

Kümmell 病伴脊柱后凸畸形对脊柱-骨盆矢状面参数的影响

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【摘要】 目的:探讨 Kümmell 病伴脊柱后凸畸形对脊柱-骨盆矢状面形态的影响。方法:回顾性分析 2015 年 8 月至 2022 年 9 月收治的 34 例 Kümmell 病伴脊柱后凸畸形的患者(Kümmell 病组),其中男 10 例,女 24 例,年龄(71.1±8.5)岁,以 37 例年龄(69.3±6.7)岁匹配的无症状人群为对照组。在站立位全脊柱正侧位 X 线片上测量脊柱-骨盆矢状面参数,包括节段性后凸角(segmental kyphosis, SK)或胸腰椎后凸(thoracolumbar kyphosis, TLK)、胸椎后凸角(thoracic kyphosis, TK)、腰椎前凸角(lumbar lordosis, LL)、骨盆入射角(pelvic incidence, PI)、骨盆倾斜角(pelvic tilt, PT)、骶骨倾斜角(sacral slope, SS)、矢状面平衡(sagittal vertical axis, SVA)、T₁ 骨盆角(T₁ pelvic angle, TPA)以及骨盆入射角与腰椎前凸的匹配关系(PI-LL)。同时测量 Kümmell 病患者患椎椎体楔角(wedge angle, WA),并分析 WA、SK 等与脊柱-骨盆矢状面参数的相关性。结果:Kümmell 病组 TK、SK、PT、SVA、TPA、PI-LL 均高于对照组($P<0.05$),Kümmell 病组 LL、SS 低于对照组($P<0.05$);两组 PI 比较,差异无统计学意义($P>0.05$)。Kümmell 病组患椎 WA 为(30.8±5.9)°,并与 SK、TK 有相关性($r=0.366, 0.597, P<0.05$),SK 与 LL、SS 有相关性($r=0.539, -0.591, P<0.05$),LL 与 PI、SS、SVA、TPA、PI-LL 有相关性($r=0.559, 0.741, -0.273, -0.356, -0.882, P<0.05$)。结论:Kümmell 病伴脊柱后凸不仅存在节段性后凸畸形,而且整体脊柱-骨盆矢状面参数亦发生改变,包括腰椎前凸丢失、骨盆后旋、躯干前倾等。Kümmell 病的手术治疗不仅要重视塌陷椎体高度的恢复,对于合并脊柱后凸患者还要着眼于脊柱-骨盆矢状面的整体平衡。

【关键词】 Kümmell 病; 脊柱后凸; 脊柱-骨盆矢状面参数

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Effect of Kümmell's disease with kyphosis on spinal-pelvic sagittal parameters

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ABSTRACT **Objective** To explore the effect of Kümmell's disease with kyphosis on the sagittal morphology of the spine-pelvis. **Methods** A retrospective analysis of 34 patients of Kümmell's disease with kyphosis (Kümmell group) admitted from August 2015 to September 2022, including 10 males and 24 females with an average age of (71.1±8.5) years old. A control group of 37 asymptomatic population aged (69.3±6.7) years old was matched. Spinal-pelvic sagittal parameters were measured on the anterior-posterior and lateral X-rays of the whole spine in the standing position, including segmental kyphosis (SK) or thoracolumbar kyphosis (TLK), thoracic kyphosis (TK), lumbar lordosis (LL), pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), sagittal vertical axis (SVA), T₁ pelvic angle (TPA) and PI-LL. Vertebral wedge angle (WA) in Kümmell was measured and differences in parameters among groups were analyzed and the relationship between spino-pelvic parameters and WA, SK were also investigated. **Results** TK, SK, PT, SVA, TPA and PI-LL in Kümmell group were significantly larger than those in control group ($P<0.05$), LL and SS in Kümmell group were significantly decreased than those in control group ($P<0.05$), and there was no significant difference in PI between two groups ($P>0.05$). In Kümmell group, WA (30.8±5.9)° showed a positive correlation with SK and TK ($r=0.366, 0.597, P<0.05$), and SK was significantly correlated with LL and SS ($r=0.539, -0.591, P<0.05$). Strong positive correlation between LL and PI, SS, SVA, TPA, PI-LL were also confirmed in patients with Kümmell with kyphosis ($r=0.559, 0.741, -0.273, -0.356, -0.882, P<0.05$). **Conclusion** Patients with Kümmell with kyphosis not only have segmental kyphosis, but also changes the overall spinal-pelvic sagittal parameters, including loss of lumbar lordosis, pelvic retrorotation, trunk forward tilt. The surgical treatment of Kümmell disease should not only pay attention

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to the recovery of the height of the collapsed vertebra, but also focus on the overall balance of the spine-pelvic sagittal plane for patients with kyphosis.

