

复发性髌骨脱位危险因素研究现状及进展

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摘要

复发性髌骨脱位是以膝关节周围持续弥漫性钝痛、膝关节不稳、肿胀以及髌骨反复向外侧脱位为主要症状的疾病。其危险因素尚不明确, 目前认为其危险因素主要包括: 膝关节外侧支持结构挛缩、股四头肌功能障碍(股内侧斜肌)、内侧髌股韧带异常、股骨滑车发育不良、膝外翻畸形、胫骨结节外侧化(扭转)、股骨前倾增大、高位髌骨、多发韧带松弛、扁平足、髌骨发育不良、胫骨结节-滑车间沟距离(TT-TG)增大、髌骨倾斜、家族基因遗传、BMI、Q角增大、性别、膝关节扭转过大、第一次脱位年龄等。治疗方式包括非手术治疗与手术治疗。手术治疗以内侧髌股韧带重建手术为基础, 根据其危险因素, 可结合行外侧支持带松解术、胫骨结节移位手术与滑车成形术。然而, 因其危险因素复杂多样, 很多患者术后仍存在膝关节不适症状甚至再次脱位。随着对膝关节及整个下肢解剖和生物力学的研究的深入细化, 复发性髌骨脱位的危险因素也逐渐被剖析出来, 但相对完整的危险因素尚未形成。本文针对目前有关复发性髌骨脱位危险因素的研究现状及最新进展进行综述, 以便更精准地指导临床个体化治疗。

关键词

复发性髌骨脱位, 危险因素, 髌骨脱位

Current Status and Advances in Risk Factor Research for Recurrent Patellar Dislocation

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Abstract

Recurrent patellar dislocation (RPD) is a clinical condition characterized by persistent diffuse dull pain around the knee joint, instability of the knee, swelling, and recurrent lateral dislocation of the patella.

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Despite extensive research, the etiological risk factors remain incompletely understood. Current evidence suggests that the primary risk factors include: lateral retinacular contracture, medial patellofemoral ligament (MPFL) dysfunction; quadriceps dysfunction (especially vastus medialis obliquus, VMO); trochlear dysplasia, femoral anteversion, genu valgum, tibial tuberosity lateralization (external torsion), increased TT-TG distance, patella alta, generalized ligamentous laxity, flat feet; patellar tilt, familial inheritance, elevated BMI, increased Q-angle, female gender, excessive knee torsion, and younger age at first dislocation. Treatment strategies for recurrent patellar dislocation (RPD) primarily include non-surgical interventions and surgical management. Among surgical options, medial patellofemoral ligament (MPFL) reconstruction serves as the cornerstone procedure, often supplemented by additional procedures—such as lateral retinacular release, tibial tubercle osteotomy, or trochleoplasty—based on individual risk factors. However, due to the complex and multifactorial nature of RPD etiology, many patients continue to experience postoperative knee discomfort or even recurrent dislocation. With advancing research on knee and lower extremity anatomy and biomechanics, the risk factors for RPD have been increasingly elucidated. Nevertheless, a comprehensive and universally accepted risk factor profile remains elusive. This review aims to summarize the current understanding and recent advances in RPD risk factor research, with the ultimate goal of providing precise guidance for personalized clinical management.

