

踝关节骨折中下胫腓联合损伤的研究进展

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摘 要

下胫腓联合的创伤性损伤通常是由高能量踝关节损伤引起的。它们可以发生为孤立的韧带损伤, 也可合并踝关节骨折。下胫腓联合韧带损伤的诊断和治疗对骨科医生来说是一个挑战。最近的文献增加了有关损伤力学分析和治疗结果的思考, 但关于诊断、植入物和术后方案仍有许多争议。本文综述了下胫腓联合韧带损伤, 包括解剖学和生物力学, 诊断, 分类和治疗选择。

关键词

踝关节骨折, 下胫腓联合韧带损伤

Research Progress of Injuries to the Distal Tibiofibular Syndesmosis in Ankle Fractures

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Abstract

Traumatic injury of lower tibiofibular syndesmosis is usually caused by high energy ankle injury. They can occur as isolated ligament injuries or ankle fractures. Diagnosis and treatment of lower tibiofibular ligament injury is a challenge for orthopedic surgeons. Recent literature has increased the thinking of damage mechanics analysis and treatment results, but there are still many controversies about diagnosis, implants and postoperative regimens. This paper reviews the injury of the lower tibiofibular ligament, including anatomy and biomechanics, diagnosis, classification and treatment options.

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Keywords

Ankle Fracture, Inferior Tibiofibular Ligament Injury

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1. 下胫腓联合解剖

下胫腓联合由胫腓骨远端和下胫腓韧带复合体构成,由四个外侧韧带稳定:前下胫腓韧带(AITFL, anterior inferior tibiofibular ligament)、骨间韧带(IOL, interosseous ligament)、横韧带(TL, transverse ligament)和后下胫腓韧带(PITFL, posterior inferior tibiofibular ligament)。在下胫腓韧带底部,胫骨和腓骨有一个小的接触区,在那里有一个约 0.5~1.0 mm 厚的透明软骨直接与各自的骨头关节面相连[1]。腓骨联合的凸起部分与胫骨侧的凹切牙一致。胫骨切迹的前结节比后结节大,防止腓骨远端向前滑动。在由外旋引起的韧带联合损伤中,后结节起着支点的作用,远端腓骨围绕其纵轴向外侧旋转。通常存在滑膜内衬的韧带联合隐窝,其头部与远端骨间韧带相连,前部与 AITFL 相连,导致胫骨关节内存在滑膜隐窝。韧带联合隐窝的宽度为 2 mm [2] [3],韧带联合断裂导致韧带联合膜损伤并逐渐增宽,关节镜下可见[4]。踝关节内侧强壮、扁平、三角形结构的三角韧带是韧带联合稳定的关键因素。

下胫腓联合的血液供应已被很好地证明。有三种不同的前胫腓动脉和两种不同的后胫腓动脉。这些模式因个人的不同而不同,甚至在一个人的体内也会有侧面的不同。腓动脉分支位于关节线以上约 3 cm 处,是前韧带联合的重要血液供应分支,与 IOL 密切相关,在联合韧带断裂及手术治疗时易受损伤[5]。

2. 韧带联合的生物力学

韧带稳定了韧带联合,防止腓骨在多个方向的过度运动:前后平移,外侧平移,内外旋转。适当的腓骨位置和有限的旋转是正常的韧带联合功能和踝关节内距骨位置所必需的[6]。在踝关节内侧,三角韧带对胫腓联合的稳定起着重要作用。如高能量外旋踝关节损伤(即“高位踝关节扭伤”或“旋前外旋踝关节骨折”),可导致距骨和腓骨相对于胫骨的过度外侧平移和旋转[7]。

