·临床研究·

个性化数字模拟辅助髋臼假体精准植入在 Crowe Ⅰ和Ⅱ型髋关节发育不良中的应用

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【摘要】　目的：探讨采用个性化数字模拟辅助髋臼假体精准植入在髋关节发育不良应用的疗效。**方法**：自 2017 年 2 月至 2019 年 7 月收治的 11 例（12 髋）髋关节发育不良行全髋关节置换术患者，男 4 例（5 髋），女 7 例（7 髋），年龄 27~61（46.64±12.93）岁；Crowe 分型Ⅰ型 8 髋，Ⅱ型 4 髋。将术前 CT 薄层扫描导入 Mimics 10.01 软件，通过术前模拟选择合适髋臼假体尺寸及安放角度，并了解髋臼骨量缺损情况，决定术中是否需要结构植骨，测量患者术前后的双下肢长度、髋臼假体前倾角、外展角、髋臼旋转中心高度、髋关节中心水平距离，观察术后脱位、植骨愈合情况及臼杯松动情况，并采用髋关节 Harris 评分评价关节功能。**结果**：所有患者获得随访，时间 18~30（23.45±3.70）个月，术后未发生假体脱位、松动、植骨均愈合。1 例因术中坐骨神经牵拉出现支配区域麻木，给予营养神经药物治疗于术后 1 个月恢复。双下肢长度差由术前（31.73±5.98）mm 下降至术后 3 个月的（4.73±1.90）mm（t=15.268，P<0.01）。术后臼杯髋臼前倾角（17.45±3.62）°、外展角（40.10±2.30）°。所有病例外展角及前倾角均位于 Lewinnek 安全范围内，术后髋关节旋转中心高度（20.64±2.58）mm，术后髋关节水平内移距离（33.46±3.61）mm。Harris 评分由术前（45.36±2.34）分提高至术后 3 个月（91.27±2.37）分（P<0.05）。**结论**：髋关节发育不良患者通过术前个性化数字模拟重建髋臼，可以更好的了解髋臼缺损情况，有助于评估髋臼假体的大小、安放角度及是否需要结构植骨，可获得满意的临床疗效。

【关键词】　模拟数字转换；　髋臼成形术；　髋关节发育不良
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DOI：10.12200/j.issn.1003-0034.2022.07.002　　开放科学（资源服务）标识码（OSID）：

Application of personalized digital analog assisted acetabular prosthesis precise implantation in Crowe type Ⅰ and Ⅱ hip dysplasia　*CHEN Jing-xiang, YU Zhuan-yi, CHENG Qiu-xin, FU Mei-qing, SHI Bai-na, YANG Jun, ZHOU Jiang-jun, and ZHAO Min. Department of Orthopaedics, 908 Hospital of the Chinese People's Liberation Army, Yingtan* 335000, *Jiangxi, China*

ABSTRACT　**Objective**: To explore the effect of personalized digital analog assisted acetabular prosthesis precise implantation in hip dysplasia. **Methods**: From February 2017 to July 2019, 11 patients (12 hips) with hip dysplasia underwent total hip arthroplasty, including 4 males (5 hips) and 7 females (7 hips), aged from 27 to 61 years old, with an average of (46.64±12.93) years old; Crowe classification: 8 hips in type Ⅰ and 4 hips in type Ⅱ. The preoperative thin-layer CT scan was imported into Mimics 10.01 software. The appropriate size and placement angle of acetabular prosthesis were selected through preoperative simulation, and the acetabular bone defect was understood to determine whether structural bone grafting was needed during the operation. The length of both lower limbs, the anteversion angle of acetabular prosthesis, the abduction angle, the height of acetabular rotation center and the horizontal distance of hip joint center before and after the operation were measured, and the postoperative dislocation, bone graft healing and acetabular cup loosening were observed. The hip Harris score was used to evaluate the joint function. **Results**: All patients were followed up for 18 to 30 months with an average of (23.45±3.70) months. There was no prosthesis dislocation, loosening and bone graft healing after operation. One case had numbness in the innervation area due to the traction of sciatic nerve during operation, and was treated with neurotrophic drugs and recovered one month after operation. The length difference of both lower limbs decreased from (31.73±5.98) mm before operation to (4.73±1.90) mm 3 months after operation (t=15.268, P<0.01). The anteversion angle of acetabular cup and acetabulum was (17.45±3.62)°and abduction angle was (40.10 ± 2.30)° after operation. In all cases, the abduction angle and anteversion angle were within the safe range of Lewinek. The height of hip rotation center was (20.64±2.58) mm and the horizontal inward displacement of hip

