Mimics软件在个体化全髋关节假体翻修中的应用**★

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Mimics software three-dimensional reconstruction for individual revision using total hip prosthesis

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Abstract

BACKGROUND: Acetabular bone defects in hip arthroplasty are often difficult to locate and quantify, and therefore the use of computer-aided design and computer-aided processing technology for preoperative preparation can reduce the difficulty and risk of acetabular reconstruction.

OBJECTIVE: To investigate the application and significance of Mimics software for individual revision of total hip prothesis.

METHODS: The hip CT scan image data of patients with total hip arthroplasty was input into Mimics software to reconstruct the three-dimensional hip joint model. The anteversion, valgus angle, neckshaft angle, femoral head diameter, acetabular wall thickness/diameter and loosening broken case of the hip prosthesis were measured; the range of acetabular bone defect was located and quantified. Meanwhile, through the simulation of the renovation, the range of bone and the implanted total hip prosthesis size were designed.

RESULTS AND CONCLUSION: Mimics three-dimensional window was used to precisey locate the broken prosthesis; the maximum longitudinal diameter of the debris was forecasted to 33.68 mm, the distance from the debris to the femoral head prosthesis was 48.93 mm, the distance from the debris to the acetabular component was 20.14 mm. The average threshold of acetabular selected 130.47 mm^2 viewable area was 339.98, the average threshold of 130.47 mm^2 viewable area in bone defect area was −481.25, and the defect area was 21.41 mm×21.38 mm. The bone defects were evaluated according to three-dimensional model assessment and classified: American Academy of Orthopaedic Surgeons classification type ⅠB, Gross classification type ⅡA, Engh classification type Ⅰ. Results confirm that Mimics software can optimize solutions and ways of hip arthroplasty and reduce complications and the risk of surgery.

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摘要

背景：人工髋关节翻修中髋臼骨质缺损常常是难以定位及定量的，因而利用计算机辅助设计与计算机辅助加工技术进行置换前准备可减少髋臼重建的难度及风险。

目的：探讨 Mimics 软件在个体化全髋关节假体翻修中的应用及意义。

方法：将全髋关节翻修患者髋关节 CT 扫描图像数据导入 Mimics 软件，重建髋关节三维模型。测量髋关节假体前倾角、外翻角、颈干角、股骨头直径、髋臼壁厚度/直径以及假体松动破碎情况，对髋臼骨质缺损范围进行定位以及定量，同时通过模拟翻修，设计植骨范围，拟植入全髋关节假体规格。

结果与结论：通过 Mimics 三维窗口，精确定位该破碎假体，碎片最大纵径预测 33.68 mm，距离股骨头假体距离 48.93 mm，距离髋臼假体 20.14 mm。髋臼选取 130.47 mm^2 可视区域平均阈值 339.98，骨质缺损区 130.47 mm^2 可视区域平均阈值 −481.25，缺损面积 21.41 mm×21.38 mm，根据三维模型评估骨质缺损并分类：AAOS 分类ⅠB 型，Gross 分类ⅡA 型，Engh 分类Ⅰ型。结果证实，在髋关节翻修中借助 Mimics 软件可优化置换方案及方式，减少并发症，降低置换风险。

关键词：髋关节翻修；Mimics；三维重建；人工假体；数字化骨科技术
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0 引言

人工髋关节翻修中髋臼骨质缺损常常是难以定位及定量的，在翻修中合理有效处理髋臼侧骨缺损是置换成功的最关键因素[1]。骨缺损常由炎症性骨溶解所致，使髋臼残余骨床的骨量少骨质差，成骨能力不良。

目前对于髋臼骨质缺损多采用颗粒植骨技术。许多研究证实单纯颗粒骨植骨治疗轻中度髋臼骨缺损简单、有效，早期随访效果较好[2-5]。但是轻度骨缺损时的翻修基本上与首次全髋置换相同，但伴有巨大骨缺损的髋臼重建具有巨大的挑战性和风险[4]。Barnett等[6]认为大部分髋臼骨缺损可使用较大型号非骨水泥假体或加松质颗粒植骨进行修复，对于影响假体稳定性的较大缺损，使用骨水泥假体臼+Cage+松质颗粒植骨的方法可获得良好效果。Loebbermann等[7]则使用认为对于节段型骨缺损，应当选用较稳固的钉板系统固定辅以颗粒骨植骨。事实上在

