

· 临床论著 ·

单节段与短节段固定治疗轻度胸腰椎骨折比较

潘俊, 季一鸣, 田一星, 梅昕, 孙佳佳, 吴宸, 刘凌, 何文野*

(苏州大学附属第一医院骨科, 江苏苏州 215006)

摘要: [目的] 比较单节段与短节段固定治疗轻度胸腰椎骨折的临床效果。[方法] 2019年1月—2021年7月收治的轻度胸腰椎骨折患者62例, 随机分成2组, 32例依据骨折位置行伤椎与上椎或下椎单节段固定, 30例行跨越伤椎的上下椎短节段固定。比较两组围手术期、随访和影像资料。[结果] 两组均顺利手术, 无严重并发症。单节段组手术时间[(39.6±21.5) min vs (54.4±26.9) min, $P<0.05$]、切口长度[(8.6±2.4) cm vs (11.3±3.9) cm, $P<0.05$]、术中失血量[(79.2±53.2) ml vs (112.6±63.7) ml, $P<0.05$]、术后下地行走时间[(3.3±2.3) d vs (5.7±3.5) d, $P<0.05$]均显著优于短节段组。两组患者随访时间平均(16.3±4.5)个月, 单节段组恢复完全负重活动时间显著早于短节段组[(28.5±11.2) d vs (40.1±24.4) d, $P<0.05$]。随时间推移, 两组疼痛VAS、ODI、JOA评分均显著改善($P<0.05$)。术前两组上述指标的差异均无统计学意义($P>0.05$), 术后1周时单节段组VAS评分显著优于短节段组[(2.4±1.5) vs (3.9±1.8), $P<0.05$], 末次随访时, 单节段组ODI评分显著优于短节段组[(10.9±2.4) vs (13.5±3.9), $P<0.05$]。影像方面, 与术前相比, 术后1周及末次随访时, 两组AVH、PVH、Cobb角均显著改善($P<0.05$)。术前两组间上述影像指标的差异均无统计学意义($P>0.05$)。术后1周, 单节段组AVH显著优于短节段组[(98.4±12.2)% vs (91.7±10.2)%, $P<0.05$], 末次随访, 单节段组AVH[(95.1±9.4)% vs (87.1±10.6)%, $P<0.05$]和局部后凸Cobb角[(2.3±5.8)° vs (5.9±7.4)°, $P<0.05$]均显著优于短节段组。[结论] 单节段固定治疗轻度胸腰椎骨折具有手术切口小, 手术时间、术中出血少等优势, 可取得良好的稳定性及治疗效果。

关键词: 胸腰椎骨折, 椎弓钉, 单节段固定, 短节段固定

中图分类号: R683.2 文献标志码: A 文章编号: 1005-8478 (2023) 20-1848-06

Mono-segment pedicle screw fixations versus short-segment counterpart for mild thoracolumbar fracture // PAN Jun, Ji Yi-ming, TIAN Yi-xing, MEI Xin, SUN Jia-jia, WU Chen, LIU Ling, HE Wen-ye. Orthopedic Department, The First Affiliated Hospital, Suzhou University, Suzhou 215006, China

Abstract: [Objective] To compare the clinical outcomes of mono-segment (MS) pedicle screw fixation versus short-segment (SS) counterpart for minor thoracolumbar fracture. [Methods] A total of 62 patients admitted our department from January 2019 to July 2021 for minor thoracolumbar fractures were randomly divided into 2 groups. Of them, 32 patients received MS fixation of the injured vertebra with the upper or lower vertebra according to the fracture location, while the other 30 patients underwent SS pedicle screw fixation of the upper and lower vertebrae over the injured vertebrae. The document regarding to perioperative period, follow-up and images were compared between the two groups. [Results] All patients in both groups had corresponding surgical procedures performed successfully without serious complications. The MS group proved significantly superior to the SS group in terms of operation time [(39.6±21.5) min vs (54.4±26.9) min, $P<0.05$], length of incision [(8.6±2.4) cm vs (11.3±3.9) cm, $P<0.05$], intraoperative blood loss [(79.2±53.2) ml vs (112.6±63.7) ml, $P<0.05$] and postoperative walking time [(3.3±2.3) days vs (5.7±3.5) days, $P<0.05$]. All patients in both groups were followed up for (16.3±4.5) months in a mean, and the MS group resumed full weight-bearing activity significantly earlier than the SS group [(28.5±11.2) days vs (40.1±24.4) days, $P<0.05$]. The VAS, ODI and JOA scores were significantly improved over time in both groups ($P<0.05$). Although there was no significant difference in the above indexes between the two groups before surgery ($P>0.05$), the MS group was significantly better than the SS group in VAS score 1 week after surgery [(2.4±1.5) vs (3.9±1.8), $P<0.05$], and ODI score at the last follow-up [(10.9±2.4) vs (13.5±3.9), $P<0.05$]. Regarding imaging, the anterior vertebral height (AVH), posterior vertebral height (PVH) and local kyphotic Cobb angle significantly improved at 1 week after surgery and at the last follow-up compared with those preoperatively ($P<0.05$). There was no significant difference in the above imaging indexes between the two groups before surgery ($P>0.05$), whereas the MS group was significantly superior to

