

支架辅助下直接前方入路微创全髋关节置换术 治疗发育性髋关节发育不良

董玉鹏¹, 季卫锋², 尚美妍¹, 曾森炎¹, 张洋¹, 沈景²

(1. 浙江中医药大学, 浙江 杭州 310053; 2. 浙江省中医院, 浙江 杭州 310006)

摘要 目的:比较支架辅助下直接前方入路(direct anterior approach, DAA)与传统后侧入路微创全髋关节置换术治疗发育性髋关节发育不良(developmental dysplasia of hip, DDH)的临床疗效和安全性。**方法:**回顾性分析 50 例 DDH 患者的病例资料,其中采用支架辅助下 DAA 微创全髋关节置换术治疗 25 例(DAA 组),采用传统后侧入路微创全髋关节置换术治疗 25 例(传统后侧入路组)。男 26 例,女 24 例。年龄 39~77 岁,中位数 58 岁。Crowe I 型 27 例, Crowe II 型 23 例。比较 2 组患者的手术时间、切口长度、术中出血量、术后引流量、术后首次下地时间和术后住院时间,以及术前和术后 1 周、1 个月、3 个月、6 个月、1 年、2 年时 2 组患者的 Harris 髋关节功能评分,观察并发症发生情况。**结果:**DAA 组患者的切口长度、术后住院时间和术后首次下地时间均短于传统后侧入路组[(8.54±1.41)cm, (13.24±2.45)cm, $t = -8.298, P = 0.000$; (7.31±1.22)d, (14.83±3.42)d, $t = -10.364, P = 0.000$; (12.14±3.52)h, (25.43±5.77)h, $t = -9.832, P = 0.000$],术中出血量和术后引流量均小于传统后侧入路组[(242.17±32.64)mL, (361.38±53.28)mL, $t = -9.542, P = 0.000$; (80.43±5.87)mL, (102.52±8.50)mL, $t = -10.699, P = 0.000$]; 2 组患者手术时间比较,差异无统计学意义[(69.30±4.45)min, (68.41±5.65)min, $t = 0.623, P = 0.541$]。Harris 髋关节功能评分,时间因素和分组因素存在交互效应($F = 4.164, P = 0.007$); 2 组患者 Harris 髋关节功能评分总体比较,组间差异有统计学意义,即存在分组效应($F = 9.327, P = 0.048$);手术前后不同时间点之间 Harris 髋关节功能评分的差异有统计学意义,即存在时间效应($F = 31.356, P = 0.000$); 2 组患者 Harris 髋关节功能评分随时间均呈升高趋势,但 2 组的升高趋势不完全一致[(41.41±2.43)分, (70.59±2.60)分, (78.23±3.37)分, (87.16±4.18)分, (92.52±4.76)分, (93.14±3.86)分, (93.21±4.71)分, $F = 17.631, P = 0.000$; (40.73±2.96)分, (62.87±4.28)分, (71.59±2.20)分, (82.87±6.33)分, (91.04±3.42)分, (92.47±4.64)分, (93.17±3.69)分, $F = 28.382, P = 0.000$];术前和术后 6 个月、1 年、2 年,2 组患者 Harris 髋关节功能评分的组间差异均无统计学意义($t = 0.888, P = 0.379$; $t = 1.263, P = 0.213$; $t = 0.555, P = 0.581$; $t = 0.033, P = 0.973$);术后 1 周、1 个月和 3 个月, DAA 组患者 Harris 髋关节功能评分均高于传统后侧入路组($t = 7.708, P = 0.000$; $t = 8.249, P = 0.000$; $t = 2.828, P = 0.007$)。2 组患者均未出现并发症。**结论:**与传统后侧入路微创全髋关节置换术相比,采用支架辅助下 DAA 微创全髋关节置换术治疗 DDH,创小,住院时间短,能使患者尽早下床锻炼,早期髋关节功能恢复快,可作为临床治疗 DDH 的一种较为理想的方法。但二者在手术时间和远期髋关节功能恢复方面无明显差异。