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自体骨移植病例中，植骨量过多势必造成取骨部位严重骨缺损，植骨量过少则可能由于骨吸收而导致植骨区域的变形甚至塌陷[8]。因此置换前对骨质缺损范围进行精确定位以及定量显得尤为必要。

人工髋关节翻修中髋臼骨质缺损常常是难以定位及定量的，因而利用计算机辅助设计与计算机辅助加工技术进行置换前准备可减少髋臼重建的难度及风险。

鉴于此，实验探讨Mimics软件在个体化全髋关节翻修的应用及意义。

1 对象和方法

设计：单一样本观察实验。

时间及地点：于2011-08在中山大学附属第六医院完成。

对象：选取2011-08中山大学附属第六医院骨科的1例47岁女性患者，诊断为全髋关节置换后髋臼假体破碎脱位并股骨假体松动。根据国务院《医疗机构管理条例》规定[9]，患者对测试知情同意。

主要仪器：SIEMENS Axiom Aristos TX数字X射线摄影系统购自德国西门子公司；Toshiba-aqullion 16层螺旋CT购自日本东芝公司。

方法：

影像数据采集：患者常规拍摄骨盆平片，可见左髋关节呈全髋关节置换后表现，髋臼假体脱位并破碎，股骨假体松动下沉，见图1。

Figure 1 Preoperative X-ray film of the pelvic
图 1 患者置换前骨盆 X 射线片

利用CT对该患者进行双侧髋关节断层扫描获得其Dicom医学数字图像通讯标准数据，共得到123张Dicom格式图像。扫描参数：扫描层厚为1 mm，120 kV，54 mA。

影像数据三维重建：将Dicom格式图像导出后输入Mimics10.01软件，根据所需重建对象的不同密度范围依次运用阈值选取技术(Thresholding)、三维区域增长技术(3D Region Growing)、三维实体(3D Object)重建所选取的实体结构区域的三维模型。其中在3D Region Growing步骤为了修补图像，每层图像经选择性编辑和补洞处理，去除冗余数据，平滑处理，最后经The Calculate 3D建立双侧髋关节三维几何模型。

三维几何模型的置换前设计与翻修模拟：以重建的双侧髋关节三维几何模型为基础，在Mimics 10.01软件中利用直线距离测量及三维空间测量工具进行两方面研究。第一方面，测量患侧髋关节假体前倾角、外翻角、颈干角、股骨头直径、髋臼壁厚度/直径以及假体松动破碎情况。第二方面，模拟翻修，评估髋臼骨质缺损情况，设计植骨范围，拟植入全髋关节假体位置。

主要观察指标：置换前置换后双侧髋臼直径、外翻角、颈干角、前倾角、股骨头冠状位直径、股骨距厚度、股骨头旋转中心与大转子顶点距离、髋臼骨缺损区平均阈值及范围等。

2 结果

2.1 数字化重建双侧髋关节三维几何模型的鉴定结果 通过应用Dicom医学数字图像通讯标准，基于CT数据的图像分割建模软件，将薄层CT横断面图像进行分割识别建立了双侧髋关节三维几何模型，立体感强，可多角度、多方向、多层次显示。见图2。

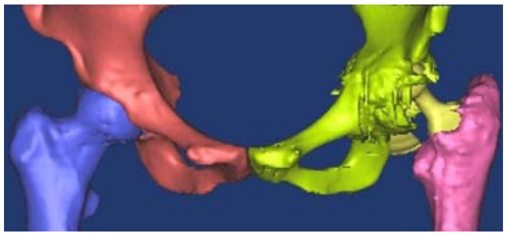
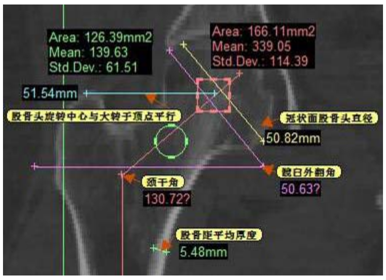
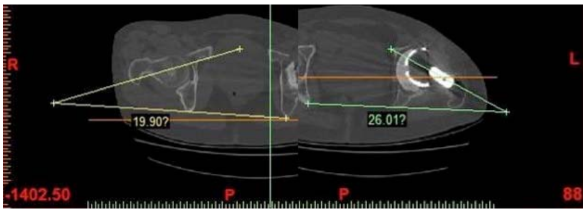