KEYWORDS Kümmell's disease; Kyphosis; Spinal-pelvic sagittal parameters

Kümmell 病又称创伤后迟发性缺血性椎体骨坏死,最早于 1895 年由 KÜMMELL^[1]提出,是一种特殊类型骨质疏松性椎体压缩骨折。该病起病隐匿,早期在无明显外伤或轻微创伤下出现的骨质疏松性椎体压缩性骨折经过数周或数月后延迟出现椎体塌陷、椎体裂隙、脊柱假关节等椎体骨折未愈合表现^[2]。患者除表现为渐进性腰背痛,活动受限,甚至神经功能损害外,同时还可伴有不同程度的脊柱后凸畸形。已有研究表明脊柱矢状面形态与患者生活质量密切相关^[3],Kümmell 病伴脊柱后凸畸形状态下机体为维持整体脊柱矢状面平衡势必会出现相应代偿性改变,但该病多发于老年人群,临床上观察到这类患者由于骨质疏松、关节突关节退变、椎旁肌薄弱等因素致使维持脊柱平衡的代偿能力有限,易出现腰椎前凸丢失、躯干前倾、矢状面失平衡等现象。目前,对于 Kümmell 病伴脊柱后凸畸形患者脊柱-骨盆矢状面形态学研究鲜有报道,本研究旨在通过比较 Kümmell 病伴脊柱后凸畸形患者与无症状老年人群的脊柱-骨盆矢状面参数差异,探讨 Kümmell 病伴脊柱后凸畸形对脊柱-骨盆矢状面形态的影响,以期为 Kümmell 病伴后凸畸形的治疗提供理论参考。

1 资料与方法

1.1 病例选择

纳入标准:Kümmell 病伴脊柱后凸畸形,脊柱后凸 Cobb 角 $>20^\circ$; 年龄 60~85 岁; 脊柱冠状面侧凸 Cobb 角 $<10^\circ$ 。排除标准:先天性、成人特发性、退变性脊柱侧后凸畸形及其他包括强直性脊柱炎、脊柱肿瘤、结核等病理原因导致的胸腰段后凸畸形患者; 合并腰椎滑脱、神经肌肉病变者; 既往有脊柱及髓关节手术史者。

1.2 临床资料

回顾性分析 2015 年 8 月至 2022 年 9 月 Kümmell 病伴脊柱后凸畸形患者 34 例(Kümmell 病组),男 10 例,女 24 例; 年龄(71.1 \pm 8.5)岁; 单纯腰背痛患者 27 例,腰痛伴有神经症状患者 7 例; 26 例接受手术治疗,8 例进行保守治疗。以 37 例年龄匹配的无症状人群为对照组,男 15 例,女 22 例,年龄(69.3 \pm 6.7)岁。两组性别、年龄比较,差异无统计学意义($P>0.05$),具有可比性,见表 1。所有病例对该研究知情同意,本研究经本院伦理委员会批准[伦(审)第 2019088 号]。

