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CT 与 MRI 扫描三维重建在四肢骨关节隐匿性骨折诊断中的应用 *

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摘要 目的:探讨电子计算机断层扫描(Computed Tomography, CT)与磁共振成像(Magnetic resonance imaging, MRI)扫描三维重建在四肢骨关节隐匿性骨折诊断中的应用。**方法:**2016 年 9 月到 2019 年 10 月选择在本院诊治的下拟诊为四肢骨关节隐匿性骨折 118 例,所有患者都给予 CT 与 MRI 扫描三维重建诊断,记录影像学特征与判断诊断价值。**结果:**在 118 例患者中,最终确诊为四肢骨关节隐匿性骨折 98 例,无骨折 20 例,其中腕关节骨折 34 例,踝关节骨折 22 例,膝关节骨折 15 例,肘关节骨折 15 例,肩关节骨折 8 例,髋关节骨折 4 例。在 98 例确诊的四肢骨关节隐匿性骨折中, MRI 三维重建显示双边征、骨质破坏、充气征、软组织影等比例显著都高于 CT ($P<0.05$)。CT 与 MRI 三维重建诊断四肢骨关节隐匿性骨折的敏感性为 89.8 % 和 99.0 %, 特异性为 95.0 % 和 100.0 %, 误诊率分别为 9.3 % 和 0.8 %, MRI 三维重建诊断的敏感性高于 CT, 漏诊率低于 CT。**结论:**CT 与 MRI 扫描三维重建在四肢骨关节隐匿性骨折诊断中的应用都有很好的价值,特别是 MRI 三维重建能清晰显示骨折特征,具有更高的诊断敏感性,能减少漏诊率,可作为四肢骨关节隐匿性骨折的首选检查方法。

关键词:CT; 磁共振成像; 三维重建; 四肢骨关节; 隐匿性骨折

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Application of CT and MRI Scan Three-dimensional Reconstruction in the Diagnosis of Occult Fractures of Extremities*

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ABSTRACT Objective: To investigate the application of CT and magnetic resonance imaging (MRI) three-dimensional reconstruction in the diagnosis of occult fractures of the extremities. **Methods:** From September 2016 to October 2019, 118 patients with occult fractures of the extremities were selected as the study subjects. All patients were underwent CT and MRI scan three-dimensional reconstruction diagnosis, recorded the imaging features and were to determine the diagnostic values. **Results:** There were 98 patients were diagnosed as occult fractures of extremities in the 118 patients that included 34 patients with wrist fractures, 22 patients with ankle fractures, 15 patients with knee fractures, and 15 patients with elbow fractures, 8 patients with shoulder fracture and 4 patients with hip fracture. In the 98 patients of occult fractures of the extremities, MRI three-dimensional reconstruction showed that the bilateral signs, bone destruction, aeration sign, soft tissue shadows were significantly higher than CT ($P<0.05$). The sensitivity of CT and MRI three-dimensional reconstruction in the diagnosis of occult fractures of the extremities were 89.8 % and 99.0 %, the sensitivity were 95.0 % and 100.0 %, and the misdiagnosis rates were 9.3 % and 0.8 %, respectively. The sensitivity of MRI three-dimensional reconstruction diagnosis were higher than the CT, the rates of missed diagnosis were lower than that of CT. **Conclusion:** Three-dimensional reconstruction of CT and MRI scans are of great values in the diagnosis of occult fractures of the extremities. In particular, MRI three-dimensional reconstruction can clearly show the fracture characteristics, have higher diagnostic sensitivity, and can reduce the rate of missed diagnosis that can be used as the first choice for occult fractures of the extremities.

Key words: CT; Magnetic resonance imaging; Three-dimensional reconstruction; Extremities; Occult fracture