Keywords

Recurrent Patellar Dislocation (RPD), Risk Factors, Patellar Dislocation

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1. 引言

复发性髌骨脱位常见于存在一种或多种解剖结构异常以及髌骨力学环境异常的膝关节，其中以外侧移位最常见。流行病学研究发现复发性髌骨脱位患者多为 10~17 岁女性青年群体[1]。其病理因素呈现出多样化的特点，根本原因是整个下肢和膝关节局部力学环境不良，因此，解决不脱位就需要从根本上矫正力学环境，包括骨性解剖因素和软组织因素。导致髌骨不稳定的因素包括：膝关节外侧支持带挛缩、膝关节内侧支持带松弛、股骨滑车发育不良[2]、膝外翻畸形、胫骨结节外侧化、股骨前倾增大、高位髌骨、胫骨结节-滑车间沟距离增大[3]-[5]、髌骨倾斜、髌骨轨迹不良(J 征)[6]、多发韧带松弛、BMI、Q 角增大、扁平足、髌骨发育不良[7][8]、家族基因遗传、性别[9]、膝关节扭转角增大、第一次脱位年龄等[10]。患者常表现为膝关节周围持续弥漫性钝痛，上下楼梯时加重，可有膝关节不稳定感、“打软腿”、髌骨摩擦音以及关节肿胀。当小腿固定不动、膝关节轻度屈曲、上肢内旋时，髌骨极易向外侧脱出，大多数脱位在膝关节伸直时可自行复位。因复发性髌骨脱位病因复杂，保守治疗容易复发，手术效果参差不齐，为了更好地让运动医学科医生全面地了解复发性髌骨脱位的危险因素，给患者提供更个性化的治疗，我们以 MEDLINE 与 PudMed 数据库为主，以主要关键词“髌骨不稳定”、“复发性髌骨脱位”、“髌骨脱位”合并次要关键词“危险因素”、“影响因素”、“风险因素”、“临床效果”、“术后效果”等进行文献检索。根据检索的文章进行主题筛选，文章题目提及复发性髌骨脱位危险因素的进行摘要浏览，摘要中有明确说明某个或多个因素有确切影响时，进行文献精读。后由资深专家进行挑选。

髌股关节的稳定性有赖于静力和动力稳定结构。任何导致稳定结构改变的因素，包括伸肌装置不对称、髌股关节发育不良、创伤、下肢力线不良等，均可能导致膝髌股关节不稳[10]。正常的髌骨内外侧关

节面应该对称, 并与股骨滑车相匹配。但在发育过程中, 髌骨或者滑车的发育不良, 会导致髌股关节匹配不佳, 以至于髌骨及滑车后续发育形态异常[8]。髌骨周围软组织对维持髌股关节稳定也具有重要作用[11], 尤其是内侧髌股韧带(medial patellofemoral ligament, MPFL)和内侧髌胫韧带(medial patellotibial ligament, MPTL)。其中, MPFL 起着主要作用, MPFL 起自股骨内上髁和内收肌结节之间, 止于髌骨内侧的中上部。在限制髌骨向外移动的应力中, MPFL 提供了大约 60%的力量[12], MPML 提供了 24%, MPTL 贡献 13% [13]。因此, 增加 MPFL 损伤的风险包括 MPFL 自身解剖功能异常的因素, 我们都有理由认为它是复发性髌骨脱位的危险因素。

髌骨在股骨滑车上的轨迹也不是直线的, 而是带有一定程度的倾斜、滑动和旋转[14]。髌骨轨迹和髌股关节的稳定性, 是由骨性解剖静力结构和软组织动力结构之间复杂的相互作用所维持的。膝关节屈曲 20~30°时髌骨在髌韧带作用下进入股骨滑车, 当髌骨进入滑车时, 骨性结构为髌股关节提供足够的静态固有稳定性[15]。如果存在高位髌骨或滑车发育不良, 髌骨进入滑车延迟, 膝关节在伸直或轻度屈曲时髌骨稳定性较差, 易发生脱位。髌骨在膝关节屈伸过程的运动主要由股四头肌、髌韧带、以及内外侧髌支持结构提供动态稳定性, 当他们的合力向外侧时, 亦容易外侧脱位。骨性结构异常与软组织不平衡往往同时存在, 很大程度上会影响髌骨的正常轨迹, 异常的髌骨轨迹我们常称为“J 征”, 高度“J 征”往往伴随着较差的临床结果[6]。因此, 影响下肢力线(膝外翻)以及增加髌骨轨迹外侧向量的因素亦被视为复发性髌骨脱位的危险因素。