损伤力学:踝关节联合的力量通常是由踝关节背屈末端过度外旋或踝关节背屈与足内收或外展的某些组合引起的。这些力量可使腓骨相对于胫骨在踝关节榫眼变宽,破坏韧带联合并导致继发性距骨不稳定[8]。当高能量使固定足旋转时(例如,由于体重或与其他球员或物体的碰撞),距骨向外侧旋转,导致 AITFL 损伤。在持续的力作用下,腓骨离胫骨更远,产生的剪切力可在骨间轴向传递,造成骨间膜[9]损伤。在持续的高强度作用下,下胫腓后韧带和三角肌可能会失效,并且腓骨、后踝或内踝可能会骨折。尸体研究表明,脚的位置会影响损伤的性质。Haraguchi 和 Armiger [10]研究表明,足外旋的同时旋前,首先对 AITFL 造成损伤,其次是三角韧带的内侧损伤。Wei 等人[11]研究表明,踝关节外旋同时外翻也更容易破坏 AITFL,首先产生距骨侧移和外旋。相反,中性足的外旋一开始更可能导致三角韧带[11]损伤,随后导致 AITFL 和韧带联合[12]损伤。至少两个外侧韧带的断裂和三角韧带的损伤才能造成韧带联合的完全不稳。然而,单独的三角韧带断裂可导致内侧间隙扩大,即使有稳定的韧带联合[13]。随着韧带联合的进行性损伤,胫骨和腓骨之间的分离会增加。正常的胫腓骨透明间隙约为 5 毫米[14]。踝关节榫眼宽度增加 1 毫米,胫距关节接触面积就会减少 42%,造成严重的踝关节不稳[1]。即使是轻度韧带联合损

伤,踝关节力学也会发生显著变化,这可能是导致韧带联合损伤长期恢复和长期功能障碍的原因[15][16]。

3. 韧带联合损伤的诊断和分类

临床诊断: 韧带联合损伤的诊断基于损伤类型、全面的体格检查和 x 线表现。当未出现骨折时,临床表现包括踝关节疼痛,前韧带联合上方的压痛,以及正向挤压和外旋试验。挤压试验是通过挤压小腿中点以上的腿来进行的,在近端挤压小腿中点以上的腓骨和胫骨时,会在远端造成两块骨头分离和[17]韧带联合疼痛。值得注意的是,在存在麦氏韧带损伤的情况下,这项测试可能会造成近端疼痛。外旋试验是通过膝关节屈曲 90°并外旋足来稳定胫骨进行的。在此操作过程中,如果韧带联合出现疼痛,则为阳性检查。这两种检测均具有高特异性但低敏感性,以 MRI 扫描为金标准[18]。

影像学诊断: x 线片评估应包括负重(在患者可耐受的情况下)和踝关节的三种视图(前后视图、樗眼视图、侧面视图)。如果临床怀疑骨折,特别是腓骨高位骨折,应进行胫腓骨 x 线检查。除了诊断骨折和腓骨近端损伤外, x 线片还可用于显示胫骨远端和腓骨远端之间的正常关系破坏,这可能表明韧带联合损伤。典型情况下,如果 x 线片显示胫腓间隙增加、胫腓重叠减少或内侧间隙增加,则可能出现联合韧带损伤[19][20]。在静态损伤 x 线片上,韧带联合损伤的证据并不总是明显的。Beumer 等人[19]表示,没有最佳的影像学参数来评估韧带联合损伤。最有用的参数是两者都存在,由于胫腓骨重叠的缺失和内侧清晰间隙的扩大,提示韧带联合增宽,内侧间隙大于上间隙提示三角肌断裂。应力 x 线片可用于诊断韧带联合损伤和确定手术指征。然而,Parikenin 等显示术中应力 x 线摄影(侧位平移和外旋)特异性很高,但敏感性很差[21]。这意味着更严重的损伤很容易被识别出来,但伴有不稳定的中度损伤很容易被应力 x 光检查忽略,即使是在麻醉状态下,侧位 x 光片也很有用。站立 x 光片可以为单个患者提供解剖正常的指示,这可能会有很大的差异[22],术中使用正侧位 x 光片可以帮助确认冠状面复位。术中计算机断层扫描(CT)已被证明是诊断韧带联合损伤和确认韧带联合复位的有效工具[23],但这项技术在实践中尚未广泛应用。