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前言

隐匿性骨折指是一种无明显临床症状的微型骨折^[1,2]。四肢骨关节隐匿性骨折是主要类型,主要发生于骨髓形态 / 解剖结

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构复杂、位置隐蔽的部位,比如踝关节、腕关节等,在外伤、交通事故等外力作用下易造成骨折^[9]。我国现阶段人口结构老龄化趋势日渐加重,使得四肢骨关节隐匿性骨折在临床上发病率逐渐增加,对该病的早期鉴别,决定了临床治疗方案的选择及后续治疗的方案^[4,5]。临床上多采用X线进行骨折的诊断,但是其分辨率比较低以及受到邻近组织投影重叠的干扰,仅能够对明显的骨折进行影像学显示,很难检出隐匿性骨折,并且容易出现误诊和漏诊的情况,从而影响患者的后续治疗^[6,7]。电子计算机断层扫描(Computed Tomography, CT)具有扫描时间短、图像清晰等优点,能够直观呈现骨和关节的三维立体结构,避免了被掩盖的缺点,能够早期发现与定位隐匿性骨折^[8-10]。磁共振成像(Magnetic resonance imaging, MRI)具有较高的组织分辨率外,还可进行多方位成像,可对肌肉、韧带、骨骼进行良好的区分与显示^[11]。其能够通过断层切面对四肢进行扫描,能了解骨折类型与周围软组织的损伤情况,还可以准确判断患者骨折的部位^[12]。不过当前MRI诊断以二维成像为主,缺乏三维成像的信息,对于一些小结构隐匿性骨折的诊断准确率还不高。MRI扫描三维重建可通过多个序列对组织器官进行立体成像,可清晰显示四肢关节骨折及周围软组织变化^[13,14]。本文具体探讨了CT与MRI扫描三维重建在四肢骨关节隐匿性骨折诊断中的应用价值,以促进四肢骨关节隐匿性骨折的早期检出。现总结报道如下。

1 资料与方法

1.1 研究对象

2016年9月到2019年10月选择在本院诊治的下拟诊为四肢骨关节隐匿性骨折118例,纳入标准:有明确外伤史,入院时受伤部位出现关节软组织疼痛肿胀,活动受限;常规X线检查未发现明确骨折线但高度怀疑者;无患侧肢体腕关节骨折病史;临床与影像学资料完整;患者年龄20-70岁;患者及家属被告知相关注意事项,同意并签署知情同意书;医院伦理委员会知情同意本研究。排除标准:病理性骨折;不愿意接受CT与MRI检查者;临床资料不完整者;中途转院或停止接受观察的患者;合并精神分裂症等精神类疾病者。

其中男60例,女58例;年龄最小26岁,最大69岁,平均年龄 54.91 ± 4.19 岁;平均体重指数 22.49 ± 1.22 kg/m²;致伤原因:跌倒及扭伤35例,硬物砸伤25例,车祸伤58例;发病到诊断时间最少3h,最长48h,平均为 16.29 ± 2.19 h。

1.2 影像学诊断方法

1.2.1 CT诊断 采用西门子SOMATOM Definition 64排螺旋CT机,患者取仰卧位,足先进,双手向头侧平伸,吸气后屏气扫描扫描参数:矩阵 256×256 ,管电压120 kV,管电流200 mA,厚、层距均为5 mm,螺距1.028:1,重建视野35 cm。将扫描后的数据进行图像的后处理,获取四肢骨关节骨折的多角度病区图像。

1.2.2 MRI诊断 采用GE 1.5T Signa Explorer MR扫描仪和配套线圈,行常规矢状位及冠状位扫描。受检者均取仰卧位,冠状位采用T2加权成像-脂肪抑制(T2WI-FS)序列,矢状位T1加权成像(T1WI)采用FLASH序列,层厚为3.5 mm,矩阵为 256×256 ,视野为 $160 \text{ mm} \times 160 \text{ mm}$ 。在三维重建中,采用GE

公司ADW 4.0软件工作站,提取采集的薄层轴位图像,分别行最大密度重组(MIP)、多平面重组(MPR)、容积再现(VR)等重建。

1.2.3 诊断金标准 均由2名具有丰富经验的骨科医师根据患者伤情、手术情况、症状作出最终诊断,当2人意见不统一时,由上一级医师讨论后得出统一意见。

1.3 观察指标

(1) 四肢骨关节隐匿性骨折诊断标准:CT可见骨皮质连续中断或骨碎片出现移位,骨小梁存在清晰明亮的骨折线;MRI显示骨折线均呈低信号,骨小梁清晰骨折线或骨皮质连续性中断或二者均有。(2) 记录所有患者四肢骨关节隐匿性骨折的部位、影像学特征,计算诊断敏感度、特异性、漏诊率等指标,其中影像学特征包括双边征、骨质破坏、充气征、软组织影等。

1.4 统计学方法

应用SPSS 20.00,以最终诊断为金标准,分别计算CT与MRI诊断的价值,灵敏度=真阳性/(真阳性+假阴性);特异度=真阴性/(假阳性+真阴性);误诊率=假阳性/(假阳性+真阴性);漏诊率=假阴性/(真阳性+假阴性)。计数资料以百分率表示,计量数据以 $(\bar{x} \pm s)$ 表示,对比用 χ^2 分析与t检验,检验水准为 $\alpha=0.05$ 。

