

临床论著

皮质骨螺钉加传统椎弓根螺钉结合卫星棒固定
治疗退变性脊柱侧凸的疗效观察

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【摘要】目的:观察皮质骨螺钉(cortical bone trajectory,CBT)加传统椎弓根螺钉(traditional trajectory,TT)结合卫星棒、远端固定至 S1 治疗成人退变性脊柱侧凸(adult degenerative scoliosis,ADS)的可行性及临床疗效。方法:回顾性分析 2014 年 6 月~2018 年 1 月在我院采用长节段融合 CBT+TT 结合卫星棒、远端固定至 S1 矫形固定治疗的 11 例 ADS 患者的资料。比较患者术前和末次随访时的腰背痛视觉模拟评分(visual analogue scale,VAS)、Oswestry 功能障碍指数(Oswestry disability index,ODI),术前、术后即刻和末次随访时的 Cobb 角、C7 铅垂线(C7 plumb line,C7PL)与骶骨中垂线(center sacral vertical line,CSVL)的相对距离(C7PL-CSVL)和脊柱矢状轴(sagittal vertebral axis,SVA)。结果:11 例患者均为女性,年龄 51~73 岁(64.36±7.63 岁),手术时间 247.64±44.96min,术中出血量 1118.18±464.37ml。1 例患者术后出现脑脊液漏,延长引流时间、换药后愈合;1 例患者术后出现一过性肌力减退,给予口服甲钴胺 2 周,于术后 3 个月恢复,无其他严重并发症发生。术后随访 13~60 个月(33.87±14.36 个月),术前 VAS 评分为 7.00±0.89 分,末次随访时为 0.91±0.70 分,差异有统计学意义($P<0.05$);术前 ODI 为(51.09±7.83)%,末次随访时为(5.45±1.13)%,差异有统计学意义($P<0.05$)。术前、术后即刻、末次随访时冠状面 Cobb 角分别为 49.10°±11.51°、12.05°±3.78°、13.06°±3.38°,C7PL-CSVL 分别为 27.27±17.61mm、12.20±8.04mm、12.40±8.05mm,SVA 分别为 25.33±18.21mm、8.60±5.31mm、9.75±6.94mm,末次随访时的 Cobb 角、C7PL-CSVL、SVA 与术前比较均有统计学差异($P<0.05$);末次随访时与术后即刻比较均无统计学差异($P>0.05$)。随访期内所有患者均未出现内固定失败征象。结论:CBT+TT 结合卫星棒矫形远端固定至 S1 长节段腰骶融合可增强脊柱骨盆固定强度,治疗 ADS 可取得较好的临床疗效。

【关键词】退变性脊柱侧凸;长节段固定;皮质骨螺钉;椎弓根螺钉;卫星棒

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【Abstract】Objectives: To explore the feasibility and clinical outcomes of cortical bone trajectory(CBT) and traditional trajectory(TT) combined with satellite rod which terminated to S1 in patients with adult degenerative scoliosis (ADS). Methods: This retrospective study included patients with ADS who underwent CBT+TT combining with satellite rods long fusion, from June 2014 to January 2018. Visual analogue score(VAS), the Oswestry disability index (ODI), Cobb angle, the distance between C7 plumb line and center sacral vertical line(C7PL-CSVL) and sagittal vertebral axis(SVA) were compared among before operation, immediately after operation and at final follow-up. Results: A total of 11 patients were enrolled, all of them were female with an average age of 64.36±7.63 years. The operation time was 247.64±44.96min, and the blood loss was 1118.18±464.37ml. Cerebrospinal fluid leakage occurred in 1 patient, and the wound healed well after prolonged drainage and dressing change. 1 patient showed transient muscle weakness after surgery, and was given mecobalamin for 2 weeks, who recovered three months after the operation. No serious complication occurred.