关键词 髋脱位;先天性;关节成形术;置换;髋;手术入路

Minimal invasive total hip arthroplasty through direct anterior approach assisted by supporting frame for treatment of developmental dysplasia of hip

DONG Yupeng¹, JI Weifeng², SHANG Meiyang¹, ZENG Senyan¹, ZHANG Yang¹, SHEN Jing²

1. Zhejiang University of Traditional Chinese Medicine, Hangzhou 310053, Zhejiang, China

2. Zhejiang Provincial Hospital of Traditional Chinese Medicine, Hangzhou 310006, Zhejiang, China

ABSTRACT Objective: To compare the clinical curative effects and safety of minimal invasive total hip arthroplasty (THA) through direct anterior approach (DAA) assisted by supporting frame versus conventional posterior approach (CPA) for treatment of developmental dysplasia of hip (DDH). **Methods:** The medical records of 50 patients with DDH were analyzed retrospectively. Twenty-five patients were treated with minimal invasive THA through DAA assisted by supporting frame (DAA group), while the others were treated with minimal invasive THA through CPA (CPA group). The patients consisted of 26 males and 24 females, and ranged in age from 39 to 77 years (Median = 58 yrs). The DDH belonged to Crowe type I (27) and II (23). The operative time, incision length, intraoperative blood loss, postoperative

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通讯作者:季卫锋 E-mail:jiweifeng1230@163.com

drainage, bed rest time, postoperative hospital stay and Harris hip function scores before the surgery and at 1 week, 1 month, 3 months, 6 months, 1 year and 2 years after the surgery were compared between the 2 groups, and the complications were observed. **Results:** The incision length, postoperative hospital stay and bed rest time were shorter and the intraoperative blood loss and postoperative drainage were less in DAA group compared to CPA group (8.54 ± 1.41 vs 13.24 ± 2.45 cm, $t = -8.298, P = 0.000$; 7.31 ± 1.22 vs 14.83 ± 3.42 d, $t = -10.364, P = 0.000$; 12.14 ± 3.52 vs 25.43 ± 5.77 hrs, $t = -9.832, P = 0.000$; 242.17 ± 32.64 vs 361.38 ± 53.28 mL, $t = -9.542, P = 0.000$; 80.43 ± 5.87 vs 102.52 ± 8.50 mL, $t = -10.699, P = 0.000$). There was no statistical difference in operative time between the 2 groups (69.30 ± 4.45 vs 68.41 ± 5.65 min, $t = 0.623, P = 0.541$). There was interaction between time factor and group factor in Harris hip function scores ($F = 4.164, P = 0.007$). There was statistical difference in Harris hip function scores between the 2 groups in general, in other words, there was group effect ($F = 9.327, P = 0.048$). There was statistical difference in Harris hip function scores between different timepoints before and after the surgery, in other words, there was time effect ($F = 31.356, P = 0.000$). The Harris hip function scores presented a time-dependent increasing trend in the 2 groups, while the 2 groups were inconsistent with each other in the increasing trend of Harris hip function scores (41.41 ± 2.43, 70.59 ± 2.60, 78.23 ± 3.37, 87.16 ± 4.18, 92.52 ± 4.76, 93.14 ± 3.86, 93.21 ± 4.71 points, $F = 17.631, P = 0.000$; 40.73 ± 2.96, 62.87 ± 4.28, 71.59 ± 2.20, 82.87 ± 6.33, 91.04 ± 3.42, 92.47 ± 4.64, 93.17 ± 3.69 points, $F = 28.382, P = 0.000$). There was no statistical difference in Harris hip function scores between the 2 groups before the surgery and at 6 months, 1 year and 2 years after the surgery ($t = 0.888, P = 0.379$; $t = 1.263, P = 0.213$; $t = 0.555, P = 0.581$; $t = 0.033, P = 0.973$). The Harris hip function scores were higher in DAA group compared to CPA group at 1 week, 1 month and 3 months after the surgery ($t = 7.708, P = 0.000$; $t = 8.249, P = 0.000$; $t = 2.828, P = 0.007$). No complications were found in the 2 groups. **Conclusion:** Minimal invasive THA through DAA assisted by supporting frame has such advantages as less trauma, shorter hospital stay, shorter bed rest time and faster hip function recovery compared to minimal invasive THA through CPA in treatment of DDH, so it can be used as an ideal therapy for treatment of DDH in clinic. However, there is no obvious difference between the two therapies in operative time and long-term hip function recovery.