2 结果

2.1 确诊结果

在118例患者中,最终确诊为四肢骨关节隐匿性骨折98例(83.1%),无骨折20例(16.9%),其中腕关节骨折34例,踝关节骨折22例,膝关节骨折15例,肘关节骨折15例,肩关节骨折8例,髋关节骨折4例。

2.2 影像学特征

肩关节骨折与膝关节骨折:CT显示骨折周围的骨髓水肿和软组织水肿清晰,MRI T1WI低信号,骨折线在各系列成低信号,T2WI低信号。

腕关节骨折与踝关节骨折:CT表现紧贴关节面下骨折部位边界模糊,MRI T1WI低信号。

肘关节骨折与髋关节骨折:CT与MRI清晰显示垂直骨皮质的低信号骨折线,骨折后缘无膨隆,关节周围无软组织肿块。

MRI三维重建都可清晰显示骨折线,小的骨折碎片,与邻近组织结构之间关系。

2.3 主要影像学指征对比

在98例确诊的四肢骨关节隐匿性骨折中,MRI三维重建显示双边征、骨质破坏、充气征、软组织影等比例显著都高于CT($P<0.05$)。见表1。

2.4 诊断效果对比

在118例患者中,CT诊断为四肢骨关节隐匿性骨折89例,MRI三维重建诊断为四肢骨关节隐匿性骨折97例,CT与MRI三维重建诊断四肢骨关节隐匿性骨折的敏感性为89.8%和99.0%,特异性为95.0%和100.0%,误诊率分别为9.3%和0.8%,MRI三维重建诊断的敏感性高于CT,漏诊率低于CT。见表2与表3。

3 讨论

隐匿性骨折通常是指位于解剖结构复杂部位的骨折,特别

表 1 MRI 联合 CT 诊断四肢骨关节隐匿性骨折的影像学特征对比 (例,%)

Table 1 Comparison of imaging features of MRI and CT in the diagnosis of occult fractures of the bones and joints of the extremities (n,%)

Groups	n	Double contour sign	Destruction of bone	Inflation sign	Soft tissue shadow
MRI	98	97 (99.0)*	97 (99.0)*	97 (99.0)*	96 (98.0)*
CT	98	90 (91.8)	91 (92.9)	89 (90.8)	88 (90.0)

Note: Compared to the CT group, * $P < 0.05$.

表 2 CT 与 MRI 三维重建诊断四肢骨关节隐匿性骨折的价值 (例,%)

Table 2 Value of three-dimensional reconstruction of CT and MRI in the diagnosis of occult fractures of the bones and joints of the extremities (n,%)

Diagnosis	CT		MRI 3D reconstruction		Total
	Positive	Negative	Positive	Negative	
Positive	88	10	97	1	98
Negative	1	19	0	20	20
Total	89	29	97	21	118

表 3 CT 与 MRI 三维重建诊断四肢骨关节隐匿性骨折的敏感性、特异性和误诊率对比 (例,%)

Table 3 Comparison of sensitivity, specificity and misdiagnosis rate of three-dimensional reconstruction of CT and MRI in the diagnosis of occult fractures of limbs and joints (n,%)

Method	Sensibility	Specificity	Misdiagnosis rate
MRI	99.0 (97/98)	100.0 (20/20)	0.8 (1/118)
CT	89.8 (88/98)	95.0 (19/20)	9.3 (11/118)

是四肢是人体活动和承重的重要部位,在内外因素的作用下容易发生骨折。该病被延误诊治或者漏诊可对患者的身体健康造成不可逆转的严重影响,也容易引起医患纠纷^[15,16]。本研究显示在 118 例患者中,最终确诊为四肢骨关节隐匿性骨折 98 例,无骨折 20 例,其中腕关节骨折 34 例,踝关节骨折 22 例,膝关节骨折 15 例,肘关节骨折 15 例,肩关节骨折 8 例,髋关节骨折 4 例。常规 X 线检查很难发现一些四肢骨关节隐匿性骨折,但对于四肢关节结构复杂的骨折,也容易出现误诊、漏诊^[17-19]。相较于 X 线片,CT 检查具有扫描迅速、范围广泛、分辨率高等优点,避免了解剖结构重叠的缺陷。特别是多层螺旋 CT 可明确显示骨折位置和周围骨碎片影,对骨关节显像十分清晰,而经后处理的 CT 扫描得到图像可丰富诊断信息,有助于提高四肢骨关节隐匿性骨折的诊断率^[20,21]。不过 CT 对骨折平面透亮度低、骨折线走形、骨内骨折的患者成像效果较差,在隐匿性骨折的诊断中存在一定局限性^[22]。MRI 是诊断隐匿性骨折最佳的手段之一,诊断敏感性和特异性都很高^[23]。其对软组织、软骨与骨骼都有很高的分辨率,能清晰显示骨折的部位、形态与周围软组织损伤情况^[24]。MRI 扫描三维重建可在多个层面显示骨碎片及骨折线,还能全面了解骨折的范围、部位、病灶周围软组织受损情况,也可判断骨折线所波及的区域,可用于显示骨骼系统的表面形态,能有效定位骨折部位,能够直观呈现骨折移位、骨折有无累及骨皮质、骨折塌陷程度等^[25]。

