

# 后路个体化三柱截骨矫形治疗结核性脊柱角状后凸畸形

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**【摘要】** 目的: 探讨后路三柱截骨矫形术治疗重度结核性脊柱角状后凸畸形的疗效。方法: 2006 年 1 月至 2019 年 1 月应用后路三柱截骨矫形术治疗结核性脊柱重度角状后凸畸形患者 33 例, 男 24 例, 女 9 例; 年龄 15~62 (40.6±23.3) 岁; 病程 4~40 (23.5±15.5) 年; 后凸畸形 Cobb 角 (118.65±28.82)°。个体化应用后路经椎弓根椎体椎间盘截骨术 (bone-disc-bone osteotomy, BDBO)、全椎体切除术 (vertebral column resection, PVCR) 和多节段椎体截骨 (posterior multilevel vertebral osteotomy, PMVO) 矫正脊柱畸形。术前后采用疼痛视觉模拟评分 (visual analogue scale, VAS)、Oswestry 功能障碍指数 (Oswestry disability index, ODI)、矢状面轴向垂直距离 (sagittal vertical axis, SVA)、顶椎椎管矢状径、美国脊髓损伤学会 (American Spinal Injury Association, ASIA) 脊髓运动功能分级、畸形矫正率进行疗效评价。结果: 33 例患者术后获得随访, 时间 15~96 (38.00±6.38) 个月。后凸 Cobb 角末次随访 (23.88±5.45)°, 较术后 12 个月 (20.40±9.13)° 无明显丢失 ( $P>0.05$ )。术后 1 年和末次随访 SVA、VAS、ODI、ASIA 脊髓运动功能评分较术前明显改善 ( $P<0.01$ )。截骨端植骨融合时间 (18.50±5.16) 个月。术前 15 例有脊髓损伤者术后 ASIA 分级较术前至少提高 2 个级别, 不同程度恢复日常生活及工作能力。术后脊髓损伤并发症 3 例。结论: 后路三柱截骨矫形术是治疗脊柱结核角状后凸畸形最有效的方法, 缜密的术前设计和个体化截骨术式施术, 既可矫正畸形, 又能对脊髓有效减压, 减少神经并发症, 促进脊髓功能恢复。

**【关键词】** 脊柱结核; 脊柱畸形; 截骨术; 并发症

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## Reposterior individualized three-column osteotomy for tuberculous spinal angular kyphosis deformity

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**ABSTRACT** **Objective** To investigate the efficacy of posterior three-columns osteotomy in the treatment of severe tuberculous angular kyphosis. **Methods** Total of 33 patients with severe tuberculous angular kyphosis were treated with posterior three-columns osteotomy from January 2006 to January 2019 including 24 males and 9 females with an average age of (40.6±23.3) years old ranging from 15 to 62 years old and an average disease duration of (23.5±15.5) years ranging from 4 to 40 years. The Cobb's angle of kyphosis was (118.65±28.82)°. Interradicular bone-disc-bone osteotomy (BDBO), posterior-only vertebral column resection (PVCR) and posterior multilevel vertebral osteotomy (PMVO) were performed to correct spinal deformity individually. The visual analogue scale (VAS), Oswestry disability index (ODI), sagittal vertical axis (SVA), ASIA spinal cord functional classification and motor function score, and deformity correction rate were measured and statistically analyzed before, after and at the final follow-up. **Results** Total of 33 patients were followed up from 15 to 96 months with an average of (38.00±6.38) months. The last follow-up of kyphosis Cobb angle (23.88±5.45)° showed no significant loss from postoperative 12 months (20.40±9.13)°,  $P>0.05$ . The SVA, VAS, ODI and ASIA spinal cord functional classification and motor function score were significantly improved at 1 year and last follow-up after operation ( $P<0.01$ ). The fusion time of the osteotomy site was (18.50±5.16) months. The ASIA classification of 15 patients with spinal cord injury were improved by at least 2 grades after operation, and their daily life and work ability were various levels of restored. Postoperative complications of spinal cord injury occurred in 3 cases. **Conclusion** Posterior three-columns osteotomy is the most effective method for the treatment of angular

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kyphosis of spinal tuberculosis. Careful preoperative design and individualized osteotomy can not only correct the deformity, but also a successful decompression to the spinal cord and promote the recovery of spinal cord function.