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The mean follow-up time was 33.87 ± 14.36 months. VAS score was 7.00 ± 0.89 points before surgery and 0.91 ± 0.70 points at the last of follow-up. The ODI was $(51.09 \pm 7.83)\%$ at the initial examination and $(5.45 \pm 1.13)\%$ at the final follow-up. The Cobb angle decreased from $49.10^\circ \pm 11.51^\circ$ preoperatively to $12.05^\circ \pm 3.78^\circ$ immediately after operation and $13.06^\circ \pm 3.38^\circ$ at the last of follow-up. C7PL-CSVL was 27.27 ± 17.61 mm, 12.20 ± 8.04 mm and 2.40 ± 8.05 mm preoperatively, immediately after operation and at the last follow-up respectively. SVA was 25.33 ± 18.21 mm, 8.60 ± 5.31 mm and 9.75 ± 6.94 mm preoperatively, immediately after operation and at the end follow-up respectively. There were significant differences of Cobb angle, C7PL-CSVL and SVA between before operation and at the final follow-up ($P < 0.05$), but there was no statistical significance difference of the above three measurements between immediately after operation and at the final follow-up ($P > 0.05$). All patients had no failure of instrument. **Conclusions:** CBT and TT combined with satellite rod which terminated to S1 has a good short and mid term outcomes in ADS, and provides a new reliable measure to enhance fixation of spine and pelvis.

[Key words] Degenerative scoliosis; Long segment fixation; Cortical bone trajectory; Traditional trajectory; Satellite rods

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成人退变性脊柱侧凸 (adult degenerative scoliosis, ADS) 是常见的脊柱侧凸类型,伴有顽固腰痛和疲劳感的脊柱侧凸患者,往往存在责任节段不明确、脊柱冠状面和矢状面严重失衡等问题,对于此类患者常需行矫形固定融合手术^[1-2],跨短节段的融合固定可有效解决部分伴有短节段腰椎椎管狭窄、椎间盘严重退变突出压迫神经、局部椎体严重倾斜、椎体滑脱或既往局部有手术史患者的腰腿痛等临床症状^[3-6]。Velis 等^[7]认为退变性脊柱侧凸患者的中老年人常伴有中重度骨质疏松,行跨 L5/S1 长节段(4 节段)融合固定存在局部承受应力大、螺钉松动拔出、假关节发生、矫形丢失等问题,故其远端固定很少终止于 S1^[8]。目前常用的脊柱骨盆远端固定方式包括:Luque-Galveston 技术^[9]、S2 髂骨螺钉 (sacral-2 alar iliac, S2AI)^[10]、S1-2 螺钉^[11]固定和髂骨钉^[12]固定等,但均存在不同的缺点,包括过多的肌肉剥离^[13]、棒塑形及置棒困难^[14]、所需植骨量大^[15]、双棒固定近端交界性后凸 (proximal junctional kyphosis, PJK),远端脱钉、经骶髂螺钉断裂^[16]以及冠状位失平衡。对比传统固定技术^[17-19],理论上皮质骨螺钉 (cortical bone trajectory, CBT) 加传统椎弓根螺钉 (traditional trajectory, TT) 固定具有以下优势:术中肌肉暴露少,要求植骨量小,手术时间较短、手术出血量少;具有更好的抗疲劳性,螺钉头突出几率小和感染发生率低;且脊柱外科医生对此手术入路和 CBT 和 TT 置入也较熟悉。2014 年 6 月~2018 年 1 月,我们采用 CBT+TT 结合卫星棒固定治疗需跨腰骶

段融合的退变性脊柱侧凸病例共 11 例,获得了满意疗效,总结报告如下。

1 资料和方法

1.1 一般资料

病例纳入标准:(1)退变性脊柱侧凸,Lenke-Silva 分型中的 V 型或 VI 型^[20];(2)患者有严重的腰背疼痛或疲劳感,无明确的相关节段;或有严重的机械性疼痛,以及马尾神经压迫症,严格保守治疗无效;(3)侧凸 Cobb 角 $> 30^\circ$ 伴明显的椎体旋转以及侧方滑移 > 3 mm,脊柱冠状面和矢状面失平衡;(4)L5/S1 退变严重;(5)L5/S1 有滑脱史;(6)L4/5、L5/S1 节段有既往手术史;(7)上固定节段超过 T12。

2014 年 6 月~2018 年 1 月,按照纳入与排除标准严格筛选,共纳入 11 例 ADS 患者,均为女性,年龄 51~73 岁 (64.36 ± 7.63 岁);全脊柱 X 线片上测量冠状面 Cobb 角为 $30.2^\circ \sim 70.0^\circ$ ($49.10^\circ \pm 11.51^\circ$),C7 铅垂线与骶骨中垂线的相对距离 (C7PL-CSVL) 为 $9.13 \sim 67.76$ mm (27.27 ± 17.61 mm),其中 2 例患者合并后凸畸形。

