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基于三维 CT 的模拟手术在大龄 DDH 患儿外科治疗中的应用研究 *

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摘要 目的:通过对大龄发育性髋关节脱位(developmental dysplasia of the hip, DDH)患儿进行术前模拟手术,实现术中精确截骨及旋转角度,从而达到个体化治疗,改善患儿预后的目的。**方法:**本研究按照术前规划方式分为两组,一组为传统手术组;另一组为模拟手术组。共 20 例患儿均采用骨盆三联截骨术+股骨截骨术治疗,传统手术组 10 例,模拟手术组 10 例,手术时平均年龄为 11.3 岁,平均随访时间 24.2 个月。所有患儿均于术前行骨盆三维重建 CT 检查,测量 CE 角、股骨前倾角及髋臼指数,在 mimics 软件中,模拟手术方案,确定术中股骨截骨需要旋转的角度及骨盆截骨的位置,术中按照模拟手术的结果进行操作。术前评价指标使用 Tonniss 分级,术后评价指标使用改进的 Trevor 评分系统。**结果:**模拟手术组 Tonniss 分级 3 级 4 髋,Tonniss 分级 4 级 8 髋;传统手术组 Tonniss 分级 3 级 4 髋,Tonniss 分级 4 级 9 髋,两组患儿术前严重程度无显著性差异。依据 Trevor 评分,模拟手术组 8 髋(67%)优秀,3 髋(25%)良好,1 髋(8%)一般。传统手术组 5 髋(38%)优秀,5 髋(38%)良好,3 髋(23%)一般。两组有显著性差异。并发症:术后传统手术组 3 例患儿有不同程度的股骨头坏死。**结论:**大龄 DDH 患儿术前模拟手术,可以达到术中精确截骨及旋转角度,可改善患儿预后,实现该类患者的个体化治疗。

关键词:计算机辅助技术;大龄儿童;发育性髋关节脱位

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Application of Simulated Surgery Based on Using Three-dimensional Computed Tomography in Older Children with Developmental Dysplasia of the Hip*

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ABSTRACT Objective: Through the preoperative surgical simulation in older children with developmental dislocation of the hip (developmental dysplasia of the hip, DDH), accurate osteotomy and rotation angle in operation, so as to achieve individualized treatment, improve the prognosis of the objective. **Methods:** The study was divided into two groups according to preoperative planning methods, one group was conventional surgery group, the other group was simulated operation group. A total of 20 cases were treated with pelvic triple osteotomy combined with femoral osteotomy. 10 cases in the traditional operation group and 10 cases in the simulated operation group, the average age of the operation was 11.3 years, and the average follow-up time was 24.2 months. All patients had pelvic reconstruction CT examination before the surgery, measure the CE angle, femoral anteversion angle and acetabular index. In the Mimics software, a simulated surgical procedure was performed to determine the angle of rotation and the location of the pelvic osteotomy in the operation of the femoral osteotomy, and the procedure was performed according to the outcome of the simulated operation. The preoperative evaluation indexes were graded by Tonniss, and the improved Trevor scoring system was used for postoperative evaluation. **Results:** In the simulated operation group, there were 4 Tonniss type 3 and 8 Tonniss type 4 hips. In the traditional surgery group, there were 4 Tonniss type 3 and 9 Tonniss type 4 hips. There was no significant difference in preoperative severity between the two groups. According to the Trevor score, 8 hips (67%) were rated excellent, 3 hips (25%) were good, and 1 hips (8%) were fair in the simulated operation group. In the traditional surgery group, 5 hips (38%) were rated excellent, 5 hips (38%) were good, and 3 hips (23%) were fair. There was significant difference between the two groups. Complications: there were 3 cases of femoral head necrosis in different degree in the traditional operation group after operation. 3 hips in the traditional surgery group had osteonecrosis of varying severity. **Conclusions:** The preoperative simulated surgery of older DDH can achieve accurate osteotomy and rotation angle, improve the prognosis of patients, and achieve individualized treatment of this kind of patients.