**KEYWORDS** Spinal tuberculosis; Spinal deformity; Osteotomy; Complication

脊柱结核早期诊治不当, 迁延不愈可继发严重角状后凸畸形。因其病程长、脊柱畸形严重、僵硬程度高和继发性椎管狭窄, 在此基础上并发脊髓神经功能障碍发生率高<sup>[1]</sup>, 导致矫形手术难度及风险大且并发症发生率高一直是脊柱外科的难题。随着脊柱截骨术的进步, 脊柱后路截骨矫形特别是经椎弓根椎体椎间盘截骨术 (bone-disc-bone osteotomy, BDBO)、全椎体切除术 (vertebral column resection, PVCR) 和多节段椎体截骨 (posterior multilevel vertebral osteotomy, PMVO) 等三柱截骨矫形术已成为治疗严重脊柱畸形的重要方法<sup>[2-5]</sup>。但因手术出血量大、截骨端移位、硬脊膜短缩皱折、脊髓压迫和局部脊髓神经根粘连等原因, 导致脊髓损伤并发症发生率较高<sup>[6]</sup>, 严重影响疗效。自 2006 年 1 月至 2019 年 1 月对 33 例结核性脊柱角状后凸畸形患者个体化应用截骨矫形技术, 报告如下。

## 1 资料与方法

### 1.1 病例选择

纳入标准: 脊柱结核继发重度角状后凸畸形患者; 脊柱后凸畸形 Cobb 角  $\geq 80^\circ$ , 柔韧度  $\leq 25\%$ ; 采用 BDBO、PVCR 或 PMVO 脊柱三柱截骨术矫形者。排除标准: 随访时间  $< 1$  年; 临床数据资料不全。

### 1.2 一般资料

本组 33 例患者, 男 24 例, 女 9 例, 年龄 15~62 (40.6 $\pm$ 23.3) 岁; 上胸椎结核 (T<sub>3</sub>-T<sub>5</sub>) 2 例, 中胸椎结核 (T<sub>5</sub>-T<sub>11</sub>) 6 例, 胸腰段结核 (T<sub>12</sub>-L<sub>1</sub>) 9 例, 腰椎结核 (L<sub>2</sub>-L<sub>3</sub>) 5 例, 腰骶段结核 (L<sub>5</sub>S<sub>1</sub>) 1 例; 结核病灶活动期 5 例, 静止期 11 例, 愈合期 17 例。病程 4~40 (23.5 $\pm$ 15.5) 年。后凸畸形 Cobb 角 80.50°~138.00° (118.65 $\pm$ 28.82)°, 矢状面轴向垂直距离 (sgittal vertical axis, SVA) 为 (9.45 $\pm$ 2.27) cm; 顶椎部椎管矢状径 (17.05 $\pm$ 1.60) mm (三维 CT 和胸腰椎 MRI 测量脊柱后凸畸形顶椎及上下相邻两椎的椎管矢状径以顶椎区位于 T<sub>3</sub>-T<sub>11</sub> 者椎管平均矢状径为 13.60 mm、T<sub>12</sub>-L<sub>1</sub> 者椎管平均矢状径为 14.80 mm、L<sub>1</sub>-L<sub>5</sub> 者椎管平均矢状径为 17.60 mm); 后凸畸形顶点部位结核累及范围 3 椎 10 例, 4 椎 18 例, 5 椎 5 例。主要症状为腰背痛和下肢运动、感觉和大小便功能障碍。术前共 15 例 (占 45.45%) 存在不同程度脊髓、神经根损害, ASIA 脊髓神经功能评定 A 级 1 例, B 级 2 例, C 级 9 例, D 级 3 例。本研究经新疆巴州人民医院医学伦理委员会讨论批准 [编号: BZRMYY (2024) 003], 患者均知情同意。