1.3 观察项目与方法

所有研究对象行站立位全脊柱正侧位 X 线片

表 1 Kümmell 病组与对照组基线资料比较

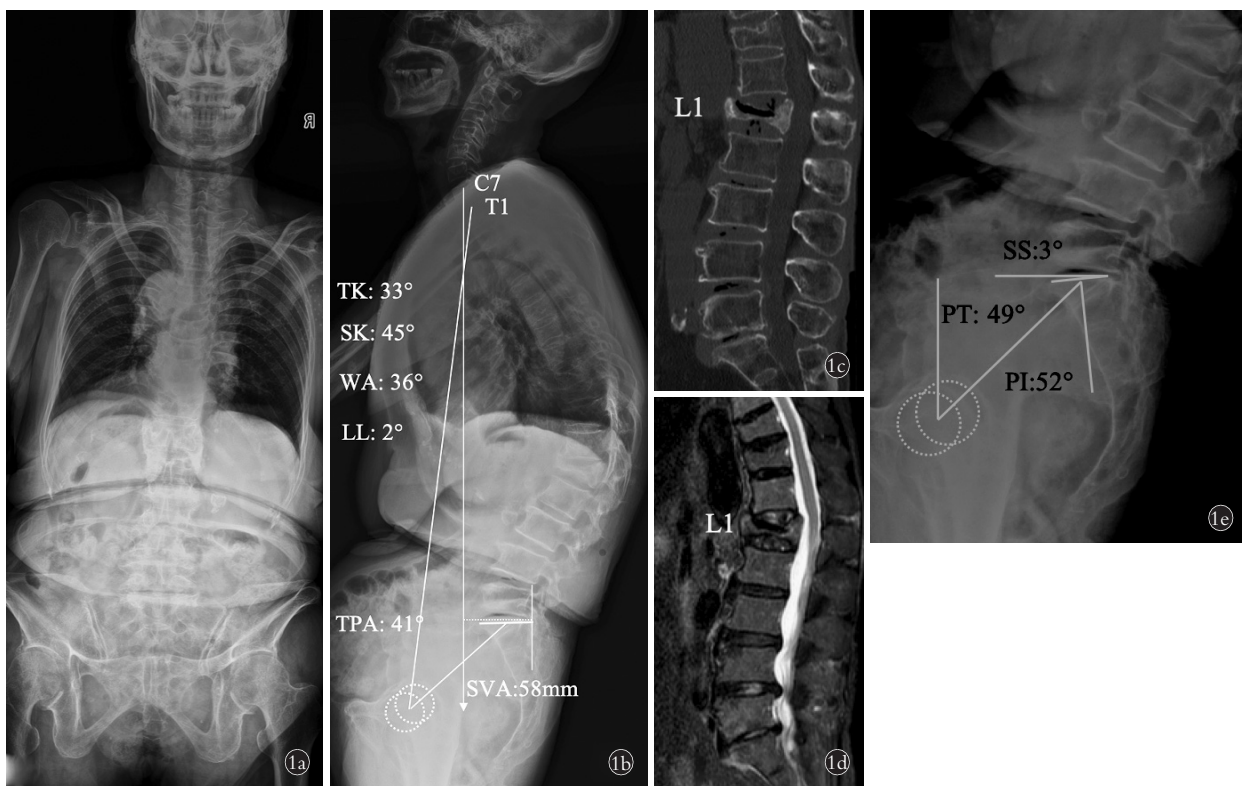
Tab.1 Comparison of general data between patients with Kümmell's disease kyphosis with and control group

组别	例数	性别/例		年龄($\bar{x}\pm s$)/岁
		男	女	
Kümmell 病组	34	10	24	71.1 \pm 8.5
对照组	37	15	22	69.3 \pm 6.7
检验值		$\chi^2=0.981$		$t=0.865$
P 值		0.327		0.399

检查,采用影像归档与通信系统(picture archiving and communication systems,PACS)读片,并在此系统测量脊柱-骨盆矢状位参数,测量及比较以下脊柱-骨盆矢状面参数。(1)节段性后凸角(segmental kyphosis,SK):后凸节段上端椎与下端椎终板切线的夹角;或胸腰椎后凸(thoracolumbar kyphosis,TLK):T₁₀椎体上终板与L₂椎体下终板间夹角。(2)胸椎后凸(thoracic kyphosis,TK):T₄上终板切线与T₁₂下终板切线的夹角。(3)腰椎前凸角(lumbar lordosis,LL):L₁上终板切线与S₁上终板切线的夹角。(4)骨盆入射角(pelvic incidence,PI):经S₁上终板中点的垂线与S₁上终板中点和双侧股骨头中点连线之间的夹角。(5)骨盆倾斜角(pelvic tilt,PT):S₁上终板中点和双侧股骨头中点连线与铅垂线之间的夹角。(6)骶骨倾斜角(sacral slope,SS):S₁上终板中点和双侧股骨头中点连线与铅垂线之间的夹角。(7)矢状面平衡(sagittal vertical axis,SVA):经C₇椎体中心所做的铅垂线与S₁后上缘的水平距离,若铅垂线位于S₁后上缘前方,则为正值,反之为负值,当SVA绝对值 ≤ 5 cm时,判定为脊柱矢状位平衡,否则为失平衡。(8)T₁骨盆角(T₁ pelvic angle,TPA):T₁椎体上终板中点与双侧股骨头中点连线和S₁上终板中心与股骨头中点连线之间的夹角。(9)骨盆入射角与腰椎前凸的匹配关系(PI-LL),若PI-LL $\geq 10^\circ$,判定为骨盆腰椎失匹配。(10)测量 Kümmell 病患者患椎椎体楔变角(wedge angle,WA):即矢状面上患椎椎体上终板与下终板间的夹角。见图 1。