Figure 2 Three-dimensional model of the bilateral hips
图 2 双侧髋关节三维模型

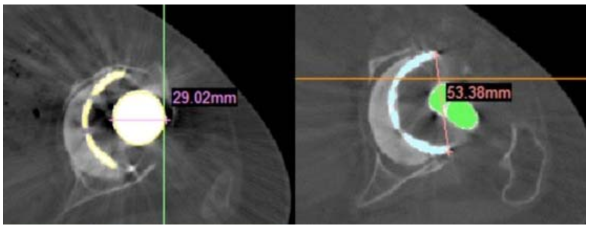
2.2 置换前测量髋关节各项指标 通过Mimics软件对模型的冠状位、横断位等三维窗口观察，选取最佳层面测量结果如下：健侧髋臼直径53.38 mm，外翻角50.63°，前倾角19.90°，颈干角130.72°，股骨头冠状位直径50.82 mm，选取166.11 mm^{2}可视区域平均阈值339.05，股骨近端皮质完整、连续，股骨距厚度5.48 mm，股骨头旋转中心与大转子顶点平行，相距51.54 mm，见图3a。患侧前倾角26.01°，水平面股骨头假体直径29.02 mm，髋臼假体直径53.38 mm，见图3b，c。



a: Contralateral acetabular diameter, valgus angle, neck shaft angle, coronal femoral head diameter, the thickness of the femur from the femoral head center of rotation and the greater trochanter vertex distance



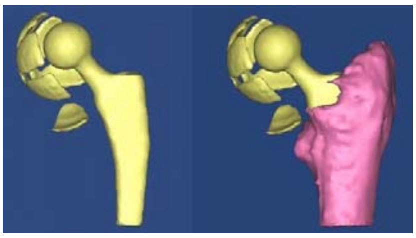
b: Contralateral anteversion and ipsilateral anteversion



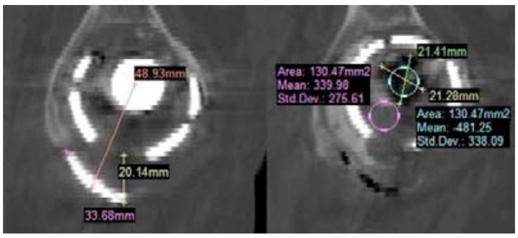
c: Horizontal diameter of the femoral head prosthesis and acetabular prosthesis

Figure 3 Measurement of the hip indexes
图 3 髋关节各项指标测量结果

2.3 置换前三维定位评估破碎髋臼假体及髋臼骨质缺损区域 见图4。



a: Three-dimensional geometry of the hip prosthesis model



b: Maximum longitudinal diameter of the debris, the distance from debris to the hip prosthesis and acetabular bone prothesisi, the average threshold of viewable area of the acetabular area and acetabular bone defect area and the defect area

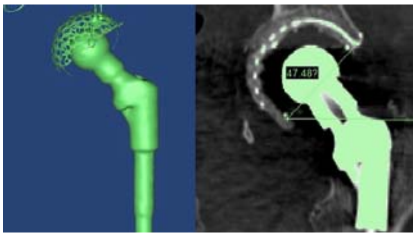
Figure 4 Three-dimensional model of hip prosthesis
图 4 髋关节假体三维几何模型

通过Mimics三维窗口，精确定位该破碎假体位于髋臼后下方，股骨颈内下方，见图4a。该碎片最大纵径预测33.68 mm，距离股骨头假体距离48.93 mm，距离髋臼假体20.14 mm。髋臼正常区域选取130.47 mm^{2}可视区域平均阈值339.98，骨质缺损区130.47 mm^{2}可视区域平均阈值−481.25，缺损面积21.41 mm×21.38 mm，根据三维模型评估骨质缺损并分类：AAOS分类ⅠB型，Gross分类ⅡA型，Engh分类Ⅰ型，见图4b。

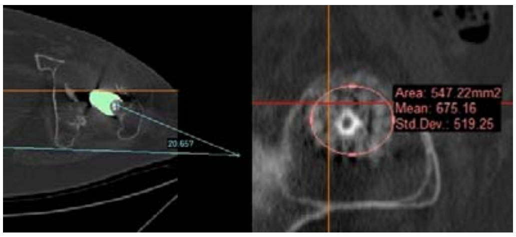
2.4 置换前模拟与置换体会 右髂前上棘取20 mm×20 mm×10 mm大小骨块打磨成骨颗粒后备用。取左髋关节前外侧入路，依次将松动髋臼、髋臼碎片以及黏附骨水泥的人工股骨头拆除，未造成骨质缺损或骨折。将骨颗粒填塞髋臼窝内上处的骨缺损，置入直径54 mm钛网并2枚螺钉固定，内侧面适量骨水泥涂抹后置入外径46 mm金属壳带多孔表面的非骨水泥型髋臼杯，适当扩髓后选用长度为210 mm骨水泥型股骨柄，置换后检查髋关节活动良好、松紧合适后关闭伤口。置换后复查X射线可见全髋假体在位，未见松动、断裂等情况，见图5。