### 1.3 手术设计与术前准备

拍摄站立位全脊柱正侧位 X 线片和左右前后 Banding 像 X 线片, 测量脊柱侧凸及后凸 Cobb 角、躯干平衡指标, 评价脊柱畸形的僵硬性和脊柱矢状位、冠状位失平衡状况; 脊柱三维 CT 扫描和 MRI 检查, 测量椎管大小、脊髓受压和损害情况。个体化设计预计截骨角度、截除脊柱畸形顶椎上下的椎节范围和矫正的程度, 选择最佳截骨术式、脊柱固定融合范围和脊柱稳定性重建方法, 预测手术操作的风险和应对措施。处于脊柱结核活动期者术前给予正规短程化疗至少 2 周, 至结核中毒症状消失, 红细胞沉降率  $\leq 40 \text{ mm} \cdot \text{h}^{-1}$  或显著下降, 纠正贫血和低蛋白血症。

### 1.4 手术方法

气管插管全麻, 患者俯卧手术台, 依患者脊柱后凸畸形程度于胸腹下横向叠放数个软垫, 使脊柱呈拱桥状体位。沿棘突连线以脊柱畸形顶椎上下关键椎体范围做切口, 骨膜下剥离显露椎板及小关节突, 按术前设计在截骨椎体上下各至少 2~3 个相邻需固定融合的相关椎体双侧置入椎弓根螺钉, C 形臂 X 线透视确认螺钉位置正常。确定以顶椎为中心包括其上下需截骨的椎体, 依次切除其上下关节突并做全椎板减压解除脊髓压迫, 再切除其双侧横突 (胸椎者) 并向外 3~4 cm 处截断肋骨并切除此肋骨段, 骨膜下剥离各椎体两侧至其前方, 向两侧推开胸膜, 骨撬显露椎体前外侧面。对活动期和静止期残留的结核病灶由脊柱两侧深入彻底清除, 直至病灶区域创面渗血。再依次切除其双侧椎弓根, 保护脊髓, 开始截骨操作。脊柱截骨以角状后凸顶椎为中心采用 BDBO (10 例)、PVCR (14 例) 和 PMVO (9 例) 截骨术。彻底清除脊髓前缘的骨质和残留的椎间盘及瘢痕组织完成环脊髓减压。截骨即将完成时先于截骨端相对两椎的椎弓根螺钉置入临时固定棒稳定截骨端, 抽取腹下软垫调平手术床, 交替互换已塑形的完整固定棒对截骨端两侧椎体进行纵向加压矫正后凸畸形; 畸形严重者则使用悬臂梁技术进行矫形, 至目测和 C 形臂 X 线透视畸形矫形和截骨端对合满意为宜。生理盐水冲洗术野, 椎旁原病灶潜在腔隙用明胶海绵链霉素粉剂“三明治”填塞。术中唤醒试验监测截骨端合拢过程中脊髓神经功能变化, 置引流管, 分层关闭切口。

### 1.5 术后处理

术后 2~3 d 切口引流量  $< 50 \text{ ml}$  后拔除引流管,





因术后低血容量性休克和另 1 例脊髓功能一过性损害致脊髓功能降至 C 级,行补充血容量、甲泼尼龙冲击、营养神经、高压氧及神经电脉冲刺激治疗,术后半年脊髓功能分别恢复至 D 和 E 级。末次随访与术前比较,A、B、C 级病例数减少,D、E 级病例数明显增加。全部患者截骨端在术后 10~24(18.50±5.16)个月达骨性融合,结核病灶均达到治愈标准<sup>[1]</sup>,不同程度恢复日常生活及工作能力。

### 3 讨论

脊柱结核因前中柱椎体和椎间盘破坏致椎体塌

陷、楔形变,继而渐进性脊柱失稳和后凸畸形;人体重心的前移又不断加重椎体破坏和脊柱畸形,呈恶性循环;椎管扭曲狭窄,前方骨嵴压迫脊髓及其牵张水肿变性、硬膜囊皱缩、瘢痕粘连增厚;长期局部慢性炎症反应导致椎管内微小血管闭塞,脊髓血循环进行性损害;漏诊误诊导致部分患者少儿时已出现脊柱后凸畸形甚至早发性截瘫;不当的椎板减压和无支撑植骨融合术也是脊柱后凸畸形的主要医源性因素,从而造成病程迁延,以致青壮年脊柱严重后凸畸形和反复结核复发甚至迟发性截瘫<sup>[1]</sup>。本组 33 例