Keywords hip dislocation, congenital; arthroplasty, replacement, hip; operative approach

全髋关节置换术已被临床证明是有效解决发育性髋关节发育不良 (developmental dysplasia of hip, DDH) 的外科手段,能有效恢复患肢功能、提高患者生活质量。目前全髋关节置换术较常用的手术入路主要包括直接前方入路 (direct anterior approach, DAA)、前外侧入路、外侧入路与传统后侧入路,除 DAA 外,其余入路均需切断部分肌肉,影响患肢术后康复速度^[1-5]。DAA 又称 Heuter 入路,是指经缝匠肌与阔筋膜张肌的 Heuter 间隙,暴露髋关节的一种手术方式,该术式相较于传统后侧入路,可避免髋关节肌肉及其周围组织的损伤。目前国内报道的 DAA 全髋关节置换术多采用专用手术牵引床、远端可下降 30° 的普通手术床相辅助,或采用侧卧位的方式以利于股骨侧的暴露和方便术中操作,但前者高昂的价格以及后者较多的并发症对 DAA 的临床应用造成了较多的限制^[6]。为解决上述问题,临床上我们采用自行设计的 DAA 支架 (专利号:201520491390.7) 辅助下 DAA 微创全髋关节置换术治疗 DDH。为比较支架辅助下 DAA 微创全髋关节置换术与传统后侧入路微创全髋关节置换术治疗 DDH 的临床疗效和安全性,笔者回

顾性分析了 2012 年 1 月至 2016 年 1 月分别采用这 2 种方法治疗的 50 例 DDH 患者的病例资料,现报告如下。

1 临床资料

1.1 一般资料 纳入研究的患者共 50 例,男 26 例、女 24 例。年龄 39 ~ 77 岁,中位数 58 岁。均为在浙江省中医院住院治疗的 DDH 患者。依据 Crowe 影像学分型标准^[7]: Crowe I 型 27 例, Crowe II 型 23 例。试验方案经医院医学伦理委员会审查通过。

1.2 诊断标准 参照《发育性髋关节发育不良诊疗指南 (2009 年版)》中的大龄 (8 岁以上) DDH 诊断标准^[8]: ①大腿皮纹、臀纹或双臀外观不对称; ②下肢不等长, Allis 征阳性; ③跛行、鸭步等步态改变; ④腹股沟内侧压痛、髋部疲劳性疼痛和髋关节运动终末挤压痛; ⑤双髋关节 X 线、CT 检查显示髋臼变浅、股骨头与髋臼位置关系异常,常用指标为中心边缘角、髋臼指数、Shenton 线等。

1.3 纳入标准 ①符合上述诊断标准; ②年龄 35 ~ 80 岁; ③初次行全髋关节置换术; ④体质量指数 ≤ 30 kg · m⁻²; ⑤ Crowe I 型、II 型 DDH; ⑥随访时间 ≥ 2

年;⑦病例资料完整。

1.4 排除标准 ①合并严重内科疾病不能耐受手术者;②既往有髋关节骨折病史者;③既往有髋关节肿瘤和感染病史者。

2 方法

2.1 分组方法 按照手术入路不同将 50 例患者分为支架辅助下 DAA 微创全髋关节置换术组 25 例 (DAA 组), 传统后侧入路微创全髋关节置换术组 25 例 (传统后侧入路组)。2 组患者基线资料比较, 组间差异无统计学意义, 有可比性 (表 1)。