隐匿性骨折为无明显临床症状的一种微型骨折,漏诊和误诊对患者的预后不利,因此准确诊断隐匿性骨折至关重要^[26]。而四肢骨关节一旦发生隐匿性骨折,关节功能会受到很大影响,严重影响患者的生活质量。多层螺旋 CT 采用容积扫描及

薄层三维重建,不需多次搬动患者,扫描剂量显著降低,具有直观、立体、多角度观察的优点,还能清晰显示下肢关节边缘撕裂骨折、关节内骨片、关节面线样骨折、关节面塌陷骨折等情况^[27]。不过髋关节组成部分较为复杂,由股骨、坐骨和耻骨等部分组成,CT 很难准确显示骨折情况;踝关节是损伤较为容易的复合关节之一,存在较多的重叠,CT 有时也不能直白地显示出骨折信息^[28,29]。腕关节骨折由于结构重叠,也使得 CT 难于显示轻度塌陷骨折与撕裂骨折。同时很多隐匿性骨折患者在发病早期 CT 表现为骨质疏松,骨密度降低,形态多样,也可呈粗点状改变,可出现周围组织较均匀的环形软组织影^[30]。本研究显示在 98 例确诊的四肢骨关节隐匿性骨折中,MRI 三维重建显示双边征、骨质破坏、充气征、软组织影等比例显著都高于 CT。主要在于 MRI 可快速地对骨折部位进行确定,能够避免关节不同结构重叠对诊断结果所产生的影响,清晰显示隐匿性骨折的骨折线走向及移位情况。并且 MRI 能够很好的显示软组织结构,并且对组织内轻微水肿、出血都会导致 MRI 信号的改变,从而有利于进行诊断判断。同时 MRI 三维重建可选择有多序列、多参数成像,能全面细致的显示出软骨损伤和骨出血、水肿等病变,对于临床诊断与病情评估具有重要指导意义^[31]。并且采用三维重建技术对检查部位进行清晰显像,避免了组织重叠、被掩盖的缺点,对于显示骨折及其周围软组织情况有巨大优势,有利于发现隐匿性骨折。

隐匿性骨折的病理改变为骨皮质和骨小梁的微小断裂,在人体四肢部位,受不规则骨髓影响,该病变不易被 X 线检出。本研究显示 CT 与 MRI 三维重建诊断四肢骨关节隐匿性骨折的敏感性为 89.8 % 和 99.0 %, 特异性为 95.0 % 和 100.0 %, 误

诊率分别为 9.3 % 和 0.8 %, MRI 三维重建诊断的敏感性高于 CT, 漏诊率低于 CT。其中多层螺旋 CT 可从多方位的观察病变部位, 一定程度上提高了隐匿性骨折的检出率, 避免漏诊的发生。而 MRI 对软组织、骨髓病变, 尤其是在隐性骨折中有明显优势, 各序列能够突出显示髓腔内弥漫性的骨髓水肿, 也能发现关节部位其他损伤。并且后续三维重建可清晰显示骨折形态、类型、移位情况, 可多角度的展现出患者的骨折线、骨折碎片和周围组织结构等, 对隐匿性骨折的诊断提供了最佳影像学依据。不过 MRI 的检查费用比较高, 且检查时间比较长, 也有一定的检查禁忌。并且本研究纳入的患者数量较少, 判断标准还不明确, 病理分析不够深入, 将在下一步研究中进行大规模总结分析。

总之, CT 与 MRI 扫描三维重建在四肢骨关节隐匿性骨折诊断中的应用都有很好的价值, 特别是 MRI 三维重建能清晰显示骨折特征, 具有更高的诊断敏感性, 能减少漏诊率, 可作为四肢骨关节隐匿性骨折的首选检查方法。

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