表 2 结核性脊柱角状后凸畸形 33 例患者术前后 ODI 评分比较( $\bar{x}\pm s$ )

Tab.2 Comparison of ODI of 33 patients with tuberculous spinal angular kyphosis deformity before and after operation( $\bar{x}\pm s$ ) 单位:分

时间	疼痛程度	日常生活自理能力	提物	行走	坐	站立	睡眠	性生活	社会活动	旅行	总分
术前	3.78±2.59	4.14±1.89	2.12±1.77	1.41±1.22	1.09±0.98	2.02±0.55	1.4±0.43	1.1±0.33	1.91±0.53	2.04±1.43	18.8±4.59
术后 12 个月	1.44±0.77	2.01±1.01	1.41±0.58	0.87±0.38	0.88±0.56	1.14±0.36	0.52±0.41	0.89±0.36	1.17±0.98	1.05±1.01	8.17±3.78
末次随访	1.01±0.56	1.05±0.88	0.89±0.65	0.53±0.43	0.5±0.172	0.7±0.243	0.39±0.33	0.48±0.12	0.97±0.88	0.54±0.39	5.84±1.94
F 值	23.44	19.87	6.58	6.99	51.44	34.98	12.07	12.77	45.67	54.20	111.77
P 值	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01

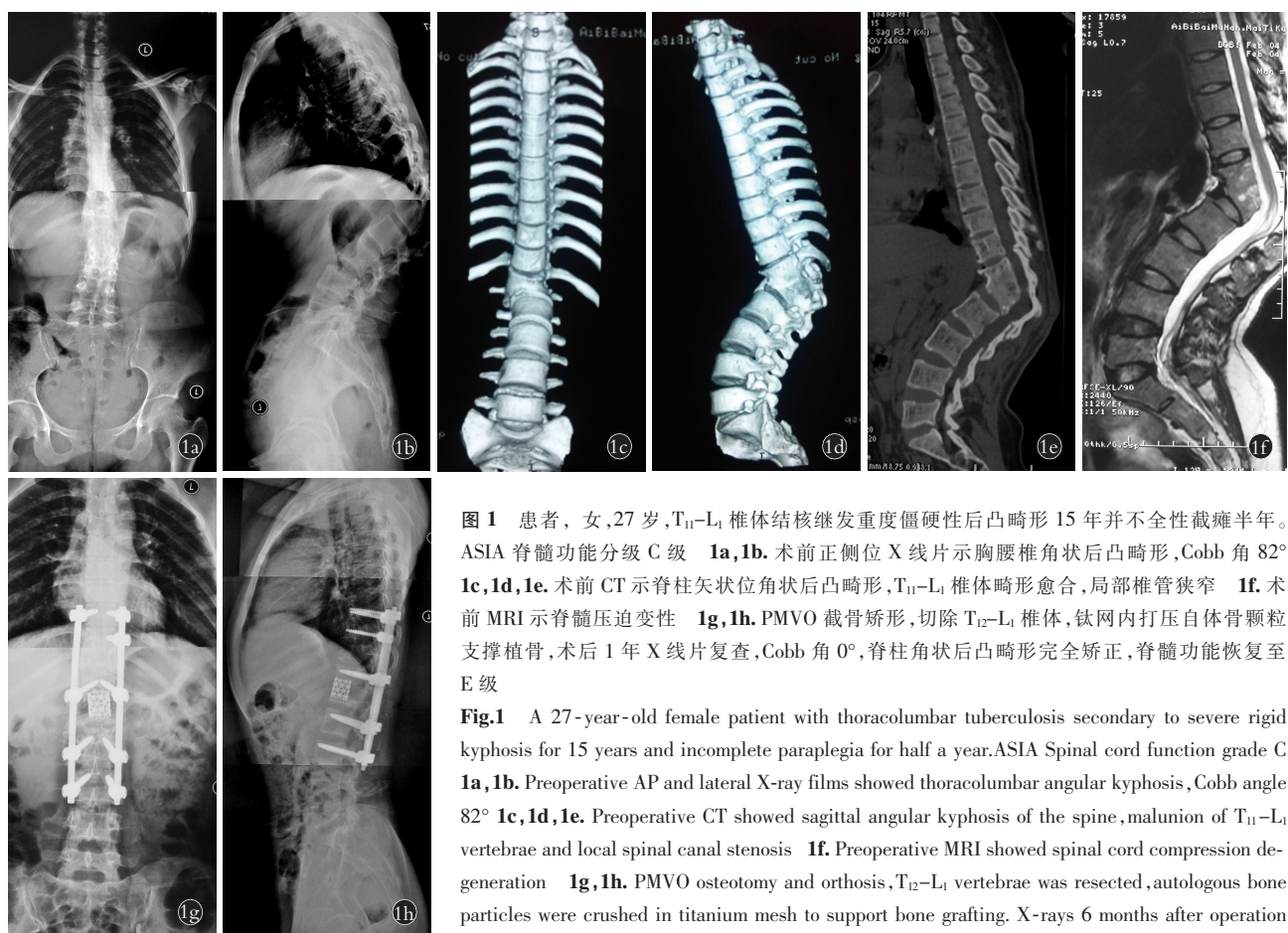


图 1 患者,女,27岁,T<sub>11</sub>-L<sub>1</sub>椎体结核继发重度僵硬性后凸畸形 15 年并不全性截瘫半年。ASIA 脊髓功能分级 C 级 1a,1b. 术前正侧位 X 线片示胸腰椎角状后凸畸形,Cobb 角 82° 1c,1d,1e. 术前 CT 示脊柱矢状位角状后凸畸形,T<sub>11</sub>-L<sub>1</sub>椎体畸形愈合,局部椎管狭窄 1f. 术前 MRI 示脊髓压迫变性 1g,1h. PMVO 截骨矫形,切除 T<sub>12</sub>-L<sub>1</sub>椎体,钛网内打压自体骨颗粒支撑植骨,术后 1 年 X 线片复查,Cobb 角 0°,脊柱角状后凸畸形完全矫正,脊髓功能恢复至 E 级