2.2 手术方法

2.2.1 DAA 组 采用全身麻醉, 患者取仰卧位, 患肢置于 DAA 支架上, 健侧外展位放置 (图 1)。常规消毒铺巾, 取髋关节前侧入路, 自髂前上棘外下方向腓骨小头方向做一长 8~10 cm 的纵形切口, 钝性分离皮下组织及深筋膜, 从阔筋膜张肌与缝匠肌之间的间隙进入, 保护好股外侧皮神经。于切口远端分离结扎旋股外侧动脉升支, 暴露髋关节囊。“三角形”切开髋关节囊, 在 DAA 支架上将患肢内旋 10°, 松解股骨颈外下方关节囊; 外旋 30°, 松解股骨颈内下方关节囊至股骨小转子。患肢水平位牵引 4 cm 后, 将其内旋 10°, 暴露股骨颈, 行股骨颈 2 次截骨, 取出股骨颈。继续保持患肢牵引 4 cm, 将其外旋 40°、后伸 30°, 用取头器取出股骨头, 保持以上体位下, 暴露髋臼并切除髋臼内圆韧带、边缘的骨赘和孟

唇。行髋臼打磨处理后, 取大小合适的髋臼假体 (由美国史塞克公司生产), 在 C 形臂 X 线机透视下将其装入并压紧, 使非骨水泥型髋臼杯位于外展 45°、前倾 25°位。拆除下肢牵引, 保持患肢外旋 90°位, 行股骨距后外侧关节囊松解术。患肢外旋 110°、内收 40°位, 将 DAA 支架下降 9 格 (后伸约 60°), 足部下降至牵引架底部, 行股骨假体准备。用带有偏心距的髓腔锉扩髓, 植入标准头颈试模, 透视确定试模位置、松紧度、活动度及稳定性良好后, 取出试模, 安装股骨假体柄、头、颈, 在患肢由内收外旋后伸位转换至中立位的过程中行髋关节复位。再次经 C 形臂 X 线机透视确认假体位置及稳定性良好后, 用 6.4% 氨甲环酸溶液浸泡关节腔, 关节腔内放置引流管, 反复冲洗切口, 逐层缝合, 外敷料包扎。典型病例图片见图 2。



图 1 术中患者体位及直接前方入路支架实物图

表 1 2 组发育性髋关节发育不良患者基线资料比较

组别	样本量 (例)	性别(例)		年龄 ($\bar{x} \pm s$, 岁)	体质量指数 ($\bar{x} \pm s$, $\text{kg} \cdot \text{m}^{-2}$)	Crowe 影像学分型(例)	
		男	女			I 型	II 型
直接前方入路组	25	14	11	66.76 ± 10.56	34.69 ± 4.56	12	13
传统后侧入路组	25	12	13	63.48 ± 9.25	32.15 ± 3.82	15	10
检验统计量		$\chi^2 = 0.321$		$t = 1.171$	$t = -0.423$	$\chi^2 = 0.725$	
P 值		0.571		0.216	0.682	0.395	



(1)术前X线片

(2)术后X线片

(3)术后切口

图 2 发育性髋关节发育不良患者手术前后图片

患者, 男, 54 岁, Crowe I 型发育性髋关节发育不良, 采用支架辅助下直接前方入路微创全髋关节置换术治疗

2.2.2 传统后侧入路组 采用全身麻醉,患者取健侧卧位,常规消毒、铺巾。取髋关节后侧入路,切口长 10~15 cm,逐层切开皮肤、皮下组织、阔筋膜,沿臀大肌纤维方向分离至髂胫束,暴露髋关节后外侧面。将患侧髋关节内旋,沿股骨大转子后缘切断梨状肌、闭孔内肌、上孖肌、下孖肌并向后反折。“T”字形切开关节囊,暴露股骨头与股骨颈,行股骨颈截骨,取出股骨头,清理圆韧带残端、关节囊及髋臼缘,行髋臼打磨处理至合适大小后,取大小合适的髋臼假体(由美国史塞克公司生产),打入非骨水泥型髋臼底座并装好陶瓷内衬。于股骨近端行股骨扩髓至合适大小,植入标准头颈试模,在 C 形臂 X 线机透视下确认模型位置良好后,植入股骨假体柄、头、颈,复位髋关节。再次经 C 形臂 X 线机透视确认假体位置和稳定性良好后,用 6.4% 氨甲环酸溶液浸泡关节腔,关节腔内放置引流管,反复冲洗切口,逐层缝合,外敷料包扎。