在缺乏最佳 x 线平片研究的情况下, MRI 和 CT 扫描可作为评估联合韧带断裂、韧带损伤程度和腓骨在联合韧带中的位置的有用静态工具。与 AP x 线(63%)和樗眼 x 线(71%)相比, MRI 在检测损伤方面具有较高的准确性(96%) [4] [24]。CT 扫描比 x 线片更准确地显示胫骨远端和腓骨的关系[25]。CT 也可以方便地测量对侧踝关节进行比较。位移差 2 毫米或更多的两边被认为是病理性。关节镜可能是评估韧带联合损伤和增宽的最好的最终工具,具有 100%的准确性[4],但并不总是可行的诊断。在手术病例中,我们将常规使用关节镜来确认诊断并在稳定[26]后复位。

损伤程度: 急性韧带联合损伤的严重程度分级系统已经被一些作者认同[16][27][28]。人们普遍认为有三个等级,从一级到三级,从最轻到最严重。虽然这些分类方案有相似之处,但量表之间也有重要的差异。值得注意的是,所有这些量表都包含了临床结果,但目前还没有一个分级系统可以根据 MRI 或超声所定义的解剖位置或韧带损伤的严重程度来进行分级,也没有一个系统可以提供足够的治疗指导或预后。

等级 1: 一般认为, I 级损伤在临床上较轻,联合韧带稳定, x 线片正常。外侧韧带有不完整损伤。这些患者在[28]韧带联合会有压痛。外旋转和挤压试验的[27]值可能为负值,尽管 Gerber 等人指出,这两种试验中的一种应该是[16]阳性。

等级 2: II 级损伤通常与完全性 AITFL 和 IOL 断裂有关。 x 光片正常,外旋和挤压试验呈阳性。然而,在联合稳定性问题上还没有达成共识。Scranton 认为 II 级损伤是不稳定的,而 Wolf 和 Amendola 则认为它们可以是稳定的,也可以是不稳定的。实验室数据表明下胫腓后韧带和横韧带的损伤是韧带联合稳定的关键。目前没有一个分类系统可以帮助区分需要稳定和不需要稳定的 II 级损伤。由于是否手术取

决于其稳定性, 因此 opti-mal 分类系统会对此作出解释, 并可能将 MRI 作为比 x 光片更准确的工具。

等级 3: III 级损伤是指外侧韧带(AITFL、IOL、PITFL)完全损伤和三角韧带撕脱。x 线平片显示关节明显不稳定(内侧间隙增宽大于 2 mm 或联合韧带增宽) [29]。所有的临床测试都呈阳性, 三级损伤需要手术稳定。

4. 踝关节骨折伴韧带联合损伤

关于韧带联合损伤的手术治疗的绝大多数资料是骨折相关的韧带联合断裂。大约七分之一的踝关节骨折与[12]韧带联合损伤有关。当踝关节旋转损伤发生在高冲击和碰撞活动中, 特别是当踝关节旋转损伤发生在高速和高身体质量指数的患者中时, 可导致特别高的机械力。当受力足够大时, 骨折可发生在内踝和后踝、腓骨近端至韧带联合关节, 或韧带联合的附着部位。这些伤害是最普遍公认的骨折分类(根据骨折的位置) [30]。值得注意的是, 至少 20%的韧带联合损伤与 Weber B 型骨折相关[31]。虽然韧带联合损伤中最常见的骨折位置是腓骨远端三分之一, 但骨折程度与韧带断裂的程度有关。这通常包括前胫腓韧带和骨间膜破裂, 严重损伤时伴有后胫腓韧带破裂(或后踝损伤)。韧带联合断裂也可导致腓骨近端骨折, 或“腓骨高位骨折”, 称为麦氏神经损伤。Maisonneuve 骨折通常发生于骨间膜广泛破裂[9]。这表明韧带联合有严重创伤。