DOI:10.3977/j.issn.1005-8478.2023.20.05

作者简介: 潘俊, 副主任医师, 研究方向: 脊柱外科, (电话)18915592012, (电子信箱)panjun@suda.edu.cn

* 通信作者: 何文野, (电话)15995720251, (电子信箱)howdy2014@163.com

the SS group in terms of AVH 1 week postoperatively [(98.4±12.2)% vs (91.7±10.2)%, $P<0.05$], AVH at the last follow-up [(95.1±9.4)% vs (87.1±10.6)%, $P<0.05$] and kyphotic Cobb angle [(2.3±5.8)° vs (5.9±7.4)°, $P<0.05$]. [Conclusion] The mono-segment pedicle screw fixation of minor thoracolumbar fracture has the advantages of small incision, less operation time and less intraoperative bleeding, and does achieve good stability and therapeutic effect over the traditional short-segment fixation.

Key words: thoracolumbar fracture, pedicle screw, mono-segment fixation, short-segment fixation

随着社会经济的发展,胸腰椎骨折的发病率呈上升趋势,严重的胸腰椎骨折治疗遵循椎体坚强固定融合、神经充分减压等原则已达成普遍共识^[1]。但更多的病例是存在一定程度的椎体压缩或粉碎,无神经症状或轻微压迫症状的“轻度”胸腰椎骨折,其治疗仍存在一定争议,包括保守治疗、开放手术、经皮微创手术等多种方式。创伤小、固定可靠、早期活动、尽快恢复功能为此类骨折治疗的目标^[2]。单节段固定具有固定节段少、出血少、恢复快等优势,但也存在生物力学强度较弱的缺陷,不适用于严重粉碎胸腰椎骨折的治疗^[3],对于其适应证范围尚有争议,笔者认为单节段固定的特点恰好适用于损伤程度轻微的胸腰椎骨折病例。因此,本研究通过前瞻性地比较单节段固定和传统短节段固定治疗载荷分享评分 3~4 分无合并脊髓神经损伤的胸腰椎骨折的疗效,为此类骨折的手术治疗提供新的思路和术式选择。

1 资料与方法

1.1 纳入与排除标准

纳入标准:(1) T₁₀~L₃ 节段内的单节段骨折,根据 X 线及 CT 检查载荷分享评分(load sharing classification)为 3~4 分;(2) MRI 示后方韧带复合体(posterior ligamentous complex)完整;(3)神经功能分级(ASIA)为 E 级;(4)年龄 18~60 岁。

排除标准:陈旧性骨折或术前骨密度 T<-2.5。

1.2 一般资料

前瞻性比较 2019 年 1 月—2021 年 7 月收治的 62 例轻度胸腰椎骨折患者的临床资料,根据上述标准共入选研究对象 62 例。采用随机数分组法,其中 32 例采用单节段固定,30 例采用短节段固定。两组患者术前一般资料见表 1,两组年龄、性别、伤因、骨折节段、BMI、损伤至手术时间、载荷分享评分的差异均无统计学意义($P>0.05$)。本研究术前告知患者征得同意并经过医院伦理委员会研究通过。

1.3 手术方法

患者采用全身麻醉,俯卧于可透视手术台上,轻度过伸以利于压缩的椎体体位复位。术前透视定位伤

椎及上下椎体并观察初步复位的效果。

表 1 两组患者术前一般资料比较

Table 1 Comparison of preoperative data between the two groups

指标	单节段固定 (n=32)	短节段固定 (n=30)	P 值
年龄(岁, $\bar{x} \pm s$)	45.4±13.3	47.6±14.5	0.330
性别(例,男/女)	22/10	18/12	0.605
伤因(例,坠落/车祸/摔倒)	14/10/8	15/9/6	0.923
节段(例, T ₁₀ /L ₁ /L ₂ /L ₃)	8/13/6/5	7/14/6/3	0.964
BMI(kg/m ² , $\bar{x} \pm s$)	26.3±7.3	26.0±8.2	0.393
损伤至手术时间(d, $\bar{x} \pm s$)	3.9±2.6	4.1±2.7	0.382
载荷分享评分(例, 3/4)	14/18	11/19	0.683