2.3 术后处理方法 术后 2 组均给予常规抗生素预防感染和低分子量肝素钙预防下肢深静脉血栓形成;DAA 组术后第 1 天在康复医师指导下开始下床功能锻炼;传统后侧入路组术后第 1 天行股四头肌等长收缩锻炼,术后第 3 天开始下床功能锻炼。

2.4 疗效和安全性评价方法 比较 2 组患者的手术时间、切口长度、术中出血量、术后引流量、术后首次下地时间和术后住院时间,以及术前和术后 1 周、

1 个月、3 个月、6 个月、1 年、2 年时 2 组患者的 Harris 髋关节功能评分^[9],观察并发症发生情况。

2.5 数据统计方法 采用 SPSS19.0 统计软件对所得数据进行统计学分析,2 组患者性别、Crowe 影像学分型的组间比较采用 χ^2 检验,年龄、体质量指数、手术时间、切口长度、术中出血量、术后引流量、术后住院时间、术后首次下地时间的组间比较采用 *t* 检验,Harris 髋关节功能评分的比较采用重复测量资料的方差分析,检验水准 $\alpha = 0.05$ 。

3 结果

DAA 组患者的切口长度、术后住院时间和术后首次下地时间均短于传统后侧入路组,术中出血量和术后引流量均小于传统后侧入路组;2 组患者手术时间比较,差异无统计学意义(表 2)。Harris 髋关节功能评分,时间因素和分组因素存在交互效应;2 组患者 Harris 髋关节功能评分总体比较,组间差异有统计学意义,即存在分组效应;手术前后不同时间点之间 Harris 髋关节功能评分的差异有统计学意义,即存在时间效应;2 组患者 Harris 髋关节功能评分随时间均呈升高趋势,但 2 组的升高趋势不完全一致;术前和术后 6 个月、1 年、2 年,2 组患者 Harris 髋关节功能评分的组间差异均无统计学意义;术后 1 周、1 个月和 3 个月,DAA 组患者 Harris 髋关节功能评分均高于传统后侧入路组(表 3、图 3)。2 组患者均未出现并发症。

表 2 2 组发育性髋关节发育不良患者手术时间、切口长度、术中出血量、术后引流量、术后住院时间和术后首次下地时间比较

组别	样本量 (例)	手术时间 ($\bar{x} \pm s, \text{min}$)	切口长度 ($\bar{x} \pm s, \text{cm}$)	术中出血量 ($\bar{x} \pm s, \text{mL}$)	术后引流量 ($\bar{x} \pm s, \text{mL}$)	术后住院时间 ($\bar{x} \pm s, \text{d}$)	术后首次下地时间 ($\bar{x} \pm s, \text{h}$)
直接前方入路组	25	69.30 ± 4.45	8.54 ± 1.41	242.17 ± 32.64	80.43 ± 5.87	7.31 ± 1.22	12.14 ± 3.52
传统后侧入路组	25	68.41 ± 5.65	13.24 ± 2.45	361.38 ± 53.28	102.52 ± 8.50	14.83 ± 3.42	25.43 ± 5.77
<i>t</i> 值		0.623	-8.298	-9.542	-10.699	-10.364	-9.832
<i>P</i> 值		0.541	0.000	0.000	0.000	0.000	0.000