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前言

大龄儿童发育性髋关节脱位 (developmental dysplasia of the hip, DDH) 一般是指 6 岁以上未经任何治疗的 DDH 患者。由于患儿持续负重,髋臼、股骨头的形态发生了较大的变化,软组织也随着股骨头的逐渐上移而明显变形。目前,其治疗仍然是一个困扰儿童骨科医生的难题^[1]。因其特殊的解剖结构,大龄 DDH 的治疗比幼年儿童更加困难^[2]。对于大龄 DDH,一些学者不建议手术治疗,另一些学者则认为要尽早手术治疗,通过一期切开复位,股骨短缩截骨+骨盆三联截骨可取得满意的效果,甚至可以达到髋关节功能的重建^[3-5]。

基于查阅的文献和临床经验,我们认为对于大龄 DDH 患儿,一期手术治疗是最有效的治疗方法^[6-8]。然而,对于大龄 DDH 患儿,其解剖结构已经发生实质性变化并且骨骼的重塑能力也减弱。特别是股骨前倾角和解剖结构可有相当大的变化,给手术带来很大难度^[9]。此外,软组织和骨的继发性改变也可导致治疗过程更加复杂。因此,术前准确评估大龄 DDH 患儿的 CE 角、髋臼角和股骨前倾角对于手术方案的制定至关重要。

在本研究中,我们采用计算机辅助技术应用于 10 例模拟手术组的股骨短缩截骨+骨盆三联截骨术,可精确股骨截骨需要旋转的角度及骨盆截骨的位置,获得了良好疗效,为大龄 DDH 患儿的治疗提供了一种更为精准的手术方法,实现了对于患者的个体化治疗。

1 资料与方法

1.1 一般资料

回顾性分析第四军医大学西京医院儿童骨科 2014 年 10 月至 2016 年 12 月大龄 DDH 行骨盆三联截骨术+股骨截骨术 20 例。纳入标准:入组患儿手术时年龄在 6 岁以上,且均行骨盆三联截骨术+股骨截骨术;排除标准:存在肌肉或染色体疾病的儿童被排除在我们的研究之外。符合纳入标准的模拟手术组患儿 10 例,在行传统手术的患儿中挑选与模拟手术组患儿年龄比例和性别组成均无明显差异患儿 10 例。20 例入组患儿(25 髋)中,男性 6 例,女性 14 例。单侧髋脱位 15 例,双侧髋脱位 5 例。手术时年龄 6-15 岁,平均 11.3 岁。所有入组患儿入院前均无任何手术史,且术前均行骨盆正位 X 线以及骨盆三维重建 CT 检查。该研究获得第四军医大学伦理委员会批准。所有参加者及其监护人签署知情同意书参加研究。

根据患儿术前是否行模拟手术分为传统手术组 10 例(13 髋)和模拟手术组 10 例(12 髋)。传统手术组患儿手术时平均年龄 11.0 岁,模拟手术组患儿手术时平均年龄 11.6 岁。双侧髋脱位患儿两髋手术的间隔时间为 4 个月。

根据术前的影像学资料,按照 Tonnis 分级方法评价患儿术前脱位程度^[10]。模拟手术组 Tonnis 分级 3 级 4 髋, Tonnis 分级 4 级 8 髋;传统手术组 Tonnis 分级 3 级 4 髋, Tonnis 分级 4 级 9 髋。所有患儿随访时间最短为 16 个月(平均 24.2 个月,

24.2±3.6 个月)。

1.2 模拟手术组骨盆以及双股骨的三维重建

采用 SIMENS 64T 扫描,患者取仰卧位,从髂前上棘至双膝关节水平平行薄层扫描,层厚 0.625 mm,64 排螺旋 CT,螺距 0.75-1.0 mm。获取骨盆以及双股骨的二维图像数据,以 dicom 格式刻录至光盘。启动医学图像处理软件 Mimics 10.0 (Materialise company, Belgium),导入二维图像数据,并对图像数据进行定位。通过阈值分割、区域增加、面罩编辑、三维重建,建立骨盆以及双股骨的三维模型。通过虚拟三维重建模型分析病例的特征,并测量相关参数。通过计算机辅助分析可精确测量 CE 角、髋臼角及股骨前倾角。

