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·综 述·

胫骨骨折髓内针术后骨不愈合的影响因素

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[摘 要] 髓内针(IMN)治疗胫骨骨折具有愈合率高、并发症发生率低等优点,已成为治疗胫骨骨折最常用的固定方式之一。但受患者自身因素、骨折部位及骨折类型、感染和手术治疗方式等因素的影响,IMN术后骨不愈合在临床中仍有发生。骨不愈合导致患者的医疗费用增加,住院时间延长,给患者造成了巨大的痛苦,同时也给骨科医生的治疗带来了巨大挑战。因此,本文对胫骨骨折IMN术后骨不愈合的影响因素作一综述,以期为临床治疗提供参考。

[关键词] 骨不愈合;胫骨骨折;髓内针骨折固定术;影响因素;综述
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Influencing factors of bone nonunion after intramedullary needle operation for tibial fracture

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Abstract: Intramedullary needle (IMN) has the advantages of high healing rate and low incidence of complications in treatment of tibial fracture, and has become one of the most commonly used fixation methods for the treatment of tibial fracture. However, due to the patient's own factors, fracture location and fracture type, infection and surgical treatment, bone nonunion after IMN still occurs in clinic. Bone nonunion leads to the increase of medical cost and prolonged the hospitalization time of patients, which causes great pain to patients, and also brings great challenges to the treatment of orthopedic surgeons. Therefore, this paper reviews the influencing factors of bone nonunion after IMN for tibial fracture, in order to provide reference for clinical treatment.

Keywords: bone nonunion; tibial fracture; intramedullary nail fracture fixation; influencing factors; review

髓内针(intramedullary needle,IMN)是治疗胫骨骨折最常用的固定方法之一,但会导致延迟愈合及骨不愈合等并发症[1-2],增加患者的疼痛与医疗费用,延长住院时间[3-5]。胫骨IMN术后骨不愈合的危险因素包括患者的自身因素(年龄、性别、BMI、吸烟史)、骨折部位及骨折类型、感染和手术治疗方式等[3,6]。骨不愈合是一种慢性疾病,不仅影响运动功能,还严重影响患者的身心健康和生活质量[7-8]。因此,本文对胫骨骨折IMN术后骨不愈合的影响因素作一综述,以期为临床治疗提供参考。

1 患者的自身因素

年龄、BMI>40 kg/m^2、吸烟、酗酒、糖尿病、动脉硬化等是导致骨不愈合的危险因素[5,9]。吸烟、酗酒、糖尿病及高能量创伤患者的骨不连发生率显著高于正常人群[10]。与不吸烟者相比,吸烟者骨不愈合的风险增加了5.1倍,手术并发症的风险增加了7.93倍[11]。胫骨骨折IMN术后接受非甾体抗炎药物治疗的患者比未接受该药的患者骨不愈合或感染等并发症的风险增加了2倍[12]。一些非手术因素(不恰当的功能锻炼、骨质疏松症和免疫抑制等)也会影响骨折愈合[9,13]。在影响因素与胫骨骨折不愈合关系的研究中,年龄>60岁、男性、吸烟、BMI>40 kg/m^2、糖尿病、使用非甾体抗炎药物、使用阿片类药物、胫骨中下1/3骨折、高能量骨折、开放性骨折和感染等对骨折愈合有显著影响[5,14-15]。一些内分泌代谢性疾病也是影响骨折愈合的重要因素,如甲状腺疾病、甲状旁腺病、佝偻病、骨软化症、维生素D缺乏、雌激素缺乏、库欣病、佩吉特病和吸收不良综合征等。患者合并基础疾病越多,骨不愈合及畸形愈合的风险就越高。