Fig.1 A 27-year-old female patient with thoracolumbar tuberculosis secondary to severe rigid kyphosis for 15 years and incomplete paraplegia for half a year. ASIA Spinal cord function grade C 1a, 1b. Preoperative AP and lateral X-ray films showed thoracolumbar angular kyphosis, Cobb angle 82° 1c, 1d, 1e. Preoperative CT showed sagittal angular kyphosis of the spine, malunion of T<sub>11</sub>-L<sub>1</sub> vertebrae and local spinal canal stenosis 1f. Preoperative MRI showed spinal cord compression degeneration 1g, 1h. PMVO osteotomy and orthosis, T<sub>12</sub>-L<sub>1</sub> vertebrae was resected, autologous bone particles were crushed in titanium mesh to support bone grafting. X-rays 6 months after operation showed Cobb angle was 0°, angular kyphosis of spine was completely corrected, and spinal cord function was restored to grade E

表 3 结核性脊柱角状后凸畸形 33 例患者术前后 ASIA 脊髓功能分级比较

Tab.3 Comparison of ASIA spinal function classification of 33 patients with tuberculous spinal angular kyphosis deformity before and after operation

时间	A 级	B 级	C 级	D 级	E 级
术前	1	2	10	2	18
术后 1 年	0	1	1	6	25
末次随访	0	0	1	4	28
$\chi^2$ 值			11.803		
P 值			0.019		

单位:例

脊柱结核性角状后凸畸形顶点处椎体破坏累及的范围、角状后凸畸形 Cobb 角大小、脊柱畸形结构性僵硬程度、脊柱矢状位失平衡程度与后凸畸形顶椎区继发椎管狭窄程度和脊髓功能障碍的发生率均呈正相关。术前 15 例已存在不同程度的脊髓损害患者均突出表现以上情况,从而增大了手术后神经并发症的风险。