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was (33.46±3.61) mm. Harris score increased from (45.36±2.34) before operation to (91.27±2.37) 3 months after operation (P<0.05). **Conclusion**: Through preoperative personalized digital analog reconstruction of acetabulum in patients with hip dysplasia, we can better understand the acetabular defect, help to evaluate the size and placement angle of acetabular prosthesis and whether structural bone grafting is needed, and obtain satisfactory clinical curative effect.

KEYWORDS　Analog-digital conversion;　Acetabuloplasty;　Developmental dysplasia of hip

髋关节发育不良(developmental dysplasia of hip, DDH)是骨科临床常见病、多发病之一,晚期常常继发骨关节炎导致患者疼痛及功能障碍，人工全髋关节置换是后期改善功能和缓解疼痛最有效的方式。这类患者由于长期脱位,髋臼小且浅、臼壁薄、骨量少,骨性正常解剖标志难以辨认,给术者术中重建髋臼带来非常大的困难。而髋臼假体的安放位置以及确保良好的髋臼覆盖率直接影响人工全髋关节置换术后脱位率、松动率的高低以及假体使用寿命。有学者[1]提出,臼杯的理想位置应该是外展角(40±10)°、前倾角(15±10)°,在该范围内人工髋关节脱位率明显下降;DDH 全髋关节置换术后翻修最常见的原因就是臼杯无菌性松动[2],臼杯无菌性松动是因为髋臼假体未获得良好的初始稳定性，而将臼杯安放在越接近真臼位置并且获得良好的臼杯覆盖率是获得初次稳定的关键[3]。

计算机辅助技术在骨科器械设计、材料及手术模拟等方面成功应用,技术应用成熟[4-5],徐海军等[5]采用 Mimics 模拟高位脱位髋臼的重建,个体化精确术前设计,取得满意的臼杯位置及覆盖率,避免髂腰肌撞击等问题的发生。为了提高髋关节发育不良髋臼假体植入准确率及手术效率,笔者于 2017 年 2 月至 2019 年 7 月收治 DDH 患者 11 例，应用 Mimics 10.0 软件术前模拟确定髋臼假体尺寸及安放角度,并了解髋臼骨量缺损情况，决定术中是否需要结构植骨，获得了满意髋臼假体位置及良好的臼杯覆盖率,现报告如下。

1　资料与方法

1.1　一般资料

本组 11 例(12 髋),男 4 例(5 髋),女 7 例(7 髋),年龄 27~61 (46.64±12.93)岁。Crowe 等[6]分型Ⅰ型 8 髋,Ⅱ型 4 髋。患者术前均行 X 线、三维 CT 检查,明确髋关节脱位程度、髋臼骨量缺损情况及质量等情况。

1.2　重建术前 CT 模拟手术

1.2.1　影像学资料收集　硬件设备:美国 GE 公司 64 排螺旋 CT (LightSpeed VCT 64),Thinkpad T440P (I3,4 G,512 GB,HD Graphics 4 600/192 MB)。软件:Win7 64 位旗舰版,Mimics 10.0(Materialise 公司,比利时),Solidworks 2011 SP0.0。对患者进行骨盆(含患髋关节及患髋股骨上段)扫描,扫描参数为层厚 0.625 mm,120 kV,240 mA。