1.2 手术方法

11 例患者均由同一组医师进行手术操作。所有患者均采用气管插管全身麻醉,麻醉成功后,患者取俯卧位,腹部垫空。依据术前影像学资料、脊柱节段僵硬程度,选择上、下端椎。所有患者均跨腰骶段长节段融合固定至 S1 并行后路关节突松解、Ponte 截骨,伴严重脊柱后凸畸形、冠状位失平

衡的患者行经椎弓根 V 形截骨 (pedicle subtraction osteotomy, PSO)。于 L4/5 和/或 L5/S1 凸/凹侧行减压、后路腰椎椎间融合 (posterior lumbar interbody fusion, PLIF) 或经椎间孔腰椎间融合 (transforaminal lumbar interbody fusion, TLIF) 手术,并置入椎弓根螺钉,短节段性撑开或加压序贯矫形,双侧置入预弯的连接棒,大力钳夹紧并旋转连接棒,矫正畸形。完成矫形后,于主弯凸侧、跨截骨区上方椎体置入皮质骨螺钉,两皮质骨螺钉加用卫星棒连接,预弯的连接棒与卫星棒之间间隔加用横联连接,横突及椎板间植骨,冲洗术野,放置引流,关闭切口。术中采用脊髓体感诱发电位 (somatosensory evoked potential, SEP) 及运动诱发电位 (motor evoked potential, MEP) 监测。

1.3 术后处理

术后给予常规心电监护、持续低流量吸氧、监测生命体征变化,记录四肢活动及术区引流情况。所有患者给予常规抗感染治疗 2d,使用糖皮质激素预防术后脊髓水肿。术后 48~72h 拔除引流管。患者早期在床上行主、被动双下肢功能训练及呼吸功能训练,拔除引流管后即下床活动。胸腰支具保护下康复锻炼 3 个月,避免过度弯腰及负重。3 个月后逐步恢复正常生活。

1.4 随访和评价标准

所有病例术后均获得随访,随访时间 13~60 个月 (33.87±14.36 个月)。术后每 3 个月于我院行全脊柱正侧位 X 线片检查,必要时行 CT 薄层扫描及三维重建,并与术前影像学资料对比。记录术前和末次随访时的腰背痛视觉模拟评分 (visual analogue scale, VAS)、Oswestry 功能障碍指数 (Oswestry disability index, ODI),术前、术后即刻和末次随访时的 Cobb 角、C7PL-CSVL、脊柱矢状轴 SVA,术后并发症及并发症改善情况。

1.5 统计学分析

采用 SPSS 21.0 软件对数据进行分析,计量资料用均数±标准差 ($\bar{x} \pm s$) 表示,各时间点间的比较采用 *t* 检验, $P < 0.05$ 为差异有统计学意义。

2 结果

2.1 临床疗效

11 例患者手术顺利,术中出血 1118.18±464.37ml,手术时间 247.64±44.96min,术中脊髓 SEP 及 MEP 未见明显变化。术前及末次随访的

VAS 评分和 ODI 见表 1,末次随访时的 VAS 及 ODI 与术前比较均有统计学差异 ($P < 0.001$),末次随访时 VAS 评分与 ODI 较术前明显改善。

2.2 矫形效果

术前、术后和末次随访时的 Cobb 角、C7PL-CSVL、SVA 见表 2,术后即刻和末次随访时与术前比较均有统计学差异 ($P < 0.05$),术后与随访末次随访时比较无统计学差异 ($P = 0.195$)。末次随访 Cobb 角较术后即刻丢失 $1.01^\circ \pm 0.60^\circ$,矫形丢失率为 9.58%。随访期内无螺钉松动和内置物断裂;椎间及椎旁植骨融合良好,未出现交界性问题,矫形效果维持良好 (图 1)。

2.3 并发症

术后 1 例出现脑脊液漏,延长引流时间,对症支持、换药治愈。1 例术后出现 L3 神经根麻痹,并一侧伸膝力下降,术后 3 个月恢复正常;无不可逆神经损伤等其他严重并发症。随访期内未出现其他并发症。