单节段组:取后路正中入路,根据伤椎骨折压缩的部位决定暴露上位或者下位椎体。如骨折压缩部位位于上终板,暴露伤椎及上位椎体;如压缩部位位于下终板,暴露伤椎及伤椎下位椎体。分别置入定向椎弓根螺钉 4 枚, C 形臂 X 线机透视位置满意后置入预弯的连接棒,通过器械纵向撑开以恢复伤椎高度,最后拧紧尾帽以锁定钉棒结构。伤口内留置负压引流管后逐层缝合手术切口。

短节段组:以伤椎为中心显露伤椎的上、下节段,分别置入定向椎弓根螺钉 4 枚,对伤椎行撑开复位后拧紧尾帽锁定钉棒结构。余下操作步骤同单节段组。

术后常规抗感染治疗,嘱患者自主滚筒式翻身,腰背部无明显疼痛感即下床行走,术后 6 个月内避免重体力劳动,术后 1 年待骨折愈合后取出内固定装置。

1.4 评价指标

记录围手术期资料,包括手术时间、切口长度、术中出血量、术中透视次数、下地时间、住院时间。采用完全负重活动时间、疼痛视觉模拟评分(visual analogue scale, VAS)、Oswestry 功能障碍指数(Oswestry Disability Index, ODI)和日本骨科协会腰评分(Japanese Orthopaedic Association, JOA)评价临床效果。行影像检查,测量伤椎前缘相对高度(anterior vertebral height, AVH)、伤椎后缘相对高度(posterior

vertebral height, PVH) 和局部后凸畸形角 (Cobb 角)。

1.5 统计学方法

使用 SPSS 16.0 软件进行统计学分析, 计量数据以 $\bar{x} \pm s$ 表示, 资料呈正态分布时, 两组间比较采用独立样本 *t* 检验; 组内时间点比较采用单因素方差分析; 资料呈非正态分布时, 采用秩和检验。计数资料采用 χ^2 检验或 Fisher 精确检验。等级资料两组比较采用 Mann-Whitney *U* 检验, 组内比较采用多个相关资料的 Friedman 检验。 $P < 0.05$ 为差异有统计学意义。

2 结果

2.1 围手术期情况

两组患者围手术期资料见表 2。所有患者均顺利完成手术, 术中均无神经根损伤或硬膜撕裂。单节段组手术时间、切口长度、术中失血量均显著优于短节段组 ($P < 0.05$), 术后下地行走时间显著早于短节段组 ($P < 0.05$), 两组术中透视次数、切口愈合等级、住院时间的差异无统计学意义 ($P > 0.05$)。短节段固定组术后出现伤口浅表感染 1 例, 经换药后治愈。

表 2 两组患者围手术资料与比较

指标	单节段组 (n=32)	短节段组 (n=30)	P 值
手术时间 (min, $\bar{x} \pm s$)	39.6±21.5	54.4±26.9	0.023
切口总长度 (cm, $\bar{x} \pm s$)	8.6±2.4	11.3±3.9	0.002
术中失血量 (ml, $\bar{x} \pm s$)	79.2±53.2	112.6±63.7	0.033
术中透视次数 (次, $\bar{x} \pm s$)	6.6±2.4	6.9±2.9	0.338
神经根损伤 [例 (%)]	0 (0)	0 (0)	-
硬膜撕裂 [例 (%)]	0 (0)	0 (0)	-
下地行走时间 (d, $\bar{x} \pm s$)	3.3±2.3	5.7±3.5	0.002
切口愈合等级 (例, 甲/乙/丙)	29/3/0	27/2/1	0.732
住院时间 (d, $\bar{x} \pm s$)	6.3±3.3	7.0±4.9	0.328

2.2 随访结果

所有患者至少随访 12 月以上, 平均随访时间 (16.3±4.5) 个月。两组患者随访资料见表 3。单节段组完全负重活动时间显著早于短节段组 ($P < 0.05$); 随时间推移, 两组疼痛 VAS 评分、ODI 评分均显著减少 ($P < 0.05$), JOA 评分显著增加 ($P < 0.05$)。术前两组上述指标的差异均无统计学意义 ($P > 0.05$), 术后 1 周时单节段组 VAS 评分显著优于短节段组 ($P < 0.05$), 末次随访时, 单节段组 ODI 评分显著优于短节段组 ($P < 0.05$); 其余时间点两组间 VAS、