1.2.2　术前三维 CT 重建　将术前 CT 图像数据以 Dicom 格式保存并导入 Mimics 10.0 软件中。Thresholding 建立骨窗 Mask,生成骨盆 3D 模型及患髋股骨近端模型;使用“Cut with Polyplane”功能于股骨小转子近 1 cm 处垂直于股骨颈方向建立 Polyplane(CP1),进行股骨颈截骨,“Split”功能将股骨近端分成股骨头及股骨近端两部分,“Rotate”功能将截下的股骨头旋转至于髋臼缺损部，制作模拟螺钉固定骨块于髋臼侧；根据 CT 测量结果于 Solidworks 2011 SP0.0 中建立直径不同的 2~3 个半球形髋臼模型,STL 格式保存后导入 Mimics 软件中,通过移动、旋转功能放入截骨后髋臼中,保留合适大小髋臼,与髋臼进行 Boolean 运算,得出最后髋臼植入模型,最后确认植入髋臼假体大小、前倾角及外展角,及髋臼假体与髋臼的接触面积，计算覆盖率达到 90%以上为合格。见图 1。

1.3　手术方法

常规全身麻醉,侧卧位,髋关节后外侧入路,暴露股骨颈、小转子及股骨颈,注意保护坐骨神经,充分松解髋臼及小转子侧，按照术前手术模拟角度进行截骨,先截股骨颈,取出股骨头,360°松解髋臼,显露真臼,将股骨头反向置入真臼上方,螺钉固定,再根据术前计划骨块尺寸截髋臼侧,锉臼,置入合适臼杯,股骨侧假体置入同常规操作,C 形臂 X 线透视确认假体位置无误后逐层缝合。

1.4　术后处理

术后 48 h 内拔除引流管,常规使用抗生素 24 h,术中静滴并术后关节腔注射氨甲环酸,术后低分子肝素钠抗凝，麻醉清醒后开始行髋部外展肌等肌力训练,术后 48 h 助行器辅助站立。

1.5　观察项目与方法

术后依据文献[7]介绍的方法测量髋臼前倾角、外展角,髋臼旋转中心高度、髋臼中心水平距离、双下肢长度。观察记录脱位情况、植骨愈合情况、臼杯松动情况。采用髋关节 Harris[8]评分通过从疼痛、功能、活动范围、畸形 4 个方面评价髋关节功能。

1.6　统计学处理

应用 SPSS 13.0 软件进行统计学分析。定量资料用均数±标准差($\bar{x}\pm s$)表示,采用配对样本 t 检验。以 P<0.05 为差异有统计学意义。

2　结果

所有患者获得随访，时间 18~30(23.45±3.70)个月。术后未发生假体脱位、松动、植骨均愈合，1 例因术中坐骨神经牵拉出现支配区域麻木，给予营养神经药物治疗于术后 1 个月恢复。双下肢长度差由术前(31.73±5.98) mm 下降至术后 3 个月的(4.73±1.90) mm(t=15.268，P<0.01)。术后臼杯髋臼前倾角(17.45±3.62)°、外展角(40.10±2.30)°，外展角及前倾角均位于 Lewinnek 安全范围内，术后髋关节旋转中心高度(20.64±2.58) mm，术后髋关节水平内移距离(33.46±3.61) mm。Harris 评分由术前(45.36±2.34)分提高至术后 3 个月的(91.27±2.37)分，术前后比较差异有统计学意义(P<0.05)，见表 1。典型病例见图 2。

3　讨论

髋关节发育不良晚期继发关节炎导致患者疼痛、功能障碍常需要手术治疗，全髋关节置换术是最好的选择，由于此类患者多为青壮年，患者活动量大、功能要求高、预期寿命长，所以就需要重建一个