1.4 统计学处理

应用 SPSS 20.0 软件进行统计学分析。脊柱-骨盆矢状面参数等符合正态分布的定量资料以均数 \pm 标准差($\bar{x}\pm s$)表示,两组间比较采用独立样本 t 检验;性别等定性资料采用 χ^2 检验,采用 Pearson 相关性检验分析脊柱-骨盆矢状面各参数间的相关性。以



注:WA, 椎体楔变角;SK, 节段性脊柱后凸角;TK, 胸椎后凸角;LL, 腰椎前凸角;TPA, T1 骨盆角;SVA, 矢状面平衡;PI, 骨盆入射角;PT, 骨盆倾斜角;SS, 骶骨倾斜角。下同

图 1 患者,女,77 岁, L₁ Kümmell's 病伴脊柱后凸畸形 **1a.** 站立位全脊柱正位 X 线片示脊柱无侧凸 **1b.** 矢状位全脊柱 X 线片示以 L₁ 病变椎体为中心的节段性脊柱后凸、胸椎后凸增大、腰椎前凸减小和躯干前倾 **1c.** CT 可见 L₁ 椎体压缩及椎体裂隙征 **1d.** MRI 上可见椎体陈旧性压缩改变,尚未累及椎管 **1e.** 骨盆侧位 X 线片示骨盆后旋转

Fig.1 A 77-year-old female with L₁ Kümmell's disease with kyphosis **1a.** AP X-ray of the whole spine on standing position showed no scoliosis **1b.** Sagittal X-ray of the whole spine showed segmental spinal kyphosis, enlarged thoracic kyphosis, decreased lumbar lordosis, and trunk forward tilt centered on the L₁ lesion vertebra **1c.** L₁ vertebral compression and vertebral fissure features were seen on CT **1d.** Old compression changes of the vertebral body were seen on MRI, and the spinal canal was not yet involved **1e.** The lateral X-ray of pelvic showed the posterior rotation of the pelvis

$P < 0.05$ 为差异有统计学意义。

2 结果

Kümmell 病组 TK、SK、SVA、PT、TPA、PI-LL 均高于对照组 ($P < 0.05$), Kümmell 病组 LL、SS 低于对照组 ($P < 0.05$), 两组间 PI 比较差异无统计学意义 ($P > 0.05$), 见表 2。Kümmell 病组患椎 WA 为 (30.8 ± 5.9)°, 并与 SK、TK 相关 ($r = 0.366, 0.597, P < 0.05$), SK 与 LL、SS 具有相关性 ($r = -0.539, -0.591, P < 0.05$), LL 与 PI、SS、SVA、TPA、PI-LL 呈相关性 ($r = 0.559, 0.741, -0.273, -0.356, -0.882, P < 0.05$), TPA 与 LL、PT、PI-LL、SVA 具有相关性 ($r = -0.356, 0.746, 0.629, 0.569, P < 0.05$), 见表 3、图 2。提示当患椎椎体发生楔形变后继发的节段性脊柱后凸畸形与腰椎前凸丢失密切相关, 而腰椎前凸丢失进一步加重了骨盆入射角与腰椎前凸的失匹配关系以及脊柱矢状面的失平衡。