1.3 术前计算机模拟手术

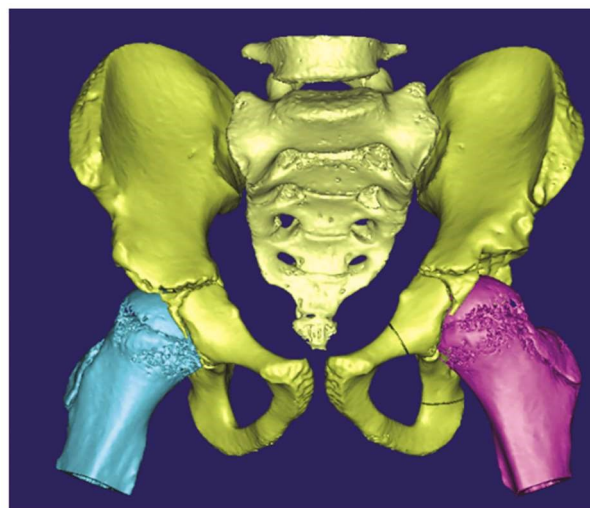


图 1 骨盆三维重建

Fig.1 Three dimensional reconstruction of pelvis

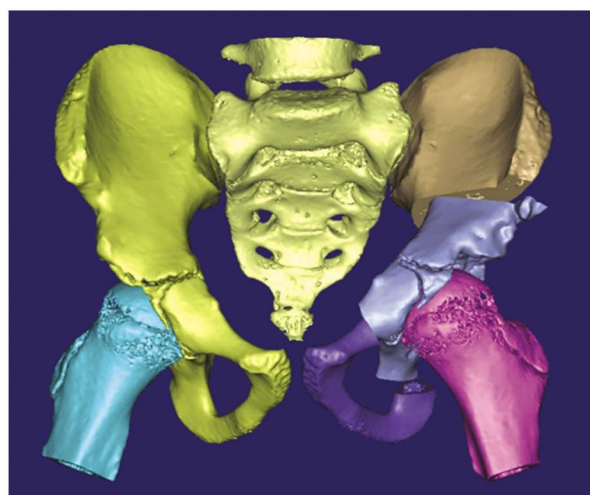


图 2 三联截骨术后骨盆旋转情况

Fig.2 Pelvic rotation after triple osteotomy

将患者的二维 CT 数据导入 Mimics 软件,通过阈值提取,区域增长,三维重建出患者髋关节三维模型,采用模型切割命令,按照三联截骨的手术方式,截断耻骨上支,坐骨支,髂骨,将