2. 危险因素

2.1. 滑车发育不良

滑车发育不良是导致髌骨脱位的重要因素[16]且髌骨形态与滑车形态在发育中是相互关联的, 越差的髌骨形态往往匹配越差的滑车形态[17]。正常情况下, 随着年龄的增加, 内侧和外侧滑车高度增加[18]。由于滑车发育不良, 底部逐渐垫高, 滑车槽变平甚至凸起, 使髌骨运动时改变正常的位置, 同时增加了髌骨关节的压力, 从而诱发脱位[19]。其主要表现为滑车沟深度和形状的异常, 主要发生于股骨滑车的近端或入口处。滑车发育不良较常用的是 Dejour [2]分型, B、D 分型被认为是较严重的[20]。正常情况下, 在膝关节轴位像上, 股骨外侧髁的最高点比股骨内髁高约 1 cm, 高级别的滑车发育不良, 使髌股关节失去了正常的对位, 同时也使髌骨在滑车中运动时失去了骨性限制。此外, 评价股骨滑车发育不良还有其他很多参数可供借鉴, 例如滑车倾斜角 $> 11^\circ$ (轴位 MRI), 滑车沟角度 $> 145^\circ$ (Merchant 位: 屈膝 45° , 投照方向由头侧至尾侧与地面成 30°), 股骨外侧髁长度指数 $\leq 90\%$ (矢状面 MRI 下测量), 滑车沟深度 $> 11^\circ$ (轴位 MRI)等。Askenberger 等[21]对首次外伤性髌骨外侧脱位的形态学和解剖学髌骨不稳定风险因素在骨骼未成熟儿童的前瞻性磁共振成像研究得出滑车发育不良是主要的解剖危险因素, 与外侧髌骨倾斜 ($\geq 20^\circ$)一起, 它们与 LPD 的关联最强。Hopper [22]等人引用了 16%的失败率, 失败定义为患者报告的复发性半脱位或复发性脱位。他们根据滑车发育不良的严重程度对失败进行分层, 发现 100%的“严重”滑车发育不良(Dejour C 型和 D 型)患者有复发性不稳定, 而“轻度”发育不良(Dejour A 型和 B 型)患者为 7.4%。股骨滑车发育不良降低了髌骨外移的骨性限制力量, 容易脱位。

2.2. 胫骨结节 - 滑车间沟(TT-TG)距离增大

胫骨结节与滑车凹槽间距(TT-TG 间距)在 CT 平面上测量平均值为伸直位(16 ± 4) mm, 屈曲位(9 ± 4) mm。目前对于需要手术纠正的 TT-TG 间距阈值尚无统一结论, 部分学者将 TT-TG 间距 > 20 mm 作为胫骨结节内侧化手术指征, 他们认为增大的 TT-TG 值与复发性髌骨脱位相关[3]。因此, 能够使胫骨结节外侧化、膝扭转角增大、滑车沟位置改变等因素都会引起 TT-TG 值增大[4] [23] [24], 增加髌骨脱位风险。

Valkering [25]等研究发现更高的 TT-TG 值导致更小的 Kujala 分数提高。然而, TT-TG 值会随着生长发育而变化,在约 16 岁时, TT-TG 值相较于稳定,这和骨骺闭合是相关的[26]。TT-TG 测量值也会随着患者年龄和身高的变化而变化,身高每增加 1 cm, TT-TG 就会增加 0.12 cm,研究者建议 TT-TG 值与患者身高进行标准化以控制距离变化,并且应该在髌骨不稳定患者的检查和管理中进行[27]。TT-TG 值增大,往往预示着膝关节增大解剖及力线异常,因此其值(≥ 20 mm)也作为手术决策因素之一。

2.3. 高位髌骨

高位髌骨可能是复发性脱位的独立诱发因素。通常髌骨在膝关节开始屈曲时即进入滑车,滑车的骨性结构限制并维持正常髌骨轨迹。髌骨初始位置过高,在屈膝开始阶段($0^{\circ}\sim 30^{\circ}$),髌骨会延迟进入滑车沟,因股骨滑车的近端失去了滑车外侧面的骨性阻挡,若髌腱和股四头肌的合力朝外或承受向外扭转应力时,易外侧脱位。如果膝关节屈曲超过 30° 时出现持续不稳定可能提示髌骨异常高、严重滑车发育不良、胫骨结节-滑车沟距离病理性增加或这些因素的组合[28]。髌骨高度评估方法常用 Caton-Deschamps 指数,通常在屈曲 30° 膝关节标准侧位 X 线片上测量髌骨高度,正常值是 0.8~1.2, >1.2 为高位髌骨。有研究发现该指数与髌骨脱位有关[29] [30]。另外,髌腱长度也被发现与髌骨脱位有关,长度 > 52 mm 为异常值[31]。Sappey-Marinier 等[32]对一系列至少随访 3 年的 211 例复发性髌骨不稳定的孤立性 MPFL 重建失败的临床结果和预测因素分析,得出高位髌骨为其高危因素。高位髌骨改变了髌骨与滑车接触的时间及稳定性,降低了股骨对髌骨外向移位的限制,导致更易脱位。

