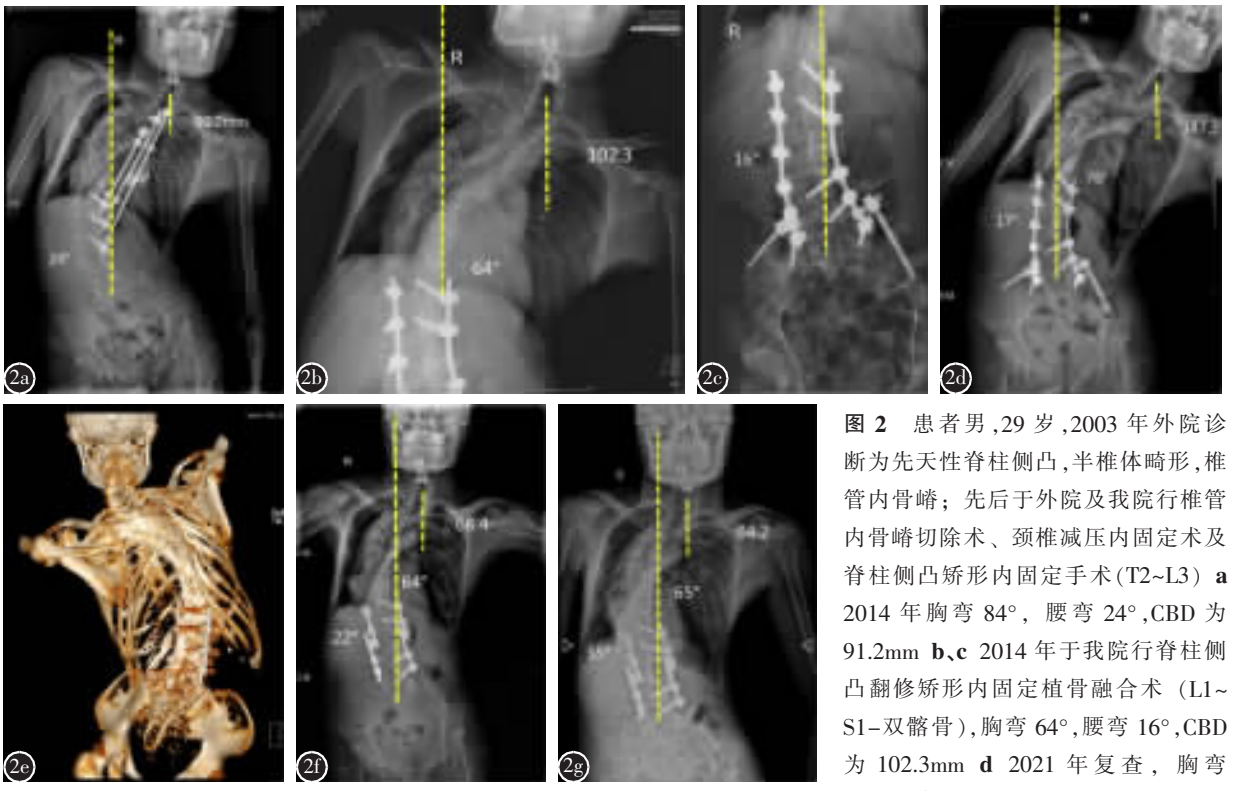

图 2 患者男,29 岁,2003 年外院诊断为先天性脊柱侧凸,半椎体畸形,椎管内骨嵴；先后于外院及我院行椎管内骨嵴切除术、颈椎减压内固定术及脊柱侧凸矫形内固定手术(T2~L3） **a** 2014 年胸弯 84°，腰弯 24°,CBD 为 91.2mm **b、c** 2014 年于我院行脊柱侧凸翻修矫形内固定植骨融合术（L1~S1-双髂骨),胸弯 64°,腰弯 16°,CBD 为 102.3mm **d** 2021 年复查，胸弯 76°,腰弯 17°,CBD 为 147.3mm,双侧髂骨内固定松动 **e** 2021 年复查全脊柱 CT 重建 **f** 2021 年于我院行脊柱侧凸翻修截骨矫形内固定植骨融合术（L1-最下固定椎,L3 PSO),多米诺撑开胸弯 64°,腰弯 22°,CBD 为 68.4mm,术中取出原双侧骶骨及髂骨内固定,更换其余椎弓根内固定 **g** 2022 年末次手术后 13 个月随访,胸弯 65°,腰弯 35°,CBD 为 64.2mm