2 骨折部位及骨折类型

胫骨骨折是最常见的长骨骨折之一,约占所有骨

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折的15%[16-18]。胫骨骨折IMN内固定术后骨不愈合的危险因素包括骨折部位、骨折间隙、骨折类型(简单或粉碎)和骨折分类(开放或闭合)。在解剖学上,胫骨中下1/3处为三角形与四方形交界部位,为骨折的好发部位;再者,胫骨骨干位于皮下,其血供较其他有肌肉包绕的骨骼差,胫骨中下段骨折并发神经血管损伤容易发生骨折延迟愈合甚至不愈合[5,19];其次,胫骨远端的髓腔较粗,IMN在固定胫骨远端骨折时存在固定不牢靠的风险,导致IMN术后延迟愈合和不愈合。由于胫骨的这些解剖学特点,胫骨骨折的不愈合发生率较高,血管损伤的发生率也较高,而良好的血供是确保骨折愈合的重要因素[20]。过大的骨折间隙及相对位移可导致骨折延迟愈合甚至不愈合。研究表明,骨折间隙>5 mm、粉碎性骨折及开放性骨折是导致IMN固定胫骨骨折术后骨不愈合发生的独立危险因素[11,15]。其中骨折间隙是唯一一个可以通过手术解剖复位避免骨不愈合发生的危险因素。另外,胫骨中下段骨折、IMN固定不牢靠以及患者年龄和体质量的增加也与较高的骨不愈合发生率相关[21-22]。

3 感染

IMN是治疗胫骨骨折的首选方法,但可能会出现延迟愈合或不愈合等并发症[2,23-24]。感染是IMN治疗胫骨骨折术后骨不愈合的常见原因之一。在临床上,骨不愈合分为非感染性骨不愈合和感染性骨不愈合,其中非感染性骨不愈合根据骨折断端活力的不同又分为肥大型(血管丰富型)和萎缩型(缺血型)骨不愈合[25]。肥大型骨不愈合具有很强的再生潜力,但由于骨折断端之间的活动度较大且不稳定,会影响新骨的形成和生长,表现为骨折部位骨痂较大。萎缩型骨不愈合是由于创伤或手术中未复位骨折或大量软组织剥离影响了骨折断端的血供,导致骨折断端没有足够的成骨反应,没有愈伤组织形成和愈合的迹象,表现为骨痂组织缺失、骨折断端变窄。感染性骨不愈合多发生于复杂开放性骨折、粉碎性骨折、高能量损伤及合并软组织缺损的患者,尤其是Gustilo Ⅲ型,常合并厌氧菌感染,与未感染患者相比,这类患者更易发生骨不愈合及骨髓炎。在机体正常的生理情况下,骨折愈合受血管内皮生长因子(vascular endothelial growth factor,VEGF)信号通路的正常调控。骨折时,受损的周围骨细胞以及炎性细胞表达VEGF,成骨细胞产生的VEGF也可通过CXCL12-CXCR4途径诱导中性粒细胞的趋化并提高血管内皮细胞活性,促进血管生成。IMN术后感染可大大降低成骨细胞的活性,造成VEGF生成受限,骨折断端的血供生成相应减少,从而导致骨折不愈合[26]。其次,感染形成的脓液不仅会阻止骨折处的纤维骨痂形成,还会造成骨折断端的滋养血管栓塞、骨坏死、吸收不良而致骨不愈合。IMN经常被用于治疗闭合性骨折,髓内感染是IMN治疗胫骨骨折的严重并发症之一,可能延伸到整个骨骼,若治疗不及时,可能导致患肢永久性丧失功能[27-28]。开放性骨折容易因伤口暴露于外界环境中而感染,感染的风险取决于软组织损伤的严重程度。患有严重和无法控制的感染患者可能需要截肢,以防止病情恶化。据国内外研究,闭合性胫骨骨折IMN术后感染发生率为2.0%~5.0%,开放性骨折感染发生率为4.3%~31.0%[18,27,29]。感染患者更有可能需要后续彻底的清创手术和抗菌药物全程治疗,住院时间更长。据统计,发生感染的患者费用是无感染患者的1.8倍,总住院时间是无感染患者的6倍[30-31]。对于开放性胫骨骨折,早期稳定骨骼和恢复健康的软组织包膜对于避免感染至关重要。