髋臼分离,采用旋转命令,将髋臼旋转到完全覆盖股骨头,分析在三维方向上的旋转角度。在术中按照该角度进行旋转髋臼。

如果有必要,采用相同方法对股骨侧进行截骨。

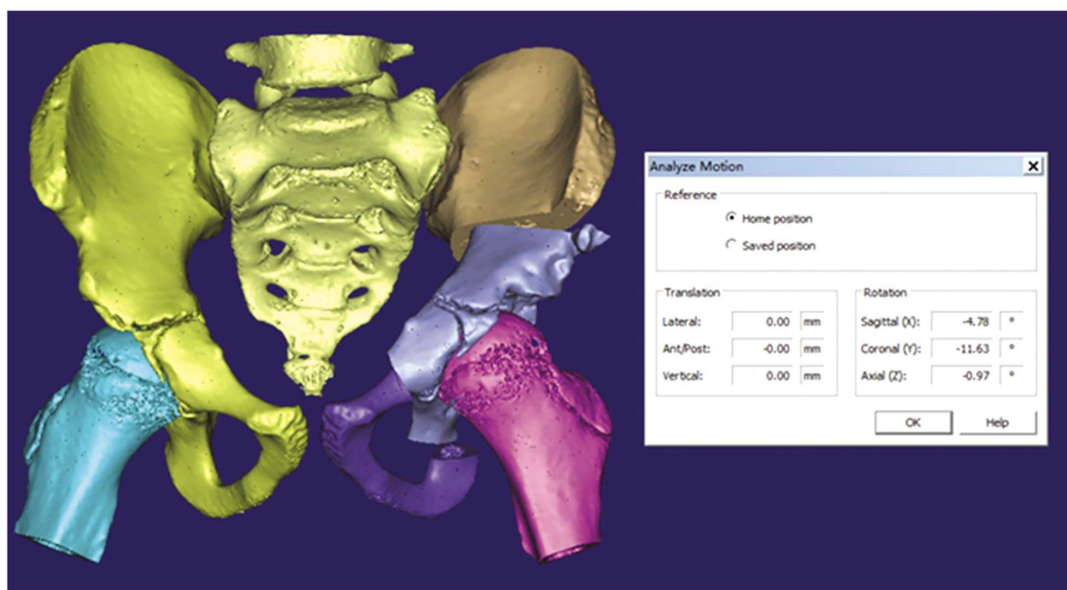


图3 三联截骨术后骨盆旋转角度分析

Fig.3 Analysis of pelvic rotation angle after triple osteotomy

1.4 手术方法

所有患儿手术包含股骨近端截骨和骨盆截骨两个步骤(模拟手术组截骨位置及旋转角度根据术前模拟手术的数值,传统手术组参照术前三维重建CT结果及术者经验)。

1.4.1 股骨近端截骨 术髋股骨近端外侧切口进入,短缩+旋转截骨,截骨后用钢板固定。

1.4.2 骨盆截骨 患儿仰卧,术髋置屈曲外展位,分二个切口进行。① 内收肌入路,在耻骨上下支汇合处的外侧作垂直于内收肌肌腱的直切口,长度约5 cm。在切口上端于腹股沟韧带下切开耻骨肌显露耻骨上支,骨膜下剥离其上、下、后方,切口下端切开深筋膜,钝性分离内收肌与股薄肌之间隙,显露耻骨下支并作骨膜下剥离。距耻骨联合外侧约2 cm处,从前外向后内略成斜形截断耻骨上下支,切口暂不缝合;② 髋关节前外侧入路(Smith-Petersen入路):松解髂腰肌,清理髋臼,修剪关节囊。以salter截骨术式截开髂骨。当三联截骨完成后,手指探入内收肌切口向后、向内推移耻骨上下支并使断端重叠;在前外侧切口中将髂骨截骨块远端向下翻压、向前旋转(注意不要向外提拉),自体股骨干骨块或异体骨块嵌入髂骨截断面的外侧作为支撑,截断面的内侧则用2-3枚克氏钢针固定。二个切口分别放置引流,缝合切口。

1.4.3 术后处置 留置导尿,术髋外展30°位人字形石膏固定6周。术后6周鼓励患儿活动术髋;术后6-8周拆除石膏,强化功能锻炼;术后3-4个月酌情允许负重;术后6个月以上可取出内固定并复查骨盆正位X线。

1.5 结果测量

术后的临床功能和影像学指标评价采用改良的Trevor评分系统^[1]。这个系统的最大评分是20分,最小评分是5分。评分18-20分为优秀,15-17分为良好,12-14分为一般,小于12分为差。对患者进行测量、评分的医生并未参与手术,同时由同

一人对诊断时、术后即刻以及最终复查时的影像学资料进行评估。术前的影像学资料显示了股骨头移位程度和髋臼指数。所有患儿髋脱位手术后即刻复查X线以观察股骨头的复位程度、髂骨截骨的位置以及股骨截骨的位置。最终的随访影像学资料用于测量髋臼指数和CE角。股骨头坏死的影像学证据根据Kalamachi和MacEwen的评分系统进行测定^[12]:1级=变化影响到了骨化中心;2级=外侧的生长损害;3级=中心的生长损害;4级=股骨头的全部损害。临床上测量双下肢长度采用从髌前上棘到内踝的方法,考虑到测量方法的变异性和不精确性,我们认为双下肢长度差距小于1 cm则可认为双下肢等长。

1.6 统计学分析

统计分析使用SPSS 19.0软件,实验数据经过Kolmogorov-Smirnov单样本检验和散点图检验不符合正态分布,因而传统手术组和模拟手术组改良Trevor评分上的差异采用Mann-Whitney U检验进行分析。检验水准定为0.05。

2 结果

我们观察到模拟手术组儿童(18.2 ± 2.2)的平均改良Trevor评分高于模拟手术组儿童(15.9 ± 2.5),差异有统计学意义($P < 0.05$)。(表1)。

随访结束时,模拟手术组中8髋(67%)评分为优秀,3髋(25%)评分为良好,1髋(8%)评分为一般。传统手术组中,5髋(38%)评分为优秀,5髋(38%)评分为良好,3髋(23%)评分为一般。