2.4. 髌骨倾斜增加

髌骨倾斜可以在 CT 上测量,通过髌骨长轴的延长线,与通髌线的夹角,即为髌骨倾斜角。髌骨倾斜角与股四头肌尤其是股内斜肌发育不良有关,也和滑车发育不良有关,其正常值介于股四头肌松弛时的 10° 和紧张时的 20° 之间[33]。有学者指出髌骨倾斜角大于 20° 是病理性的[34]。髌骨倾斜的增加,使髌骨侧向基础应力增加,更容易发生脱位。Neri [35]等研究发现术前髌骨倾斜度较高且仅对倾斜进行小幅矫正的患者以及股骨隧道错位(与隧道加宽相关)的患者临床结果改善较少。髌骨倾斜增加是多种因素致使膝关节不稳定的综合表现,其值越大,可能预示更高脱位风险。

2.5. 膝关节外侧支持结构挛缩

膝关节外侧支持结构对髌骨形成外向牵拉,当其挛缩紧张时,增加了髌骨外向合力及髌骨倾斜,使髌骨更容易外侧脱位;研究发现在膝关节屈曲 30° 之前,外侧拉伸应力显著增加,这支持髌骨半脱位/脱位发生在大约 20° 至 30° 膝关节屈曲角度的临床发现[36]。髌股疼痛患者的内外侧支持带厚度增加,表明与髌股疼痛发病机制相关的结构可能变化[37]。相应的术中行外侧支持带松解手术也可取得良好术后效果[38]。

2.6. 股四头肌功能障碍

股四头肌在髌骨的水平与垂直运动中有重要作用。股外侧肌与股骨矢状面成 $7^{\circ}\sim 10^{\circ}$ 的外向牵拉;股内侧肌斜与股四头肌肌纤维方向成 $50^{\circ}\sim 70^{\circ}$ 角向内侧牵拉限制髌骨向外侧脱位,是对抗股外侧肌牵拉稳定髌骨的重要动力性因素, Liu 等[39]利用磁共振成像(MRI)和弥散张量成像(DTI)评估复发性髌骨脱位患者的股内侧斜肌(VMO)纤维束,发现 VMO 的功能状态与复发性髌骨脱位密切相关。同样的, Shu [40]等在复发性髌骨脱位患者的核磁共振图像中测量了与 VMO 相关的形态学参数和髌骨倾斜参数(髌骨倾斜角、平分偏移比),发现复发性髌骨脱位患者明显存在 VMO 和髌骨倾斜异常,且具有相关性。当股外侧肌挛缩或肌力增强,股内侧斜肌萎缩或功能不足时,髌骨在运动时外向合力增大,容易外侧

脱位。Stephen 等[41]的研究结果支持股四头肌(特别是股内侧肌)强化对于抵抗髌骨外侧轨迹不良和重新平衡髌股关节接触压力远离外侧关节面的作用。Beit 等[42]也证实了 VMO 特征改变(肌肉横截面积)与髌骨不稳定之间存在统计学上显著的关联。股四头肌的功能障碍,可直接影响 Q 角,破坏髌骨的稳定性。