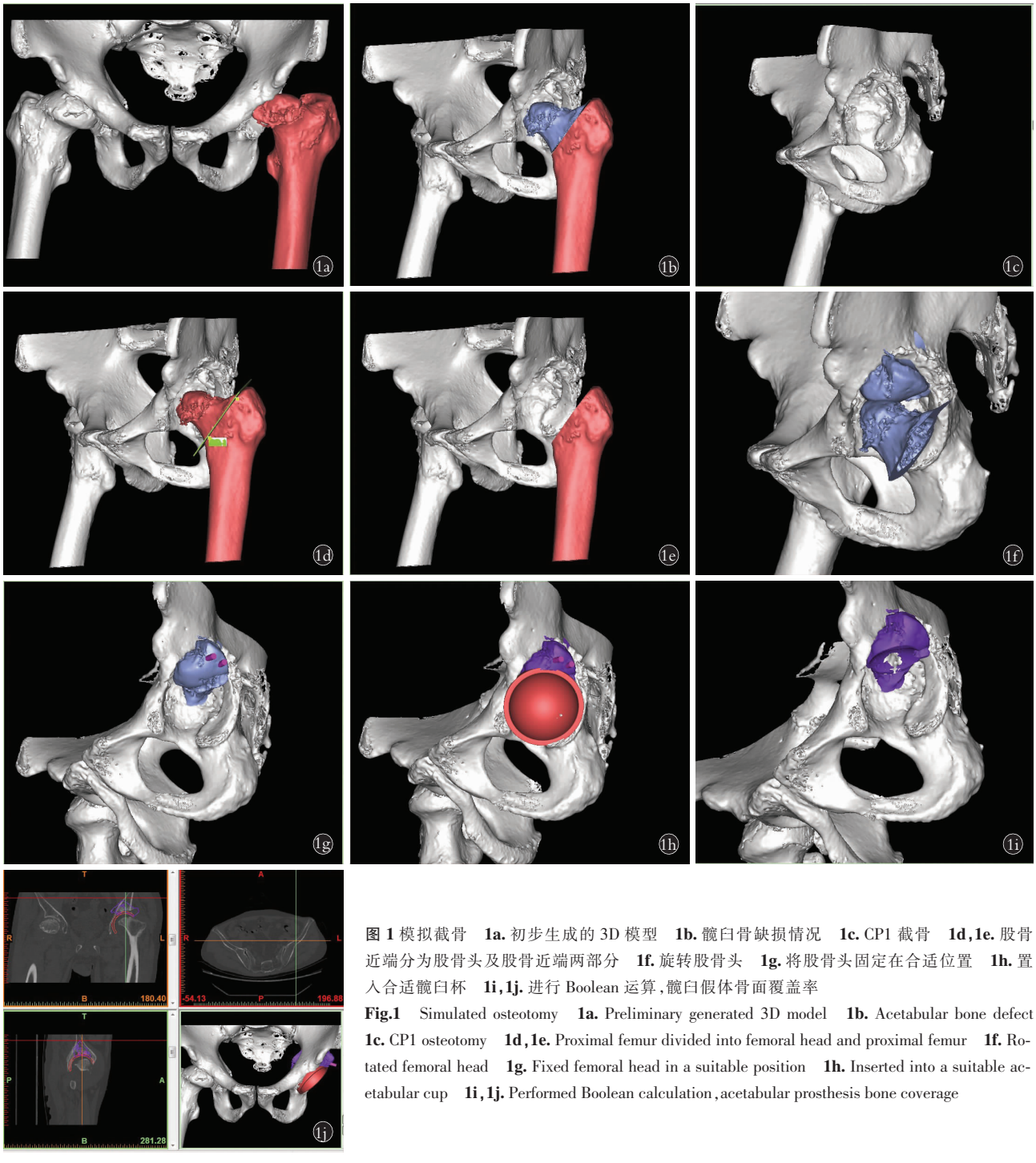

图 1 模拟截骨　**1a.** 初步生成的 3D 模型　**1b.** 髋臼骨缺损情况　**1c.** CP1 截骨　**1d，1e.** 股骨近端分为股骨头及股骨近端两部分　**1f.** 旋转股骨头　**1g.** 将股骨头固定在合适位置　**1h.** 置入合适髋臼杯　**1i，1j.** 进行 Boolean 运算，髋臼假体骨面覆盖率

Fig.1　Simulated osteotomy　**1a.** Preliminary generated 3D model　**1b.** Acetabular bone defect　**1c.** CP1 osteotomy　**1d，1e.** Proximal femur divided into femoral head and proximal femur　**1f.** Rotated femoral head　**1g.** Fixed femoral head in a suitable position　**1h.** Inserted into a suitable acetabular cup　**1i，1j.** Performed Boolean calculation，acetabular prosthesis bone coverage