5. 胫腓联合韧带的受伤

在不平坦的地形或人工地面上进行高速运动时, 穿着带夹板的运动鞋会造成或增加脚和踝关节相对于胫骨的背屈和外旋的可能性[32] [33]。此类损伤通常发生在涉及跳跃和着陆地机动的撞击和碰撞活动中(如足球、足球、篮球、橄榄球、滑雪、曲棍球等), 已知这些活动会导致外旋转力矩, 增加了韧带联合踝关节扭伤的发生率。韧带联合的韧带损伤通常被称为“高位踝关节扭伤”, 因为它们发生在更常见的内翻外侧踝关节扭伤的近端。这些损伤一般可分为不完全韧带损伤(如“扭伤”)或完全韧带断裂。完全性韧带损伤很少没有骨折, 但一般都需要手术修复[32]。高位踝关节扭伤不如“内翻”侧位踝关节扭伤常见, 约占所有踝关节扭伤的 10% [15] [34], 但在美式橄榄球等碰撞运动中, 踝关节扭伤的比例高达 25% [16] [32] [35]。与内翻性扭伤相比, 高位踝关节扭伤更容易产生长期功能障碍, 需要更多的时间恢复[15] [36]。

6. 韧带联合损伤的治疗

保守治疗: 较低级别(I 级和 II 级)的孤立性韧带联合扭伤一般可以成功的非手术治疗, 因为它们不会导致韧带分离和完全断裂[32]。然而, 这可能需要 3 倍的时间愈合踝关节内翻扭伤。伴有骨折和樗眼明显失稳的损伤通常需要手术治疗。在这些损伤中, 可以在术中评估韧带联合的不稳定性, 以确定是否需要韧带联合的稳定。对于适当的损伤, 对韧带联合的稳定损伤进行保守治疗已显示出良好的效果[16] [37], 通常采用典型的三阶段入路。Nassbaum 等人[37]对 60 名临床发现的“高位脚踝扭伤”的大学生运动员进行了康复治疗, 其中包括短时间(1~4 天)的非负重和靴内固定, 然后进行积极的康复计划。平均回归运动时间为 13.4 周, 回归时间与骨间压痛长度阳性挤压试验相关。由于他们没有进行核磁共振扫描, 在他们的系列中, 一些运动员可能有轻微的外侧韧带扭伤, 这在临床上可以模拟韧带联合损伤, 并且有恢复得更快的趋势。对于级别较高的损伤, 手术治疗可能优于非手术治疗, 即使是单纯的韧带损伤[38] [39]。Kennedy 等人的[38]比较了 III 级韧带联合损伤的手术治疗与石膏固定保守治疗, 虽然在症状和运动表现方面的长期差异不大, 但手术组的恢复运动平均要快 3 周。对于 II 级损伤, 即 x 线平片或应力测试没有不稳定的证据, 但 MRI 或超声研究表明有更高级别的损伤(即韧带联合完全断裂, 三角肌损伤等), 并可能存在动态不稳定, 关节镜检查是一个有用的工具, 可以准确评估损伤的动态不稳定, 并可以在必要的

同时建立稳定[27]。

外科治疗：腓骨骨折或后踝骨折引起的韧带联合损伤大多需要手术稳定。孤立性韧带损伤导致韧带联合完全断裂的情况并不常见，但它们也需要手术稳定以优化短期和长期预后。虽然有许多技术可以稳定韧带联合[40]-[46]，但根据最近的文献，目前最常用的方法是螺钉和缝合扣[6] [39] [41] [47]-[54]。两种治疗的结果一般都很好。最重要的临床预后预测指标是韧带联合的解剖复位[31] [51] [55]。据大量报道，韧带联合损伤的非计划再手术率高达 27% [56]。Symeonidis 等人的一项研究[56]中，再次手术最常见的原因是韧带联合损伤漏诊(47%)、解剖复位失败(31%)和固定失败导致复位失败(21%)。

Trans-syndesmotic 螺丝：跨韧带联合螺钉是实现稳定固定的一种非常有效的方法，允许联合韧带在适当的术后护理下愈合。有大量的文献介绍了联合韧带联合螺钉材料和配置的技术属性。不锈钢螺钉与钛螺钉的固定失败率无明显差异[57]。较大的 4.5 mm 螺钉比 3.5 mm 螺钉具有更大的抗剪切应力能力[58]，但尸体实验表明，在旋前外旋损伤[59]中，不同的螺钉类型没有生物力学优势。与一枚[45]相比，两枚联合椎间带螺钉具有更好的稳定性，但三枚皮质联合椎间带螺钉与四枚皮质联合椎间带螺钉相比，生物力学稳定性和结果没有区别[48] [57] [59] [60]。在插入韧带联合螺钉时，足部的位置并不影响最终的踝关节活动范围或临床结果[61] [62]。