2.7. 内侧髌股韧带(MPFL)异常

内侧髌股韧带是限制髌骨外侧脱位的主要限制力量。核磁研究[43]表明 MPFL 的形态随上髌间距离、外髌距离以及患者年龄的不同而变化,其厚度与外髌和上髌间距离呈正相关,与患者年龄呈负相关。这或许能解释当存在高级别滑车发育不良时,内侧髌股韧带也很大程度上存在异常。生物力学研究表明 MPFL 提供总限制力量中的 50%~60%,在急性髌骨脱位的病例中,MPFL 的损伤几率高达 95%以上[44]。Felus 等[45]研究了 50 名创伤性髌骨脱位患者,也发现 94%的病例在手术时存在内侧髌股韧带损伤,最常见于髌骨附着处(66%),其次是纤维中部(50%)和股骨附着处(32%),46%的患者损伤发生在不止一处。而且在复发性髌骨脱位病例中,MPFL 基本都不正常。若对这些创伤性髌骨脱位患者行保守治疗,很可能因为 MPFL 损伤后对髌骨外移限制不足而复发。因此,内侧髌股韧带损伤或缺陷是复发性髌骨脱位或是急性髌骨脱位后髌骨不稳定的主要致病因素。

2.8. 膝关节外翻

膝外翻是较常见的一种下肢力线异常,为已确定的复发性髌骨脱位危险因素,从生物力学角度来看,其会增加髌骨的侧向力,增加轨迹不良(髌骨倾斜和半脱位),减少接触面积,并增加髌股关节的压力[5]。外翻膝力线位于膝关节外侧,导致髌腱和股四头肌之间成角增大,使髌骨承受过度的外向合力,增加髌骨脱位风险[46]。此外,膝外翻还是固定性髌骨脱位的高危因素。

2.9. 胫骨结节外侧化(外扭转)

胫骨结节过度外偏会使髌腱对髌骨向外牵拉力增大,增加 Q 角及 TT-TG 值,从而增加髌骨脱位风险。研究发现[47]胫骨结节扭转与 TT-TG 距离、髌骨倾斜度和髌骨侧化之间存在良好的相关性,相关系数大于 0.85。有生物力学研究证实了通过胫骨结节内扭转能改善髌骨的不稳定[4]。

2.10. 股骨前倾增大

股骨前倾角过度增大会导致患肢在步态的负重期出现代偿性大腿内旋,将大粗隆由后方旋转至侧方以增大臀中肌的力臂。研究表明,20°的股骨内扭转可能是 MPFL 完整的复发性髌骨脱位的危险因素,而当 MPFL 异常时,10°扭转异常则可能是危险因素[48]。MPFL 重建作为一种孤立疗法似乎仅对股骨前倾增加 10°是合理的,而对增加 20°的股骨前倾,侧化力矢量仍然存在,建议进行额外的股骨去旋转截骨术[49]。股骨前倾角增加(>30°)的患者术后临床结果较差,包括髌骨松弛度更大、残余 J 征发生率更高以及内侧髌股韧带重建和胫骨结节联合截骨术后患者报告的结果更低[50]。股骨前倾角增大增加了髌骨外侧向力及 Q 角,增加了髌骨脱位发生的可能。

2.11. 体重指数(BMI)增大

BMI 也被认为是复发性髌骨脱位的危险因素[51]。体重指数的增加加重了下肢的负担,引起力学环境的改变,如果存在引起髌骨外侧应力或 Q 角增大的因素(如外翻膝),则会增加髌骨脱位风险。

2.12. Q 角增大

Q 角即股四头肌角,其大小在一定程度上可以表示髌骨的外向矢力大小,Q 角越大,髌骨外侧合力

越大,越易脱位。虽然近来 Q 角的地位因胫骨结节-滑车沟距离而下降[31]。但复发性髌骨脱位病因复杂, Q 角的存在仍需重视[52]。

2.13. 多发韧带松弛

多发韧带松弛表现为关节过度活动,关节过度活动是髌骨不稳定的危险因素,该类患者在髌骨稳定手术后效果不佳,需要进行术后监测,多发韧带松弛会导致髌骨稳定结构的限制力量减弱,使关节过度活动,当合并其他高危因素时,髌骨更容易外侧脱位[53],关节过度活动(全身多发韧带松弛)是髌骨不稳定的危险因素,识别高风险人群可能有助于预防脱位并进行适当的治疗。另一荟萃分析也发现关节过度活动综合征(JHS)患者需要后续手术和翻修手术干预的髌股不稳事件的几率较对照组显著增加[54]。