表 3 2 组发育性髋关节发育不良患者手术前后 Harris 髋关节功能评分比较

组别	样本量 (例)	术前	术后 1 周	术后 1 个月	术后 3 个月	术后 6 个月	术后 1 年	术后 2 年	合计	<i>F</i> 值	<i>P</i> 值
直接前方入路组	25	41.41 ± 2.43	70.59 ± 2.60	78.23 ± 3.37	87.16 ± 4.18	92.52 ± 4.76	93.14 ± 3.86	93.21 ± 4.71	79.47 ± 3.70	17.631	0.000
传统后侧入路组	25	40.73 ± 2.96	62.87 ± 4.28	71.59 ± 2.20	82.87 ± 6.33	91.04 ± 3.42	92.47 ± 4.64	93.17 ± 3.69	76.39 ± 3.93	28.382	0.000
合计	50	41.07 ± 2.70	66.73 ± 2.44	74.91 ± 2.79	85.02 ± 5.26	91.78 ± 8.18	92.81 ± 4.25	93.19 ± 4.20	77.93 ± 3.82	31.356 ¹⁾	0.000 ¹⁾
检验统计量		<i>t</i> = 0.888	<i>t</i> = 7.708	<i>t</i> = 8.249	<i>t</i> = 2.828	<i>t</i> = 1.263	<i>t</i> = 0.555	<i>t</i> = 0.033	9.327 ¹⁾	<i>F</i> = 4.164 ²⁾	
<i>P</i> 值		0.379	0.000	0.000	0.007	0.213	0.581	0.973	0.048 ¹⁾	<i>P</i> = 0.007 ²⁾	

1) 主效应的 *F* 值和 *P* 值; 2) 交互效应的 *F* 值和 *P* 值

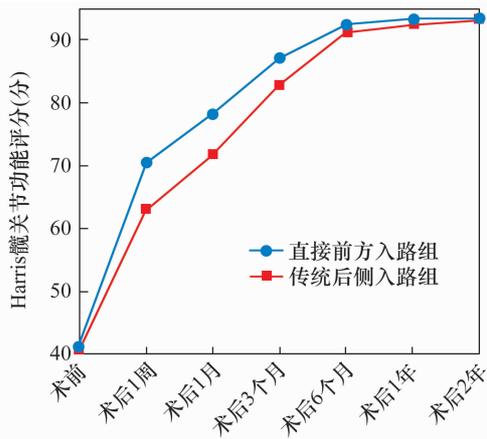


图3 2组发育性髋关节发育不良患者手术前后 Harris 髋关节功能评分变化趋势图

4 讨论

术中组织损伤程度、术后康复速度和术后并发症发生情况是评价手术质量的重要指标。DAA 通过阔筋膜张肌与缝匠肌之间的间隙进入,保留了后方关节囊和肌腱的止点,可以避免对臀肌的损伤,使患者能较早地进行患肢功能锻炼,从而有利于髋关节功能的快速康复^[10]。Zawadsky 等^[11]研究发现,DAA 全髋关节置换术较传统后侧入路全髋关节置换术,能显著缩短住院时间和明显提高患者的康复速度^[12]。本研究的治疗结果显示,DAA 组患者的术中出血量、术后引流量均小于传统后侧入路组,术后3个月内 Harris 髋关节功能评分也均高于传统后侧入路组,且术后首次下地时间也较于传统后侧入路组缩短。其主要原因是该入路对髋关节周围肌肉组织损伤小,可以保证髋关节的稳定性,使患者能更早进行功能锻炼,从而有利于髋关节功能的恢复^[13]。国外有研究报道^[11-12,14-15],随着术后时间的推移,DAA 全髋关节置换术在恢复髋关节功能方面的优势逐渐降低;认为术后3个月内 DAA 全髋关节置换术在恢复髋关节功能方面明显优于传统后侧入路,但术后3个月以后该优势逐渐缩小甚至无明显优势。严卫锋等^[16]研究结果显示,DAA 全髋关节置换术后6个月、24个月 Harris 髋关节功能评分与后外侧入路全髋关节置换术比较,差异均无统计学意义($P=0.015, P=0.319$)。本研究的结果与文献报道基本一致,说明 DAA 的优势主要体现在全髋关节置换术后早期,远期在恢复髋关节功能方面与传统后侧入路并无明显差别。有学者报道,DAA 不仅有利于术中透视,可精确评价术中假体位置,还能减少术中 X 线对患者和医护人员的辐射