经后路脊柱三柱截骨矫形术可使脊柱结构重新排列,对于结核性重度脊柱后凸畸形的矫正具有很好的适应证<sup>[12-13]</sup>,是脊柱结核继发角状后凸畸形最佳治疗方法,既可进行多椎体结核病灶彻底清除,又可硬膜囊 360°脊髓减压、椎间支撑植骨和脊柱稳定性重建<sup>[14]</sup>。然而个体化评估脊柱后凸 Cobb 角大小、僵硬性和脊柱失平衡状况,设计手术截骨角度、截除脊柱畸形顶椎上下的椎节范围、选择最佳截骨手术方式、脊柱固定融合范围和稳定性重建方法对提高截骨矫形疗效具有十分重要的作用。把握不同截骨术的适应证和截骨切除椎体的范围取决于脊柱畸形的程度。笔者对角状后凸畸形其顶椎为相邻两椎椎间盘且相对侧骨质严重破坏塌陷、Cobb 角为 60°~80°者,采用 BDBO 截骨术,将结核破坏塌陷严重一侧椎体的椎弓根、坏死骨质和椎间盘及相对侧椎体部分骨质楔形截骨,或对破坏塌陷的 2 个相邻椎体椎弓根的上、下缘向前方椎体连同椎间盘进行楔形截骨,可取得 40°~60°后凸矫正效果,且不对称截骨可同时矫正冠状面及矢状面失衡<sup>[15]</sup>。SUK 等<sup>[3]</sup>于 2002 年首次报道 PVCRC 截骨术式,与 GAO 等<sup>[16]</sup>认为 PVCRC 的应用指征为 Cobb 角  $\geq 80^\circ$  的僵硬性脊柱畸形。如果脊柱后凸畸形长而广泛,Cobb 角为 80°~100°,顶椎单个椎体 PVCRC 切除即可<sup>[17]</sup>。若畸形长且 Cobb 角 >100° 的严重角状后凸畸形其顶椎上下多椎体融合于一体,笔者认为应采用 PMVO,截除顶椎区 2~3 个或以上椎体范围。本组 33 例中角状后凸畸形 Cobb 角 73.50°~83°者 10 例行 BDBO 截骨术;

13 例 Cobb 角 86°~105°行 PVCRC 截骨术,单节顶椎加相邻两椎间盘切除 10 例,以顶椎为中心 2 节段椎体切除 3 例;9 例 Cobb 角 103°~138°,均采用 PMVO 截骨术,截除椎体节段 2~3 节 9 例,4 节 2 例,5 节 1 例,但尽可能以短节段有限截骨为原则。对于结核病灶处于活动期的脊柱角状后凸畸形可对顶椎区上下多个椎体结核病灶进行彻底清除,同时对脊柱侧前方的良好显露和大血管、胸膜的保护,给多节段截骨创造了良好的条件。对 PVCRC 和 PMVO 多椎体截骨后致截骨端长段骨缺损,于截骨端间植入钛网或髂骨块支撑植骨致前柱张开,可达到更好的矫形效果,并重建脊柱的结构连续性和稳定性<sup>[18-19]</sup>;同时扩大椎板切除减压范围,可在加压合拢矫形时避免脊髓过度短缩折叠和神经根牵拉与卡压,防止发生严重神经并发症<sup>[20-21]</sup>。

神经并发症是脊柱畸形截骨矫形术最严重的并发症,文献报道其发生率 12%~15.2%<sup>[22-23]</sup>,本组发生 3 例。脊柱结核严重角状后凸畸形局部脊髓压迫和血循环障碍功能损害程度、年龄、病程、畸形程度、截骨方式、手术操作技术和术中术后低血容量等与神经并发症都有密切关系。特别是 Cobb 角 >100° 的重度僵硬性脊柱侧后凸畸形和术前已存在脊髓功能损害均为神经并发症的高危因素<sup>[24-25]</sup>。本组术后神经系统并发症 3 例,其术前均有脊髓功能部分损害。术后硬膜外血肿压迫脊髓 1 例;术后脊髓血循环障碍 1 例(术中和术后全身有效循环血容量不足和脊髓短缩过程中脊髓血管牵拉、痉挛及血栓形成)和一过性脊髓功能障碍 1 例;其中行 PMVO 截骨术者 2 例,表明脊柱畸形 Cobb 角 >100°,且截骨节段为 2 椎节以上者神经系统并发症较其他截骨术明显增高<sup>[26-27]</sup>。

后路三柱截骨矫形术是治疗脊柱结核继发角状后凸畸形具有很好的适应证,但技术难度和手术风险高。个体化术前设计与截骨方式的选择、严谨规范的手术操作和神经并发症的预防与处理,可取得良好的疗效。

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