ODI、JOA 评分差异均无统计学意义 ($P > 0.05$)。

表 3 两组患者随访结果 ($\bar{x} \pm s$) 与比较

指标	单节段组 (n=32)	短节段组 (n=30)	P 值
完全负重活动时间 (d)	28.5±11.2	40.1±24.4	0.023
疼痛 VAS 评分 (分)			
术前	5.2±2.2	4.7±2.8	0.315
术后 1 周	2.4±1.5	3.9±1.8	<0.001
末次随访	0.8±0.6	1.1±0.8	0.134
P 值	<0.001	<0.001	
ODI 评分 (%)			
术前	45.2±5.6	45.7±4.2	0.377
术后 1 周	20.4±8.3	24.5±9.6	0.077
末次随访	10.9±2.4	13.5±3.9	0.003
P 值	<0.001	<0.001	
JOA 评分 (分)			
术前	18.8±6.7	17.5±8.3	0.319
术后 1 周	23.2±4.1	23.0±4.9	0.391
末次随访	27.1±3.7	25.9±5.4	0.241
P 值	<0.001	<0.001	

2.3 影像评估

两组患者影像学资料见表 4。与术前相比, 术后 1 周及末次随访时, 两组 AVH、PVH、Cobb 角均显著改善 ($P < 0.05$)。术前两组间上述影像指标的差异均无统计学意义 ($P > 0.05$)。术后 1 周, 单节段组 AVH 显著优于短节段组 ($P < 0.05$), PVH 及 Cobb 角差异无统计学意义 ($P > 0.05$)。末次随访, 单节段组 AVH、Cobb 角显著优于短节段组 ($P < 0.05$), PVH 两组间差异无统计学意义 ($P > 0.05$)。两组病例至末次随访时均达到临床愈合, 均未发现骨折不愈合、钉棒松动断裂现象。

典型病例影像见图 1、2。

3 讨论

目前对于轻度胸腰椎骨折尚无明确的定义与归类, 但此类病例确实大量存在于临床工作中。借助载荷分享评分系统, 有学者提出了轻度胸腰椎骨折的概念, 将载荷分享评分在 3~4 分的病例归类于“轻度”^[2]。载荷分享评分基于椎体压缩程度、粉碎程度、后凸程度 3 个维度评估胸腰椎骨折, 是目前最能

体现胸腰椎骨折稳定性的分型，并且对其有直观的量化体现。而最新的胸腰椎脊柱脊髓损伤程度评分系统 (Thoracolumbar Injury Classification and Severity Score, TLICS) 通过引入 MRI 检测提出了骨折椎体后方韧带复合体损伤的概念，认为后方韧带复合体的完整与否对椎体稳定性起到至关重要的作用^[4, 5]。因此，本研究认为载荷分享评分 3~4 分并且后方韧带复合体完

整的病例稳定性较好，这类病例可归于“轻度”。对于这类轻度病例的治疗也存在一定的争议。在任何外科干预之前首先仍应考虑保守治疗，但胸腰椎骨折保守治疗需要至少 1 个月左右的卧床期，并且会存留一定的后凸畸形，甚至远期后凸畸形加重致脊髓神经受损。手术治疗具有恢复后凸畸形、即刻固定、缩短卧床时间，快速康复等优势^[6]。