模拟手术组髋臼指数明显下降,从术前平均为38.7(范围29-48)下降到18.8(范围14-27)。平均中心边缘角为24.3(范围15-38)。传统手术组髋臼指数从术前平均39.2(范围26-53)下降到19.4(范围14-36),平均中心边缘角为27.3(范围13-37)。传统手术组和模拟手术组术前髋臼指数差异无统计学意义

($P>0.05$)；传统手术组和模拟手术组术后髋臼指数差异无统计学意义($P>0.05$)。术后两组中心边缘角差异无统计学意义($P>0.05$)。(表2)。

传统手术组中3例患儿出现股骨头坏死(3/10),模拟手术组未出现股骨头坏死病例,传统手术组儿童出现股骨头坏死的

概率显著高于模拟手术组儿童。

在我们的研究中没有神经、血管损伤或深部伤口感染的病例。随访结束时,所有患儿的双下肢长度相等,行走时均无明显跛行。1例患儿在拆除石膏后3周由于外伤导致股骨干骨折,骨折经钢板固定,愈合良好,未出现并发症。

表1 患者随访时间及术后 Trevor 评分

Table 1 The patient's follow-up and postoperative Trevor score

Parameters	Simulated operation group	Traditional operation group	P value
Follow-up time / month	23.8± 3.99	24.5± 3.11	-
Trevor score /(°)	18.2± 2.2	15.9± 2.5	0.039

表2 患者术前、术后髋臼指数和中心边缘角的变化

Table 2 Changes of acetabular index and center-edge angle before and after operation in patients

Parameters	Simulated operation group		Traditional operation group	
	Preoperative	Postoperative	Preoperative	Postoperative
Acetabular index	38.7(29-48)	18.8(14-27)	39.2(26-53)	19.4(14-36)
Center edge angle		24.3(15-38)		27.3(13-37)

3 讨论

大龄儿童 DDH 的治疗是一项全球性的挑战。大龄 DDH 患儿的髋关节位移严重,髋臼变形明显,股骨前倾角增加,颈干角增大,给手术带来很多困难。通过查阅文献和经验表明一期手术包括切开复位、股骨短缩截骨、骨盆三联截骨术可以取得满意的效果,甚至可以达到大龄儿童髋关节功能的重建^[3,5,13,14]。多数专家认为手术是最佳的治疗方法,但患儿年龄越大手术的疗效也越差^[5,15]。Ashley 等人^[15],Kliscic 等人^[14],和 Galpin 等人^[16]的文章表明髋关节切开复位合并股骨短缩截骨+骨盆三联截骨的手术方式可以取得令人满意的效果。大多数研究都包含多种治疗形式,因而很难单独判定某一特定因素对治疗效果的影响^[18]。

DDH 是最常见的儿童骨科畸形之一,常导致髋关节炎的发生,并最终发展为需要全髋关节置换手术。对于外科医生来说,大龄 DDH 患儿手术方式的选择主要依靠髋臼以及股骨的畸形程度。髋臼指数和股骨前倾角的大小与髋关节的稳定性密切相关^[19],并且髋臼角还与髋部的疼痛和骨关节炎病相关^[20]。因此,术前精确的评估髋臼角和股骨前倾角对于 DDH 患儿来说至关重要,同时可以有效的避免术后并发症的发生。对于 7-16 岁大龄 DDH 患儿,手术治疗是必要,手术复位可以改善髋关节功能以及继发畸形,提高生活质量,并为日后人工髋臼及股骨头的置换提供了前期有利条件。

对 DDH 患儿实施骨盆三联截骨术,恢复其正常的髋臼角是至关重要的。髋臼角增大会导致髋关节不稳定性增加,最终可能导致髋关节的疼痛或骨关节炎病^[20-22]。通过术前模拟手术,我们可以精确的确定术中股骨截骨的位置、需要旋转的角度及骨盆截骨的位置,术中按照模拟手术的结果进行操作,具有精确、客观、可重复的优势,可以减少不同医生由于经验差异导致的截骨差异。因此我们认为术前基于患儿的三维 CT 进行模拟手术,为患儿制定个体化治疗方案,可有效纠正改变的髋臼角,从