损伤^[17-19]。

DAA 全髋关节置换术最大的难点在于受小切口和体位的限制,术中松解股骨侧关节囊和植入假体较困难。因普通手术床限制了股骨远端的下降,导致股骨颈截面抬高不充分,股骨侧后伸受限,所以股骨侧扩髓和假体植入时易导致位置偏移或造成股骨皮质破裂^[20]。临床上我们从以下2个方面解决上述难点:①术中选择性松解股骨侧关节囊。术中松解股骨侧关节囊的重点在于股骨距后侧和后外侧关节囊的松解^[21]。笔者认为,股骨侧关节囊的松解程度以股骨近端能被轻松提起为度,过多的松解将导致联合腱和梨状肌止点的破坏^[22],而过少的松解将限制股骨截面的抬高,不利于扩髓与后续假体植入。②专用手术床辅助。专用手术床的益处主要是术中可协助医师对患肢进行后伸、内旋、外旋和牵引,并可标识其具体角度与数值,减少术中助手数量,降低手术难度。DAA 的专用手术床最早在国外开展,目前国外较为广泛使用的是直接前方小切口微创手术床^[23]和 DAA 特殊牵引床^[6],但因其价格昂贵、适配度低,在我国一直未曾广泛应用。目前国内应用较为普及的是远端可下降 30° 的活动手术床^[6],但该手术床仅具有股骨侧后伸 $0^\circ \sim 30^\circ$ 的单一效果^[24]。我们自行设计的 DAA 支架不仅具有轻便、移动性好和固定患肢方便的特点,又可弥补国内手术床单一后伸的不足,而且可与普通手术床无缝衔接,一定程度上降低了 DAA 的难度。

此外,也应注意 DAA 术中暴露关节、分离肌肉较困难^[25],股外侧皮神经易损伤^[26-27]。本研究所选患者均为 Crowe I 型、II 型 DDH,且其体质量指数 $\leq 30 \text{ kg} \cdot \text{m}^{-2}$,这样有利于降低术中关节暴露难度,减少并发症的发生。切口位置的正确选择可在一定程度上避免股外侧皮神经损伤。我们在阔筋膜张肌体表投影中线(髂前上棘外下方向腓骨小头方向延长)上做切口,临床上均未发现股外侧皮神经损伤患者,说明该切口在一定程度上可降低股外侧皮神经损伤的几率。

本研究的结果显示,与传统后侧入路微创全髋关节置换术相比,采用支架辅助下 DAA 微创全髋关节置换术治疗 DDH,创口小,住院时间短,能使患者早期下床锻炼,早期髋关节功能恢复快,可作为临床治疗 DDH 的一种较为理想的方法。但二者在手术时间

和远期髋关节功能恢复方面无明显差异。

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都与 ACL 损伤有一定关系。另外,诸如膝关节紊乱、髌间窝狭窄及内侧胫骨平台坡度增加等解剖因素都会增加 ACL 的负荷^[10-12]。股四头肌和髌腱的活动、胫骨平台的平移和旋转等生物力学因素同样与非接触性 ACL 损伤密切相关,但是对于其潜在的解剖学联系目前并未明确。Saper 等^[13]研究了负重情况下髌韧带与胫骨之间的轴间角和膝关节弯曲角度之间的关系,结果显示在股四头肌紧张的情况下,髌韧带与胫骨之间的轴间角越大,平台所受到的前方剪切力越大。在股四头肌紧张的情况下,较大的 TT - TG 距离会增加胫骨平台旋转的角度,进而增加平台的前方剪切力,使 ACL 承受更大的张力。

本研究的结果提示,TT - TG 距离可能与非接触性 ACL 损伤发生有关,但 TT - TG 距离相关参数与非接触性 ACL 损伤的发生无明显关系,能否将其作为预测非接触性 ACL 损伤的可靠指标还有待进一步研究。

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