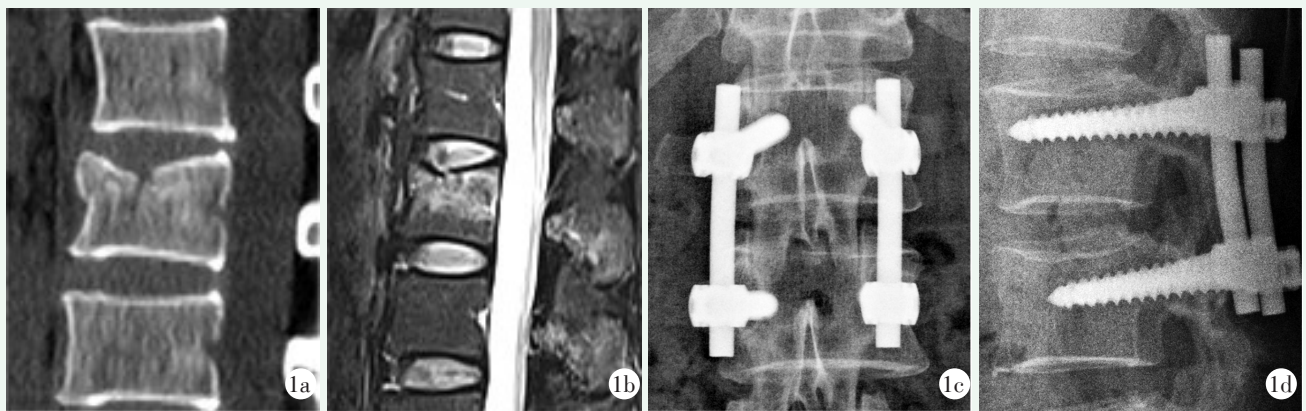


图 1 患者，女，48 岁，高处坠落致背部疼痛，术前载荷分享评分 3 分，神经功能正常，行单节段固定。1a: 术前矢状位 CT 显示 L₂ 压缩性骨折，上终板轻度压缩粉碎改变；1b: 术前 MRI 示椎体内高信号改变，后方韧带复合体无损伤表现；1c, 1d: 末次随访时正侧位 X 线片示伤椎及上位椎体内钉棒在位椎体高度复位满意，愈合良好。

Figure 1. A 48-year-old female got back pain caused by a fall from a height with preoperative load sharing score of 3, and normal nerve function, and received mono-segment fixation. 1a: Preoperative sagittal CT showed slight L₂ compression fracture involving the upper endplate. 1b: Preoperative MR showed high signal changes in the vertebra without injury to the posterior ligament complex. 1c, 1d: Anteroposterior and lateral radiographs at the last follow-up showed screw-rod of the injured vertebra in proper position, satisfactory reduction of vertebral height and good fracture healing.

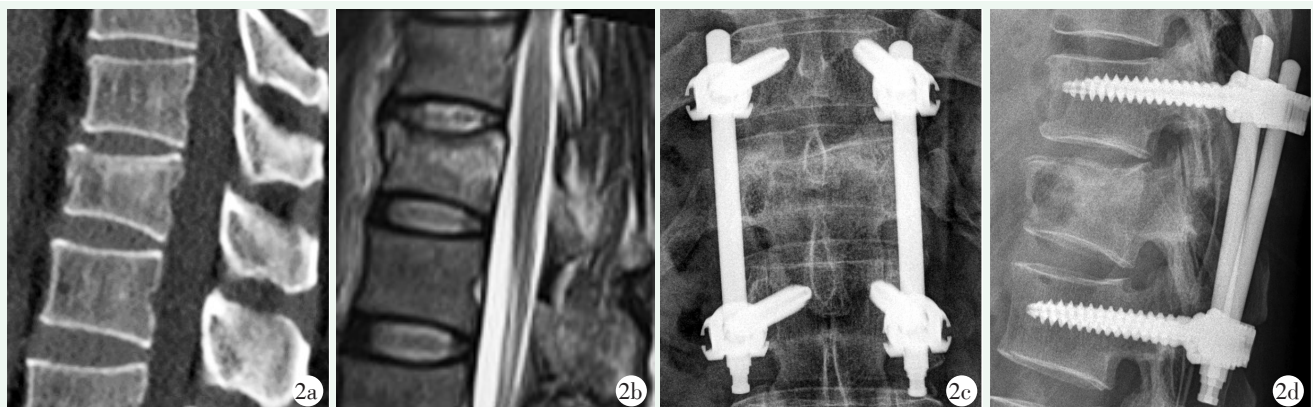


图 2 患者，男，52 岁，车祸致背部疼痛，术前载荷分享评分 3 分，神经功能正常，行短节段固定。2a: 术前矢状位 CT 显示 T₁₂ 压缩性骨折，上终板轻度压缩粉碎改变；2b: MRI 示椎体内高信号改变，后方韧带复合体无损伤表现；2c, 2d: 末次随访时正侧位 X 线片示伤椎上下位椎体内钉棒在位，椎体高度复位良好，骨折已愈合。

Figure 2. A 52 years-old male was surfed from back pain caused by car accident, with preoperative load sharing score of 3, normal nerve function, and received short-segment fixation. 2a: Preoperative CT sagittal view showed slight T₁₂ compression fractures involving the upper endplate. 2b: MR Showed high signal changes in the vertebra, without posterior ligament complex injury. 2c, 2d: At the last follow-up, the anteroposterior and lateral radiographs showed the screw-rod in proper place, vertebral height reduced well and the fracture healed.