螺钉固定并发症：在使用下胫腓联合螺钉治疗的患者中，有多达一半的患者出现明显的下胫腓联合复位不良[25] [48] [51]。已发现复位不良是临床预后的主要预测因素[31] [51] [55] [63]。对于螺钉拆卸的必要性也存在一些争议[64]。最近的研究表明，取下韧带联合螺钉并不影响临床结果。事实上，矛盾的是，螺钉断裂的患者比螺钉完好的患者预后稍好一些[64] [65] [66]。此外，螺钉取出后的并发症发生率高达 15.8% (伤口感染或复发分离) [67]。一般来说，螺丝应由至少 3 个月，如果 1) 螺丝导致局部触痛或其他身体不适，2) 背屈受阻，或 3) 病人在知情讨论后更与愿意取出，包括潜在的硬件损坏或松动的问题。根据 Schepers [64]的研究，当一颗或两颗联合韧带螺钉沿三皮质方向置入时，需取出固定物的比例为 10%。

缝合固定按钮：缝合按钮(销售由 Arthrex 公司“钢丝”，那不勒斯，FL)，一个相对较新的外科植入物，由一个 5 号纤维丝环组成的低剖面系统，它可以被拉紧和固定在两个金属内扣之间放置在胫骨和腓骨的外皮质(或腓骨板，如果存在)。该设备提供了踝关节榫眼的稳定性，减少了后续设备移除和理论上的后期分离的需要。许多生物力学研究表明，其强度相当于或仅略低于螺钉[47] [68]。然而，尚不清楚这些研究中使用的力是否接近常规步行时传递的力，或可能发生在体育活动中。虽然关于缝合扣的临床文献令人鼓舞[44] [51] [52] [69]，但也有局限性。事实上，在本文发表前 6 年发表的一篇 JAAOS 关于韧带联合损伤的综述文章中并没有提到缝合扣装置[46]。与四皮质韧带联合螺钉相比，使用缝合装置可提供同等[69]或经证实[44] [70]的临床结果。Coetzee 和 Eberling [70]发表了一项前瞻性随机试验的初步结果，该试验比较了缝合扣和螺钉固定。他们认为，“钢索组的患者客观的运动范围测量更好，主观报告的僵硬和不适更少。” AOFAS 踝关节评分在平均 18 个月的随访中较高，虽然这没有达到统计学意义[70]。Naqvi 等人[51]在一项前瞻性队列研究中显示，与螺钉固定相比，缝合扣固定提供了一种更准确的韧带联合稳定方法，且具有同等的临床结果。根据以往研究[31] [63]，韧带联合复位不良是临床结果最重要的独立预测因子[51]。这既强调了精确的韧带联合复位的重要性，也强调了缝合扣装置可能在优化复位中发挥的潜在好处。

并发症与钢丝：尽管缝合扣技术的一个优点是减少了植入物移除的需要，但仍有一些关于感染、皮肤刺激和肉芽肿形成需要移除的报道。在最近一项 102 例用缝合扣固定治疗的损伤的研究中，8% 的损伤因疼痛、感染或植入物松动而需要移除[53]。尽管如此，这仍比螺钉固定的脱除率低[65]。尽管需要拆除缝合扣的并发症率高于预期，但这是通过一个小伤口完成的，并发症很少。需要进一步精心设计的前瞻性研究来确认缝合扣固定的长期临床结果。

7. 结论

下胫腓联合的创伤性损伤相对较常见, 可伴有踝关节骨折或发生纯韧带损伤, 这在接触性运动中很常见。韧带联合损伤的诊断和治疗对骨科医生来说是一个挑战。最近的文献大大增加了我们对损伤力学和新技术治疗结果的理解。损伤分类应有利于预后, 恢复和手术决策。与螺钉相比, 缝合扣装置具有更好的复位、复位保持、足够的生物力学强度和无需常规取出的优点。然而, 还需要进一步的关于缝合扣装置的前瞻性和长期临床数据。

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