3 讨论

Kümmell 病发病率为 7%~37%^[4], 发病机制至今尚未明确, 目前大部分学者倾向于椎体缺血坏死假

说, 即其发病是由椎体供血管的解剖异常或机械损伤引起, 椎体前 1/3 区域动脉血供应中断可能是缺血性坏死的机制, 而椎体塌陷则是椎体骨折部分塌陷引起动脉供血不足所致。该病早期误诊、漏诊率较高, 由于轻微外伤导致椎体骨小梁损伤通常难以被及时发现和治疗, 骨折后反复、过早的运动使得骨折断端愈合受阻, 最终导致骨折不愈合, 特别是对于骨质疏松患者, 发生骨折和骨折不愈合的可能性更大^[5], 临床上患者通常因持续性腰背痛和(或)伴有下肢感觉活动障碍前来就诊^[6], 确诊本病时大多已经出现了椎体塌陷、神经功能损害以及不同程度的脊柱后凸畸形^[7-8]。

3.1 Kümmell 病脊柱后凸畸形发生进展原因分析

Kümmell 病继发脊柱后凸畸形与伤椎/病椎病理状态密切相关。Kümmell 病典型影像学表现为迟发性椎体塌陷和椎体内裂隙征 (intravertebral cleft, IVC), 通过病理学检查可在塌陷的椎体中发现大量的反应性纤维增生组织和坏死骨组织, 同时伴少量

表 2 Kümmell 病组与对照组脊柱-骨盆矢状面参数比较 ($\bar{x} \pm s$)

Tab.2 Comparison of sagittal spinopelvic parameters between patients with Kümmell's disease with kyphosis and asymptomatic control group ($\bar{x} \pm s$)

组别	例数	TK/°	SK(TLK)/°	LL/°	PT/°	PI/°	PI-LL/°	SS/°	TPA/°	SVA/mm
Kümmells 病组	34	35.6±17.8	45.2±8.9	32.3±18.9	25.7±8.5	50.3±9.3	18.1±15.8	24.6±10.5	24.7±8.1	57.9±47.6
对照组	37	27.1±8.1	9.5±7.6	47.3±6.9	13.2±5.7	46.7±7.5	6.6±4.4	33.5±6.2	8.9±4.5	14.4±24.5
t 值		1.727	11.670	2.918	5.473	2.438	3.770	2.174	6.685	3.355
P 值		0.047	<0.001	0.005	<0.001	0.057	0.007	0.038	<0.001	0.002

表 3 Kümmell 病伴脊柱后凸畸形组脊柱-骨盆参数间 Pearson 检验的相关性

Tab.3 Correlation of Pearson test between spine and pelvic parameters in Kümmell's disease with kyphosis

测量参数	SK	TK	LL	PT	PI	PI-LL	SS	TPA	SVA
WA	$r=0.366$ $P=0.018$	$r=0.597$ $P=0.031$	$r=0.079$ $P=0.796$	$r=0.330$ $P=0.270$	$r=0.107$ $P=0.728$	$r=-0.025$ $P=0.935$	$r=-0.172$ $P=0.575$	$r=0.209$ $P=0.491$	$r=-0.147$ $P=0.633$
SK		$r=0.142$ $P=0.643$	$r=-0.539$ $P=0.033$	$r=0.254$ $P=0.402$	$r=-0.439$ $P=0.133$	$r=0.274$ $P=0.365$	$r=-0.591$ $P=0.033$	$r=0.119$ $P=0.696$	$r=-0.105$ $P=0.732$
TK			$r=0.619$ $P=0.039$	$r=0.262$ $P=0.388$	$r=0.234$ $P=0.442$	$r=-0.481$ $P=0.096$	$r=-0.005$ $P=0.987$	$r=0.077$ $P=0.802$	$r=-0.275$ $P=0.363$
LL				$r=-0.319$ $P=0.287$	$r=0.559$ $P=0.041$	$r=-0.882$ $P=0.000$	$r=0.741$ $P=0.004$	$r=-0.356$ $P=0.032$	$r=-0.273$ $P=0.017$
PT					$r=0.298$ $P=0.323$	$r=0.552$ $P=0.050$	$r=-0.543$ $P=0.055$	$r=0.746$ $P=0.003$	$r=-0.019$ $P=0.740$
PI						$r=-0.092$ $P=0.764$	$r=0.639$ $P=0.018$	$r=0.365$ $P=0.219$	$r=0.019$ $P=0.949$
PI-LL							$r=-0.526$ $P=0.065$	$r=0.629$ $P=0.021$	$r=0.334$ $P=0.265$
SS								$r=-0.279$ $P=0.355$	$r=0.099$ $P=0.747$
TPA									$r=0.569$ $P=0.042$