表 4 两组患者影像资料 ($\bar{x} \pm s$) 与比较

指标	单节段组 (n=32)	短节段组 (n=30)	P 值
AVH (%)			
术前	68.3±18.3	70.5±19.5	0.362
术后 1 周	98.4±12.2	91.7±10.2	0.025
末次随访	95.1±9.4	87.1±10.6	0.002
P 值	<0.001	<0.001	
PVH (%)			
术前	93.6±9.0	92.4±7.4	0.341
术后 1 周	98.7±5.5	97.9±6.5	0.346
末次随访	97.5±6.1	97.1±5.5	0.382
P 值	<0.001	<0.001	
后凸 Cobb 角 (°)			
术前	17.9±10.3	14.6±12.3	0.204
术后 1 周	1.0±7.3	2.5±6.3	0.284
末次随访	2.3±5.8	5.9±7.4	0.040
P 值	<0.001	<0.001	

单节段固定是对传统短节段固定的大胆改良, 其优点在于手术切口小、固定节段少、操作相对简单, 手术时长、术中出血量相应减少^[7-10], 这与本研究中的结果相符合。也正因为上述优势, 所以本组研究观察到单节段组下床行走、完全负重时间上明显早于短节段组。术后 1 周的 VAS 评分以及末次随访 ODI 评分也明显优于短节段组。对于单节段固定普遍的担忧主要是其固定的强度, 伤椎内的螺钉是否能通过正常的骨性结构是保证整个内固定系统强度的关键^[8, 11-13]。而载荷分享评分 3~4 分的病例, 其椎体压缩粉碎的程度有限, 椎体内有充足的空间用于置钉。此外, 后方韧带复合体的完整也保证了后柱的稳定性^[14]。因此, 结合这两种骨折分类系统筛选病例, 采用单节段固定可以提供有效的稳定性。从随访结果来看, 本组所有病例均未出现内固定松动或断裂的现象。单节段固定同样保留了伤椎置钉撑开复位时的优势^[15-19], 由于两组螺钉之间距离更短, 器械复位时纵向撑开的力量更大, 并且复位的力量更直接作用于骨折椎体, 减少了一个相邻椎间隙的无效撑开, 这可能是术后及末次随访椎体高度及 Cobb 角的维持均优于短节段固定组的原因。

单节段固定是一项优缺点鲜明的技术^[20-24], 其应用具有一定的局限性^[25], 本研究旨在尝试寻找归类总结这一技术的最优适宜病例, 使其能扬长避短, 发挥最大的临床效能。在术前规划时, 笔者认为详细

的 CT、MR 检查对病例的分类至关重要。对骨折压缩部位的细心观察不但决定了另一组螺钉固定于上位还是下位椎体, 也提示了伤椎螺钉置入的部位和方向, 尽可能避开骨折部位并靠近完好的终板可取得充足的稳定性和把持力, 这对于初期应用单节段固定的医师亦十分关键。此外, 术中选用椎弓根螺钉应达到螺钉通道长度的 80% 以上, 也是保证可靠固定强度的关键。

综上所述, 本研究认为: 对于载荷分享评分 3~4 分并且后方韧带复合体完整的胸腰椎骨折病例, 采用单节段固定可取得充足的稳定性及优良的治疗效果, 相较于传统短节段固定, 具有手术切口小、固定节段少、操作简单、手术时间、术中出血少等优势。