3 讨论

ADS 主要见于 60 岁以上中老年人,既往没

表 1 术前及末次随访时 VAS 和 ODI ($\bar{x} \pm s$)

Table 1 VAS and ODI preoperation and final follow-up

	术前 Preoperation	末次随访 Final follow-up
VAS 评分 (分) VAS score	7.00±0.89	0.91±0.70 ^①
Oswestry 功能障碍指数 (%) ODI	51.09±7.83	5.45±1.13 ^①

注:①与术前比较 $P < 0.05$

Note: ①Compared with preoperation, $P < 0.05$

表 2 术前、术后即刻与末次随访时的 Cobb 角、C7PL-CSVL 和 SVA ($\bar{x} \pm s$)

Table 2 Cobb angle, C7PL-CSVL and SVA pre-operation, post-operation and final follow-up

	术前 Preoperation	术后即刻 Post-op im	末次随访 Final follow-up
Cobb 角 ($^\circ$) Cobb angle	49.10±11.51	12.05±3.78 ^①	13.06±3.38 ^①
C7 铅垂线与骶骨中垂线的相对距离 (mm) C7PL-CSVL	27.27±17.61	12.20±8.04 ^①	12.40±8.05 ^①
脊柱矢状轴 (mm) SVA	25.33±18.21	8.60±5.31 ^①	9.75±6.94 ^①

注:①与术前比较 $P < 0.05$

Note: ①Compared with preoperation, $P < 0.05$

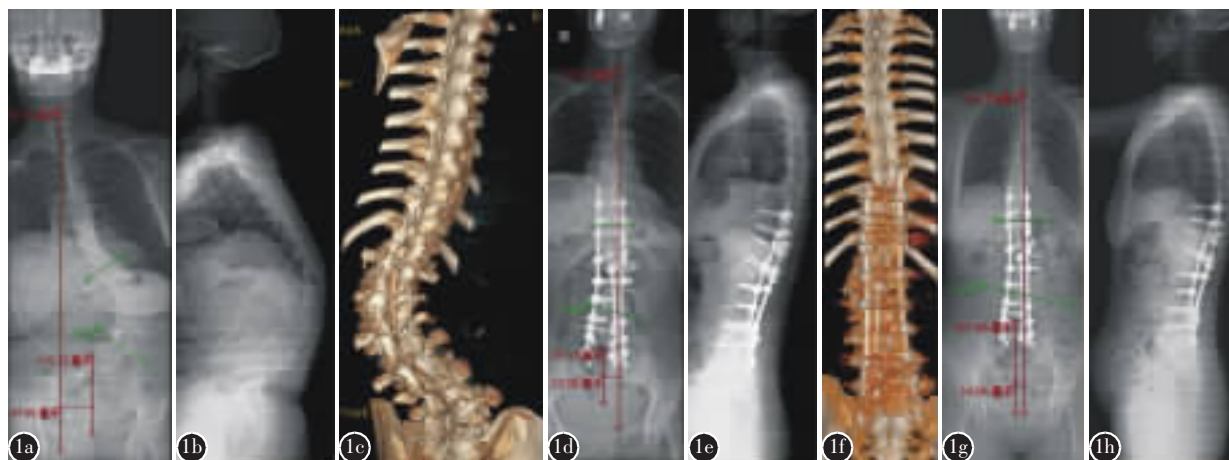


图 1 患者女,51 岁,腰腿痛 3 年余 **a** 术前全脊柱正位 X 线片示 Cobb 角 70.0° ,C7PL-CSVL 为 47.7mm **b** 术前全脊柱侧位 X 线片示合并胸腰段后凸畸形 **c** 术前全脊柱 CT 三维重建示侧凸合并后凸及旋转畸形 **d** 术后即刻全脊柱正位 X 线片示 Cobb 角 14.8° ,C7PL-CSVL 为 22.8mm **e** 术后即刻全脊柱侧位 X 线片示后凸畸形纠正 **f** 术后即刻全脊柱 CT 三维重建示侧凸、后凸畸形纠正 **g** 末次随访(术后 26 个月)全脊柱正位 X 线片示 Cobb 角 12.8° ,C7PL-CSVL 为 14.0mm **h** 末次随访(术后 26 个月)全脊柱侧位 X 线片示后凸畸形矫正无丢失