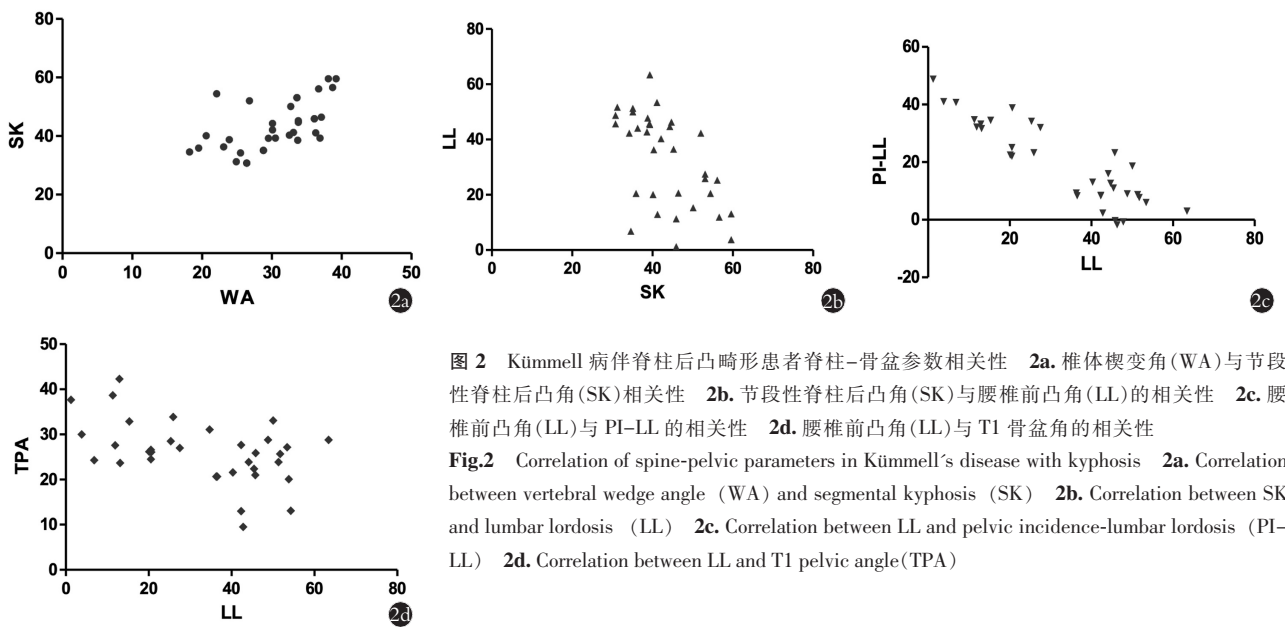


图 2 Kümmell 病伴脊柱后凸畸形患者脊柱-骨盆参数相关性 2a. 椎体楔变角(WA)与节段性脊柱后凸角(SK)相关性 2b. 节段性脊柱后凸角(SK)与腰椎前凸角(LL)的相关性 2c. 腰椎前凸角(LL)与 PI-LL 的相关性 2d. 腰椎前凸角(LL)与 T1 骨盆角的相关性

Fig.2 Correlation of spine-pelvic parameters in Kümmell's disease with kyphosis 2a. Correlation between vertebral wedge angle (WA) and segmental kyphosis (SK) 2b. Correlation between SK and lumbar lordosis (LL) 2c. Correlation between LL and pelvic incidence-lumbar lordosis (PI-LL) 2d. Correlation between LL and T1 pelvic angle(TPA)

新鲜骨组织形成,此为典型的椎体缺血性坏死表现^[9]。病变椎体因骨微结构改变、椎体塌陷、持续压缩进而出现椎体楔形变。既往研究显示,不论是退变性脊柱后凸畸形亦或是陈旧性胸腰椎骨折致脊柱后凸畸形,椎体楔形变尤其是顶椎椎体楔形变都是脊柱后凸畸形出现及进展的重要因素^[10-11]。本研究中 Kümmell 病伤椎均为胸腰段椎体(T₁₀-L₂),平均 WA 为 30.8°,并与 SK 具有显著相关性。由于 Kümmell 病变节段椎体高度丢失未能恢复,导致局部矢状面形态异常持续存在,再加之此类患者多为老年人群,由于椎间盘、关节突关节以及椎旁肌等组织结构退变,维持脊柱节段稳定性及力线平衡的代偿能力有限,促成了节段性后凸畸形的进展并引起患者持续性腰背部疼痛。当脊柱后凸角度>30°时,患者腰背肌疲劳、腰背部疼痛症状明显加重。本研究所纳入 Kümmell 病伴脊柱后凸畸形患者平均后凸角 45.2°,均有不同程度腰背部疼痛表现。