参考文献

- [1] 潘俊, 史金辉, 王根林, 等. 后路椎弓根内固定治疗载荷分享评分 9 分的胸腰椎爆裂骨折 [J]. 中国矫形外科杂志, 2019, 27 (4): 305-309. DOI: 10.3977/j.issn.1005-8478.2019.04.04. Pan J, Shi JH, Wang GL, et al. Posterior pedicle screw instrumentation for thoracolumbar burst fracture with the load sharing score of 9 [J]. Orthop J Chin, 2019, 27 (4): 305-309. DOI: 10.3977/j.issn.1005-8478.2019.04.04.
- [2] Sun C, Guan G, Liu X, et al. Comparison of short-segment pedicle fixation with versus without inclusion of the fracture level in the treatment of mild thoracolumbar burst fractures [J]. Int J Surg, 2016, 36 (Pt A): 352-357. DOI: 10.1016/j.ijisu.2016.11.086.
- [3] 杨惠林. 如何选择单节段椎弓根内固定治疗胸腰椎骨折的手术适应证 [J]. 中华创伤杂志, 2007, 23 (9): 658. DOI: 10.3760/j.issn:1001-8050.2007.09.034. Yang HL. How to choose the surgical indications for single segment pedicle internal fixation in the treatment of thoracic and lumbar vertebral fractures [J]. Chin J Traumatol, 2007, 23 (9): 658. DOI: 10.3760/j.issn:1001-8050.2007.09.034.
- [4] Pizones J, Sanchez-Mariscal F, Zuniga L, et al. Prospective analysis of magnetic resonance imaging accuracy in diagnosing traumatic injuries of the posterior ligamentous complex of the thoracolumbar spine [J]. Spine (Phila Pa 1976), 2013, 38 (9): 745-751. DOI: 10.1097/BRS.0b013e31827934e4.
- [5] 刘凌, 孙佳佳, 季一鸣, 等. 伤椎置钉短节段固定韧带复合体损伤胸腰椎骨折 [J]. 中国矫形外科杂志, 2020, 28 (22): 2060-2064. DOI: 10.3977/j.issn.1005-8478.2020.22.10. Liu L, Sun JJ, Ji YM, et al. Short-segment pedicle screw fixations with or without screw placed on the fractured vertebra for thoracolumbar fracture accompanied with posterior ligamentous complex rupture [J]. Orthop J Chin, 2020, 28 (22): 2060-2064. DOI: 10.3977/j.issn.1005-8478.2020.22.10.
- [6] Carazzo CA, Yurac R, Guiroy A, et al. Minimally invasive versus open surgery for the treatment of types B and C thoracolumbar injuries: A PRISMA systematic review [J]. Int J Spine Surg, 2021, 15