而避免术中及术后并发症的发生。

在我们的研究中(图2和图3),模拟手术组患儿10例(12髋),传统手术组患儿10例(13髋)。结果表明模拟手术组髋脱位患儿疗效优于传统手术组的患儿。我们得到的结果和其它文章的结论相似^[17,23]。对于大龄 DDH 患儿,髋脱位严重且大多存在髋臼变形,所需要截骨的位置不尽相同,单纯依靠经验性手术治疗疗效一般。模拟手术可在术前寻找最佳截骨位置,为不同患者提供个体化治疗方案,可有效改善患儿预后。

股骨头坏死是 DDH 患儿手术以后最严重的并发症^[24]。由于大龄 DDH 患儿长期负重行走,股骨头上移,关节囊被拉长,肌肉和关节囊黏连,髋关节周围的软组织存在严重的挛缩。我们在术中也发现股骨头过高难以复位,即使勉强复位,股骨头对髋臼的压力也很高,会影响股骨头对营养物质的吸收,因此股骨缩短截骨十分必要。在我们的研究中,股骨头坏死的整体发生率是12%,比其它文章股骨头坏死的发生率稍低^[17,25]。但模拟手术组中未出现股骨头坏死发生病例,说明模拟手术可有效测定 DDH 患儿股骨需要短缩的长度,减少术后并发症的发生。

我们的研究存在以下局限性。第一,临床资料来自于回顾性分析,目前还不知道最终的随访结果,可以为将来的前瞻性研究提供参考依据。第二,与超声或者磁共振检查相比,三维重建 CT 检查有一定的辐射,可能会对患儿的生长发育造成影响。第三,随访的时间为16个月到30个月,远期临床疗效还不得而知。第四,两组的病例数较少,待模拟手术大量开展后可以得到更加有说服力的证据。第五,两组患儿的 Trevor 评分均存在优秀、良好、一般,表明模拟手术虽然可以有效改善患儿预后,但对于一些复杂以及髋部严重变形患者的治疗效果有限。

通过本研究我们发现,大龄 DDH 患儿术前模拟手术,可以达到术中精确截骨及旋转角度,相较于传统手术组,患者术后评价结果更好,术后并发症更少。由此,我们认为术前进行模拟手术,可以改善大龄 DDH 患儿预后,疗效优良,能达到个体化治疗水平。

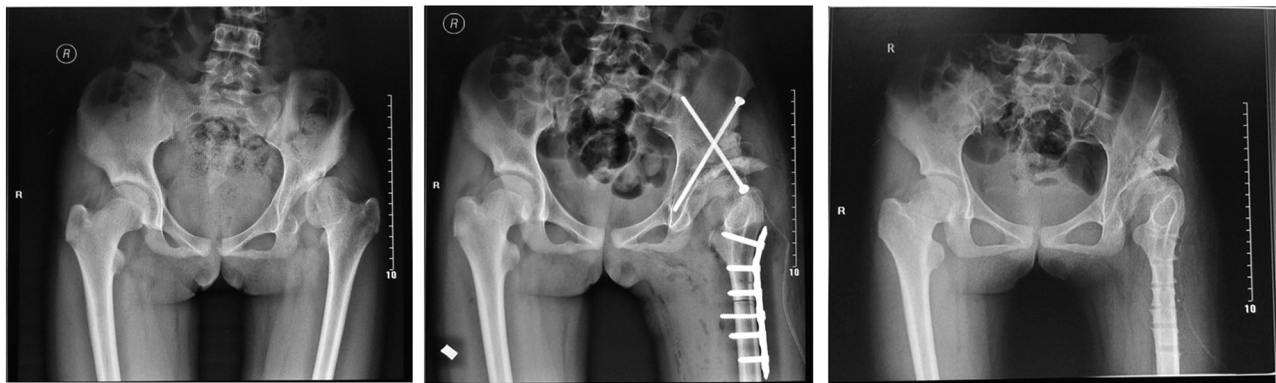


图4 12岁单侧发育性髋脱位女孩术前及术后X线。骨盆三联截骨、股骨缩短及截骨

Fig.4 Preoperative and postoperative X ray in 12 year old girl with unilateral developmental dislocation of hips. Pelvic triple osteotomy, shortening of femur, and osteotomy



图5 12岁单侧发育性髋脱位女孩拆除内固定后功能照。

Fig.5 A 12 year old girl with unilateral developmental dislocation of the hip underwent removal of the internal fixation

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