接近解剖位置的人工关节。髋臼假体位置如何安放，目前多数学者公认的就是安装于真臼位置[8-9]，因为若将髋臼安放于假臼位置术后不仅无法恢复肢体长度，使得术后可能产生跛行、关节撞击，并因旋转中心外移等造成髋关节应力增加，加速假体的磨损缩短使用寿命，并且安放于真臼位置相对于高旋转中心放置技术[10]及髋臼内陷技术[3]等方法保留更多骨量，更利于年轻患者后期翻修。但 DDH 患者由于髋臼小且浅、臼壁薄、骨量少，且髋关节周围存在大量瘢痕组织，解剖标志不清晰，导致术中锉臼定位不准确，这给术者术中放置髋臼假体带来非常大的困难，所以行初次 THA 时，由于解剖标志不清楚、定位不准确造成臼杯安装位置不良的风险较高。因此，采用传统的锉臼定位方法，需要很高的手术技巧和临床经验，但由于这类病例相对较少，想通过大量病例来积累手术技巧相对比较困难。

术前三维分析有助于术前充分了解髋臼的形态特征、评估骨质缺损程度，Zeng 等[11]对伴有高脱的先天性髋关节脱位患者进行术前三维模拟手术，但由于操作技术高，广泛推广有难度。Sugano[12]采用术中髋臼 CAD 设备提高臼杯植入精准度，但设备昂贵，术中操作相对繁琐，推广受到影响。Zhang 等[13]采用定位导向导板辅助技术给先天性髋关节脱位患者进行术中髋臼磨锉定位，定位准确，术中操作方便，但由于导向模板的设计需要 CAD 软件操作技巧及经验，制作设计难度相对较高。邬培慧等[14]设计了一种自主研发的计算机辅助设计软件/快速成形/术中定位器(CAD/RP/G)系统模拟臼杯假体植入，采

表 1　髋关节发育不良 11 例患者手术前后 Harris 功能评分比较($\bar{x}\pm s$，分)

Tab.1　Comparison of Harris score of 11 patients with hip dysplasia before and after operation($\bar{x}\pm s$, score)

时间	疼痛	畸形	功能	活动范围	总分
术前	19.09±3.02	2.36±0.50	20.73±2.57	3.64±0.81	45.36±2.34
术后 3 个月	41.45±2.02	4.00±0.00	40.91±1.14	4.91±0.30	91.27±2.37
t 值	−23.162	−10.757	−30.668	−5.369	−45.721
P 值	<0.01	<0.01	<0.01	<0.01	<0.01