Figure 5 Plain film of the pelvic after total hip arthroplasty
图 5 全髋假体置换后患者骨盆平片

2.5 全髋关节翻修后假体松动情况 见图6。



a: Three-dimensional model of the hip prosthesis and valgus angle of the acetabular bone after operation



b: The anteversion of the hip prosthesis and the recovery of the acetabular bone defect after operation

Figure 6 Indexes of the hip prosthesis after revision
图 6 翻修置换后假体各项指标

患者置换后1个月复查CT，根据前述方法重建髋关节三维模型。可见全髋假体在位，未见松动、断裂等情况，患侧髋臼外翻角为47.48°(图6a)，股骨假体前倾角20.65°，与健侧接近。原髋臼骨质缺损区可见均匀骨质填充，与周围骨质融合，选取547.22 mm^{2}可视区域平均阈值675.16。

2.6 三维模型、置换中测量及植入假体各参数比较 本文在对患侧髋关节假体前倾角、外翻角、颈干角、股骨头直径、髋臼壁厚度/直径以及假体松动破碎情况等进行测量的同时，重点评估髋臼骨质缺损情况，设计植骨范围，模拟翻修，拟植入全髋关节假体位置，见表1。

表1 三维模型、置换中测量及植入假体各参数比较
Table 1 Comparison of the parameters of three-dimensional (3D) reconstruction, measurement and implantation

Item	3D reconstruction	Measurement	Implantation
Acetabular			
Diameter (mm)	53.38	54	54
Range of bone defects (mm)	21.41×21.38	–	–
Fragment size (mm)	33.68×19.17	33.00×20.00	–
Lined size (mm)	45.30	–	46
Femoral head			
Diameter (mm)	29.02	28	28
Femoral neck			
Neck-shaft angle (°)	130.72	–	135
Femoral stem	–	–	210
Length (mm)			

3 讨论

利用计算机辅助设计与计算机辅助加工技术进行置换前准备可减少髋臼重建的难度及风险。髋臼重建的目的是恢复解剖学上的髋关节中心和构建髋臼周围的支持带以及使新的髋臼假体与髋臼骨充分接触并保持长期稳定性和耐久性，并使置换中形成的骨缺损降低到最低限度[10]。目前普遍认为髋臼重建需要符合以下原则[11]：①重建宽关节的正常生物力学性状和髋关节旋转中心。②重建髋臼的连续性。③确保人工臼具有足够的骨性覆盖。④确保移植骨质具有坚强的固定。⑤确保假体良好的初始和远期固定。

此病例中，髋臼骨缺损区域置换前可视区域平均阈值−481.25，缺损面积21.41 mm×21.38 mm，置换前即根据三维模型评估骨质缺损并分类：AAOS分类ⅠB型，Gross分类为ⅡA型，Engh分类为Ⅰ型，较精确的评估了骨缺损的范围及髂骨取骨量，置换后1个月再次利用Mimics软件三维重建患髋以评估置换效果时发现，原髋臼骨质缺损区可见均匀骨质填充，与周围骨质融合，选取547.22 mm^{2}可视区域平均阈值675.16。

总之，包括髋臼重建在内的全髋关节翻修中是一个具有挑战性的工作，良好的疗效除了需要术者对于复杂髋臼骨缺损的经验和熟悉程度，更需要术者在置换前对各项髋关节基本参数、髋臼骨质缺损情况及植骨量有精确的估算。因此，通过置换前对翻修髋关节进行各临床参数测量以及假体规格的研究有助于医生更清楚了解不同患者特异性解剖结构，制定更详细、合理的个体化置换置换方案，优化置换方式，减少并发症，降低置换风险[12]。

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伦理要求：根据国务院《医疗机构管理条例》规定，患者对测试知情同意并签署知情同意书。

文章概要：

本文特点：人工髋关节翻修中髋臼骨质缺损常常是难以定位及定量的，而在翻修中合理有效处理髋臼侧骨缺损是置换成功的最关键因素。

关键信息：利用 Mimics 软件快速构建人体三维几何模型，进行置换前设计和反复置换模拟是数字化骨科和导航置换的基础，具有极高的研究价值和应用前景。