4 手术治疗方式

Küntscher[32]于1940年首次使用IMN治疗胫骨骨折,这是目前IMN技术的基础。IMN治疗胫骨骨折具有创伤小、愈合率高、并发症发生率低等优点,已成为治疗胫骨骨折的金标准[33]。IMN固定具有微创性,与手术相关的并发症(如软组织损伤、出血或术后感染)较少,但更容易发生脂肪栓塞及下肢深静脉血栓[34-35]。胫骨骨折患者IMN术后最常见的并发症是膝关节疼痛(23%),其次是骨不愈合(11%)[32,36]。IMN治疗胫骨骨折的愈合率为90%~100%,尽管治疗愈合率较以往显著提高,但骨折延迟愈合和不愈合仍有发生。相比于髓外固定,IMN旋转不稳定,骨折断端容易出现内翻位移。远近端交锁螺钉可以在一定程度上对抗IMN的旋转不稳定,但这并不是绝对的。研究表明,IMN直径与扩髓直径的比值在0.80~0.99之间可以防止螺钉断裂,从而增强IMN术后的旋转不稳定[2]。当这一比值过大或者过小,可能造成螺钉固定失效,影响骨折的稳定性,不利于骨折愈合。另外,胫骨骨折IMN固定术中未能获得或维持解剖复位也是导致骨不愈合的重要因素[37]。胫骨骨折易出现骨折远端旋转移位和分离移位,若骨折对位对线未纠正即强行攻入IMN可使骨折端存在间隙,容易引起断端延迟愈合或不愈合。同样,如果IMN的长度过短或尺寸过细均可导致与胫骨髓腔不匹配,可能会造成骨折断端固定不牢靠,使得断端存在微动。研究表明,骨折断端的微动

量在0.2~1.0 mm之间有利于骨痂形成,微动能够促进断端血管的形成和分布,但如果微动过大,骨折端生成的血管数量反而会减少,导致骨皮质供血不足,影响骨折愈合(肥大型骨不愈合)。IMN扩髓会造成更多的骨内膜血管损伤和骨皮质坏死,从而出现骨折不愈合(萎缩型骨不愈合)。此外,术后不恰当的功能锻炼也是导致骨不愈合的重要因素,功能锻炼与负重必须是动态的平衡,不可一味地追求早期下地活动,超过其限度的锻炼可导致IMN固定失败、断钉及再次骨折等不良后果的发生。因此,术后恰当的功能锻练至关重要。

综上所述,IMN固定失败、手术过程中对血供的破坏及术后不恰当的功能锻炼是骨不愈合的危险因素。此外,避免胫骨骨折IMN术后骨不愈合还依赖于外科医生对植入物的选择和手术技术的改进等。

5 总结与展望

骨折愈合是一个多因素共同参与的极其复杂的生物学修复过程。胫骨的骨折部位及骨折类型、感染和手术治疗方式等是导致延迟愈合及不愈合的重要因素。除此之外,患者的自身因素如年龄、性别、吸烟、既往病史、合并用药等也是引起胫骨骨折不愈合的危险因素[38]。上述因素相互影响、相互促进、共同作用,最终导致骨不愈合。胫骨骨折不愈合或畸形愈合发生率为2%~12%[39]。虽然IMN治疗胫骨骨折已有几十年的历史,但使用IMN治疗胫骨骨折的患者有可能发生膝关节疼痛、二次手术和骨不愈合等不良事件,仍有改进的空间。胫骨骨折除了直接增加医疗负担外,还可能因骨不愈合和感染而使病情复杂化[30,40]。骨折延迟愈合及不愈合目前仍然是骨科医生面临的重要难题之一[41]。然而,根据目前的数据,仍然很难确定有并发症风险的患者的指标和决定因素。外科医生应该系统地寻找各种相关的并发症,以排除对愈合产生负面影响的可逆原因。通过更好地了解目前有关胫骨骨不愈合的趋势和最新文献,骨科医生将更容易处理这些棘手的问题。

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