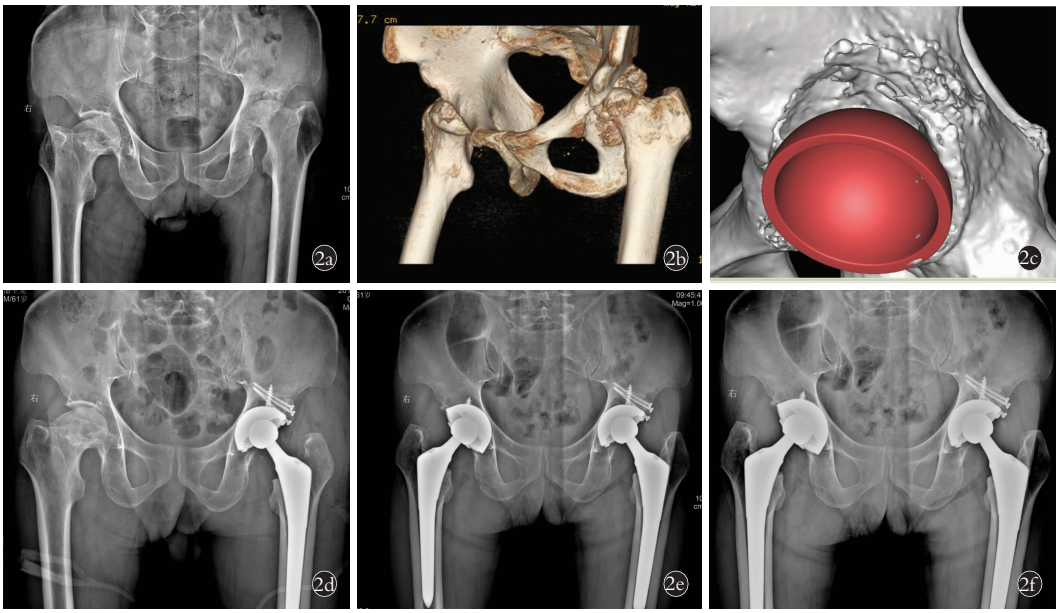

图 2　男，61 岁，左髋关节跛行 50 余年，右髋关节疼痛并活动困难 2 年余，诊断为左髋关节发育不良并股骨头坏死，右股骨头坏死　**2a.** 术前骨盆正位 X 线片　**2b.** 术前髋关节 CT 三维重建　**2c.** 模拟 58 mm 髋臼，髋臼顶与骨缺损顶距离约 2.8 cm　**2d.** 术后 3 d 骨盆正位 X 线片示假体置入　**2e.** 术后 6 个月骨盆正位 X 线片示假体位置良好　**2f.** 术后 2 年骨盆正位 X 线片示假体位置良好

Fig.2　A 61-year-old male patient with left hip claudication for more than 50 years, right hip pain and movement difficulties for more than 2 years, diagnosed as left hip dysplasia with femoral head necrosis and right femoral head necrosis　**2a.** Preoperative AP X-ray film of pelvis　**2b.** Preoperative CT three-dimensional reconstruction of hip joint　**2c.** Simulate the 58 mm acetabulum, and the distance between the acetabulum top and the bone defect top is about 2.8 cm　**2d.** Three days after operation, the pelvic X-ray showed the prosthesis placement　**2e.** Six months after operation, the positive X-ray film of pelvis showed that the position of prosthesis was good　**2f.** Two years after operation, the pelvic X-ray showed that the position of the prosthesis was good

用自主开发的 DLP 3D 打印机-光固化面成形技术(digital light processing, DLP) 将髋臼定位器爪尖与模型外口边缘匹配定位,指引髋臼磨锉方向,但由于定向杆操作占据一定空间,术中操作并不简单。

本研究术前均采用 Mimics 软件进行三维模拟,评估髋臼假体大小,选择合适大小髋臼假体,然后明确髋臼骨质缺损及髋臼覆盖率情况,操作相对简单,只需术前模拟测量简单数据,术中使用简单易行,推广使用相对容易。

髋臼不仅需要安放良好的位置,获得良好覆盖率是影响术后效果的重要因素之一,目前对于臼壁缺损的处理方法包括小臼杯、钛网、钽块、加强杯以及结构植骨等方法。小臼杯由于股骨头直径缩小较正常假体使用寿命更短且脱位率更高,钛网、钽块及加强杯等虽然可以填充髋臼缺损,但是由于费用较高。所以本研究对于臼壁缺损严重假体覆盖率不足的患者采用髋臼外上方结构植骨,有多数学者[15-16]采用本方法获得均获得满意的效果,但对于臼杯宿主骨最佳覆盖率尚无统一定论,多数学者认为臼杯宿主骨覆盖率应>70%。因为当结构植骨块承受负荷较大移植骨块可被再吸收,出现假体松动,为保证假体的稳定性,当臼壁骨缺损较大时,除了大块的结构性植骨,还应强化植骨块的内固定处理,提高骨融合的概率[17-18]。本研究采用自体股骨头外上方结构植骨术后骨愈合良好,未出现臼杯松动,但结构植骨病例数较少,缺乏大量的随访研究。

综上所述,髋关节发育不良患者通过术前个性化数字模拟重建髋臼,可以更好的了解髋臼缺损情况,有助于评估髋臼假体的大小、安放角度及是否需要结构植骨,获得满意的临床疗效。

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