Figure 1 51-year-old female with more than 3 years lumbocrural pain **a** Total spine anteroposterior and lateral radiographs showed that the Cobb angle was 70.0° and C7PL-CSVL was 47.7mm **b** Thoracolumbar kyphosis was shown by lateral radiographs **c** Total spine CT and three-dimensional reconstruction demonstrated scoliosis, kyphosis and rotation **d** Total spinal anteroposterior radiographs showed the Cobb was 14.8° and C7PL-CSVL was 22.8mm post-operatively immediately **e** Total spinal lateral radiographs showed correction of kyphosis post-operatively **f** Total spine CT with three-dimensional post-operative reconstruction demonstrated the correction of scoliosis, kyphosis and rotation **g** Last follow-up, coronal radiographs of the total spine showed Cobb angle was 12.8° and C7PL-CSVL was 14.0mm at 26 months after operation **h** Total spinal lateral radiographs at final follow-up showed no loss of kyphosis correction

有脊柱侧凸病史,女性发病率较男性高,且随着年龄增长,发病率逐渐升高。发病初始因素常为一个或多个椎间盘和(或)关节突关节不对称性退变,此种非对称改变导致椎体左右两侧所受应力不均等,因此产生左右两侧不对称畸形,此不对称畸形又加速了不对称性退变,形成恶性循环,最终导致脊柱侧凸。

对 ADS 的治疗不同于其他类型脊柱侧凸,主要以缓解症状为主。在患者生活质量不受影响前提下可行保守治疗。对于保守治疗后仍存在腰痛、下肢放射痛的患者应行手术治疗。其手术指征包括长期非手术治疗无效的腰腿痛或下肢间歇性跛行,严重影响生活质量;神经压迫症状显著并进行性加重;影像学表现为明显的脊柱不稳、冠状位或矢状位失平衡及侧凸进行性加重。

对于具有手术指征且需行跨腰骶段长节段固定融合治疗的患者,跨腰骶融合的常用固定方法包括 S1-2 螺钉固定^[11]、髂骨钉固定^[12]、S2A1 螺钉固定^[10]、Luque-Galveston 技术^[9]等双棒固定技术,

但这些固定方式具有过多的肌肉暴露,要求植骨量大,手术时间长和手术出血量大,脊髓损伤风险高、螺钉易松动,螺钉头突出和感染发生率高、术后假关节形成^[13-16]等弊端。

针对目前长节段融合存在的诸多问题,Li 等应用 CBT+TT 结合卫星棒加强固定,远端固定至 S1,通过中短期临床效果随访观察显示,于同一节段置入 CBT 和 TT 增加了该椎体尤其骨量减少椎体中螺钉的抗拔出^[17]。应用卫星棒使椎体应力分布于三根矫正棒,在增强固定的同时分散了受力,降低了因局部应力过大带来螺钉松动、断棒、畸形丢失风险。

本研究中对远端 L4/5 和/或 L5/S1 退变椎间盘切除、行 PLIF 和/或 TLIF 椎间融合,卫星棒选择置入主弯凸侧,分散骶骨应力,增强支撑,维持脊柱整体平衡。术后和术前 Cobb 角、C7PL-CSVL、SVA、VAS 评分、ODI 比较,差异均具有统计学意义($P<0.05$),患者症状及影像学表现均获得改善;末次随访与术后即刻的 Cobb 角、

C7PL-CSVL、SVA 比较差异均无统计学意义 ($P>0.05$),说明随访期间无明显畸形丢失。随访期间,患者未出现严重并发症。CBT+TT 结合卫星棒固定矫形后,脊柱整体平衡改善,三棒及螺钉应力分散较均匀,未出现局部或整体应力过大致断钉断棒及内固定松动情况。

本研究通过随访观察了 CBT+TT 远端固定终止于 S1 结合卫星棒固定治疗退变性脊柱侧凸的中短期临床疗效,证实该技术是治疗退变性脊柱侧凸的一种可靠方式。但本研究只有中短期观察,缺少长期随访,病例样本少,研究样本间的变量难以完全控制;个体脊柱差异缺乏同质化标准;尚无生物力学验证,无法对新手术技术的效果量化体现。针对这些问题,后期研究中,拟通过增加研究样本量、制定个体差异同质化标准、增加生物力学验证、增长随访周期完善研究。

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