- (4): 803–810. DOI: 10.1056/NEJMoa1806395.
- [7] Li X, Ma Y, Dong J, et al. Retrospective analysis of treatment of thoracolumbar burst fracture using mono-segment pedicle instrumentation compared with short-segment pedicle instrumentation [J]. *Eur Spine J*, 2012, 21 (10): 2034–2042. DOI: 10.1007/s00586-012-2214-2.
- [8] Wei FX, Liu SY, Liang CX, et al. Transpedicular fixation in management of thoracolumbar burst fractures: monosegmental fixation versus short-segment instrumentation [J]. *Spine (Phila Pa 1976)*, 2010, 35 (15): E714–720. DOI: 10.1097/BRS.0b013e3181d7ad1d.
- [9] Defino HL, Herrero CF, Romeiro CF. Monosegmental fixation for the treatment of fractures of the thoracolumbar spine [J]. *Indian J Orthop*, 2007, 41 (4): 337–345. DOI: 10.4103/0019-5413.36998.
- [10] Defino HL, Scarparo P. Fractures of thoracolumbar spine: monosegmental fixation [J]. *Injury*, 2005, 36 (Suppl 2): B90–97. DOI: 10.1016/j.injury.2005.06.019.
- [11] Xu G, Fu X, Du C, et al. Biomechanical comparison of mono-segment transpedicular fixation with short-segment fixation for treatment of thoracolumbar fractures: a finite element analysis [J]. *Proc Inst Mech Eng H*, 2014, 228 (10): 1005–1013. DOI: 10.1177/0954411914552308.
- [12] Wang H, Mo Z, Han J, et al. Extent and location of fixation affects the biomechanical stability of short- or long- segment pedicle screw technique with screwing of fractured vertebra for the treatment of thoracolumbar burst fractures: An observational study using finite element analysis [J]. *Medicine (Baltimore)*, 2018, 97 (26): e11244. DOI: 10.1097/MD.00000000000011244.
- [13] Li C, Zhou Y, Wang H, et al. Treatment of unstable thoracolumbar fractures through short segment pedicle screw fixation techniques using pedicle fixation at the level of the fracture: a finite element analysis [J]. *PLoS One*, 2014, 9 (6): e99156. DOI: 10.1371/journal.pone.0099156.
- [14] Wang W, Pei B, Pei Y, et al. Biomechanical effects of posterior pedicle fixation techniques on the adjacent segment for the treatment of thoracolumbar burst fractures: a biomechanical analysis [J]. *Comput Methods Biomech Biomed Engin*, 2019, 22 (13): 1083–1092. DOI: 10.1080/10255842.2019.1631286.
- [15] 赵豪, 高山, 陈文恒, 等. 经伤椎与跨伤椎固定胸腰椎爆裂骨折的比较 [J]. *中国矫形外科杂志*, 2022, 30 (22): 2039–2044. DOI: 10.3977/j.issn.1005-8478.2022.22.05.
Zhao H, Gao S, Chen WH, et al. Comparison of thoracolumbar burst fractures with or without screw placement in the fractured vertebrae [J]. *Orthop J Chin*, 2022, 30 (22): 2039–2044. DOI: 10.3977/j.issn.1005-8478.2022.22.05.
- [16] 孙乐乐, 梁成民, 尹稳, 等. 经伤椎与跨伤椎 6 钉固定屈曲牵张型胸腰椎骨折 [J]. *中国矫形外科杂志*, 2023, 31 (6): 481–486. DOI: 10.3977/j.issn.1005-8478.2023.06.01.
Sun LL, Liang CM, Yin W, et al. Three-pair pedicle screws with or without placement in the injured vertebrae for flexion-distraction thoracolumbar fractures [J]. *Orthop J Chin*, 2023, 31 (6): 481–486. DOI: 10.3977/j.issn.1005-8478.2023.06.01.
- [17] 王小刚, 杨彬, 王亚寒, 等. 附加伤椎钉治疗单节段胸腰椎骨折的疗效观察 [J]. *中国矫形外科杂志*, 2017, 25 (10): 942–945. DOI: 10.3977/j.issn.1005-8478.2017.10.17.
Wang XG, Yang B, Wang YH, et al. Observation on the therapeutic effect of additional injured vertebral nails in the treatment of single segment thoracolumbar fractures [J]. *Orthop J Chin*, 2017, 25 (10): 942–945. DOI: 10.3977/j.issn.1005-8478.2017.10.17.
- [18] 罗狄鑫, 金勋杰, 徐汪洋, 等. 胸腰椎骨折患者经伤椎置钉与跨节段椎弓根螺钉内固定治疗的临床效果比较 [J]. *中国矫形外科杂志*, 2017, 25 (14): 1320–1323. DOI: 10.3977/j.issn.1005-8478.2017.14.16.
Luo DX, Jin XJ, Xu WY, et al. Transvertebral screw placement and cross segmental pedicle screw internal fixation in patients with thoracolumbar fractures: a comparison study [J]. *Orthop J Chin*, 2017, 25 (14): 1320–1323. DOI: 10.3977/j.issn.1005-8478.2017.14.16.
- [19] Chokshi JJ, Shah M. Outcomes of including fracture level in short-segment fixation for thoracolumbar fracture dislocation [J]. *Asian Spine J*, 2019, 13 (1): 56–60. DOI: 10.31616/asj.2018.0064.
- [20] 刘少喻, 李浩淼, 梁春祥, 等. 后路单节段椎弓根钉复位固定治疗创伤性胸腰椎骨折 [J]. *中华创伤杂志*, 2007, 23 (9): 646–649. DOI: 10.3760/j.issn:1001-8050.2007.09.003.
Liu SY, Li HN, Liang CX, et al. Treatment of traumatic thoracolumbar fracture with posterior monosegmental pedicle screw instrumentation [J]. *Chin J Traumatol*, 2007, 23 (9): 646–649. DOI: 10.3760/j.issn:1001-8050.2007.09.003.
- [21] Liu L, Gan Y, Zhou Q, et al. Improved monosegment pedicle instrumentation for treatment of thoracolumbar incomplete burst fractures [J]. *Biomed Res Int*, 2015, 2015: 357206. DOI: 10.1155/2015/357206.
- [22] Perera A, Qureshi A, Brecknell JE. Mono-segment fixation of thoracolumbar burst fractures [J]. *Br J Neurosurg*, 2015, 29 (3): 358–361. DOI: 10.3109/02688697.2014.987216.
- [23] Ibrahim FM, Abd El-Rady Ael R. Mono segmental fixation of selected types of thoracic and lumbar fractures: a prospective study [J]. *Int Orthop*, 2016, 40 (6): 1083–1089. DOI: 10.1007/s00264-016-3152-0.
- [24] La Maida GA, Luceri F, Ferraro M, et al. Monosegmental vs bisegmental pedicle fixation for the treatment of thoracolumbar spine fractures [J]. *Injury*, 2016, 47 (Suppl 4): S35–S43. DOI: 10.1016/j.injury.2016.07.052.
- [25] 周跃. 关于单节段椎弓根内固定临床应用之我见 [J]. *中华创伤杂志*, 2007, 23 (9): 653. DOI: 10.3760/j.issn:1001-8050.2007.09.033.
Zhou Y. My Opinion on the Clinical Application of Single Segment Pedicle Internal Fixation [J]. *Chin J Traumatol*, 2007, 23 (9): 653. DOI: 10.3760/j.issn:1001-8050.2007.09.033.

(收稿:2023-01-27 修回:2023-05-10)
(同行评议专家: 赵廷宝, 赵志刚)
(本文编辑: 郭秀婷)