Figure 2 A 29 years old male, diagnosed as congenital scoliosis, hemivertebra deformity, and intravertebral ridge in other hospital in 2003. Intravertebral ridge resection, cervical decompression and internal fixation, and scoliosis orthopedic internal fixation (T2-L3) were performed successively in other hospital and our hospital **a** In 2014, thoracic curve was 84°, lumbar curve was 24°, CBD was 91.2mm **b, c** In 2014, revision surgery was performed in our hospital (L1-S1-iliac bone), the postoperative thoracic curve was 64°, lumbar curve was 16°, CBD was 102.3mm **d** Re-examination in 2021, thoracic curve was 76°, lumbar curve was 17°, CBD was 147.3mm, and internal fixation of bilateral iliac loosening **e** Total spinal CT reconstruction was reviewed in 2021 **f** In 2021, revision osteotomy and orthopaedic internal fixation and bone graft fusion with Dominos distraction for scoliosis(L1-lowest fixed vertebra, L3 PSO) was performed in our hospital, thoracic curve was 64°, lumbar curve of 22°, CBD was 68.4mm. The original bilateral sacrum and iliac bone internal fixation were removed intraoperatively, and the remaining vertebral pedicles internal fixation was replaced **g** In 2022, at 13-month follow-up after the final operation, thoracic curve was 65°, lumbar curve was 35°, CBD was 64.2mm

侧后外侧楔形椎体切除可显著矫正脊柱侧凸和腰椎前凸。Cecchinato 等[24]也认为不对称性 PSO 截骨技术在改善脊柱失衡方面优于全椎体切除术，并根据冠状面的朝向，制定截骨策略；当冠状面失衡朝向腰椎主弯凸侧时，应在腰椎主弯的基部进行不对称 PSO；当冠状面失衡朝向腰主弯椎凹侧时，应在腰椎畸形近端进行不对称截骨术。对脊柱长节段融合骨盆倾斜患者，并不适用 Bridwell[6]、邱勇等[25]、Bao 等[26]及 Obeid 等[27]的冠状面失衡分型及矫形策略。我们在既往文献基础上，充分考虑胸弯、腰弯僵硬度、骨盆倾斜角以及腰弯等与冠状面失衡之间的关系，综合考虑骨盆倾斜、脊柱僵硬程度及手术风险等因素，采取不对称 PSO 截骨增加腰弯，人为制造新的腰弯对抗原有的胸弯，同时反向撑开腰骶交界区，尽可能将最下固定椎水平化，减少骨盆倾斜；对于同样存在骨盆倾斜、腰椎尚未完全融合，腰弯大于胸弯的患者，CIB 系胸弯、腰弯不平衡所致，采取 Ponte 截骨松解后，延长最下固定节段，增加胸弯、腰弯的矫正，尽可能最下固定椎水平化，减少骨盆倾斜。所有患者冠状面失衡较前明显改善。虽不及文献报道中成人退变性脊柱侧凸冠状面失衡的矫正效果[28,29]，但在加强腰骶区水平化的同时，减少腰骶椎融合及对原融合区的干扰，避免增加手术出血、时间及风险。本组手术时间 346.14±64.65min，术中出血量 1342.86±687.65ml，与既往翻修手术文献报道相仿[30,31]。

三柱以上截骨对脊柱畸形矫正效果良好，但神经损害、内固定失败及胸腔积液等并发症发生率较高[32]，尤其对于经历多次翻修手术的患者，正常的骨性结构及参照被破坏，出现并发症的概率更大。本研究中 7 例患者经历 2~13 次不等的手术，翻修手术与初次手术的脊柱结构及分型明显不同，缺乏参考性，脊柱后方软组织瘢痕化，主胸弯及腰弯基本融合，手术风险大。7 例患者中 5 例出现包括脑脊液漏、下肢神经痛、胸腔积液等并发症，虽没有严重感染、永久神经损伤及死亡等严重并发症的发生，仍提示该类患者手术并发症多，风险大，需要慎重选择术式。所有患者并发症经对症处理后均治愈顺利出院，随访中未出现其他并发症或需要再手术情况。针对多次翻修手术的患者，本组主要采取截骨手段，短缩椎管，避免矫形时出现脊髓张力增高而出现脊髓损伤；截骨端完全闭合，增加前柱融合；大量植骨，增加后柱融合；对于脊柱僵硬的患者，采取多米诺纵向连接多个椎弓根钉，撑开多米诺连接器，完成提拉及平移矫形，以避免内固定失败。

4 小结

本研究针对多次脊柱侧凸融合矫正术后，随访 2 年以上仍存在严重冠状面失衡（CBD>4cm）患者的数据进行回顾性分析。依据冠状面失衡程度、主胸弯、腰弯、骨盆倾斜角及最下固定椎倾斜度，采取针对性的矫正策略，术后垫脚垫纠正双下肢及骨盆倾斜，取得了较好的临床效果，改善了生活质量。但由于出现脊柱侧凸术后严重冠状面失衡的患者较少，本研究样本量小；随访时间较短，远期效果仍需进一步随访统计；单中心数据回顾性分析数据存在多样性及异质性，后续还需要进行多中心大样本以及长期随访的临床数据分析。

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（收稿日期:2022-10-17 末次修回日期:2023-03-02）
（英文编审 谭 啸）
（本文编辑 娄雅浩）