3.2 Kümmell 病伴脊柱后凸畸形脊柱-骨盆矢状面形态改变及其对治疗的指导意义

近年来,随着脊柱生物力学和临床影像学研究的进展,人们对脊柱-骨盆矢状面形态的认识越来越深入和广泛,相对于脊柱冠状面参数,矢状面参数与患者术前和术后的健康相关生活质量(health related quality of life, HRQOL)具有明显相关性^[12]。既往对成人退行性脊柱侧后凸畸形、强直性脊柱炎后凸畸形、陈旧性胸腰椎骨折后凸畸形等脊柱疾患引起的脊柱-骨盆矢状面形态异常的相关研究已有报道,目前对于 Kümmell 病伴脊柱后凸畸形的研究主要集中于临床治疗,有关其脊柱-骨盆矢状面形态学的变化鲜有研究。本研究通过比较 Kümmell 病伴脊柱后凸畸形患者与年龄匹配的正常人群的脊柱-骨盆矢状面形态差异,发现 Kümmell 病除表现为病变椎体塌陷、楔形变以及所继发的胸腰椎节段性脊柱后凸畸形外,其整体脊柱-骨盆矢状面形态亦发生改变,主要表现为 LL 减少、骨盆后旋、骨盆腰椎不匹配、躯干前倾等。这一改变不同于陈旧性胸腰椎骨折继发的脊柱后凸畸形,后者一般仅表现为以骨折为中心的局部后凸畸形及胸椎后凸减少,而并未出现明显腰椎前凸丢失、躯干前倾等代偿性改变^[13]。随着年龄增加,脊柱退变自然进程即会出现 TK 增大以及 LL 减小,而胸腰段后凸畸形的出现则进一步加剧了这一改变,致使 C₇ 铅垂线前移,骨盆通过后倾旋转获得矢状面平衡,这也是机体代偿的结果^[12]。由于 PI 成年后是一个固定值,故学者们目前将 PI-LL 作为评估矢状面形态的主要参考指标之一, SCHWAB 等^[12]认为 PI-LL 值过大与脊柱畸形患者功能障碍加重以

及 HRQOL 的降低关系最为密切,而通过手术矫正这一参数可显著改善患者的生活质量,也有学者提出随着年龄增加,脊柱-骨盆矢状面形态有其自然退变进程,手术治疗的目标也应顺应患者年龄的增加及 PI 值的个体差异^[14]。SVA 是广泛使用的判断脊柱矢状位整体平衡的影像学参数,以往文献报道 SVA>50 mm 时患者的功能评分较低,而通过手术改善这一失平衡参数可使患者生活质量亦能获得提高^[15-16]。TPA 可同时反应 SVA 和 PT 变化,且不受患者体位变化等代偿因素以及影像学测量方法的影响,能够较为全面、客观地评价整体脊柱-骨盆矢状位平衡状态,并与 HRQOL 的关系密切^[17],有学者将 TPA≤20°作为目标值能让矢状面失衡患者获得更好的术后长期功能状态^[18-19]。本研究结果发现 TPA 与 PI-LL、SVA、PT 均具有正相关性,这一结果与 PROTOPSALTIS 等^[17]的研究一致,表明 TPA 对 Kümmell 病伴脊柱后凸畸形患者矢状面平衡状态的评估以及指导后续治疗上均具有重要指导意义。

综上所述,Kümmell 病由于椎体压缩、塌陷、不愈合等持续存在,不仅会进展为胸腰椎节段性后凸畸形,而且整体脊柱-骨盆矢状面参数亦发生改变,节段性后凸的出现使得腰椎前凸丢失、骨盆后旋、躯干前倾等而影响整体脊柱-骨盆矢状面形态。Kümmell 病的手术治疗不仅要重视塌陷椎体高度的恢复,对于合并脊柱后凸畸形的患者还要着眼于恢复脊柱-骨盆矢状面的整体平衡。

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