2.14. 扁平足

扁平足是下肢常见的畸形,表现为前足旋前、跟骨外翻,足底负重面积增大。这一系列的改变会导致膝关节胫骨结节外偏增大,研究[55]表明扁平足会导致 Q 角增大,增加髌骨外侧脱位风险。类似的研究也证实了扁平足和 BMI、Beighton 评分、Q 角之间存在相关性,且研究者认为青春期体重过重和韧带松弛是扁平足和髌骨不稳定的危险因素[56]。扁平足会引起膝关节内旋增加,加重膝外翻,增大 Q 角,增加髌骨脱位风险。

2.15. 髌骨发育不良(形态异常)

髌骨的形态对髌股关节的稳定至关重要,髌骨与滑车形态在发育中是相互关联的,越差的髌骨形态往往匹配越差的滑车形态[17]。正常髌骨形态内外侧关节面基本相等,随着发育不良程度增加,内侧关节面逐渐减小,外侧关节面逐渐增大,外侧关节面的显著增大与髌骨脱位相关,可以解释为髌骨形状与其所受拉力相关,外侧关节面大,所受拉力大,更容易外侧脱位[8]。也有类似的观点,Thouvenin 等[57]研究证实了髌骨不稳定患者中髌骨呈现出更大的外侧关节面、更窄的内侧关节面、更平坦的表面以及更内侧的髌骨嵴,相当内侧的髌骨嵴可能会导致髌骨更大的倾斜,并破坏已经受损的髌骨-滑车沟一致性。然而,有研究却得出不一样的结论,Jimenez 等[58]发现有和没有髌骨不稳定的膝关节的髌骨形态变化很大,二者测量值之间未见统计学差异,且认为髌骨形态测量值与滑车发育不良之间的关联极小。Fucentese 等[59]也认为髌骨形态可能不是滑车发育不良膝关节内侧髌股压力缺失的结果,而是内侧髌股牵引力降低的结果,内侧髌股关节的营养不良限制和增加的外侧髌骨倾斜引起内侧髌骨小平面上的张力降低。总的来说,髌骨内外侧形态差异太大,所附着的软组织越不平衡。

2.16. 性别

性别是复发性髌骨脱位的危险因素之一[9]。流行病学调查显示,复发性髌骨脱位总体发病率为 1/1000,在所有膝关节损伤中占 3%,且多见于 10~17 岁青少年女性[60]。Balcerek 等对此现象进行了进一步研究,发现滑车发育不良和 TT-TG 距离增大在髌骨脱位的女性中更为突出,这两个因素都可能导致女性患者髌骨外侧不稳定的风险增加,这一点可以从女性低风险或无风险旋转活动中最常发生脱位的事实来说明[61]。然而,Pruneski [62]等认为骨骼生长和成熟期间髌股关节形态的变化与性别无关,但与年龄有关。总体来说,临床中复发性髌骨脱位患者女性比例偏高。

2.17. 膝关节扭转旋转

膝关节主要由胫股、髌股关节构成,膝关节的胫股旋转,特别是相对的胫骨外旋转,已被确定为导

致髌骨不稳定的潜在因素。Lin [63]等通过调查三个临床队列中不稳定严重程度与胫股旋转程度之间的关系得出胫股旋转的程度与髌骨不稳定的严重程度相关，固定或习惯性脱位患者的胫骨外旋最大，其次是创伤性不稳患者有轻微的胫骨内旋。胫股骨高外旋可能是固定或强制性脱位的重要病理解剖因素，随着进一步了解可能成为预后因素或手术目标，胫骨过度外旋导致足行进角增大，同样通过大腿内旋进行代偿，结果造成了髌骨承受向外的过度应力而出现不稳定。过度的股骨前倾及胫骨外旋增加了膝关节扭转角，间接导致了 TT-TG 及“Q 角”增大。胫股旋转角度增大与髌骨轨迹异常有关，胫股旋转角度增大的患者髌骨轨迹异常通常更严重。类似的，Xu 等[64]的研究表明在多个股骨节段，髌骨脱位患者的股骨扭转比健康人更大，过度的股骨中段、远端和总扭转与更显著的髌骨倾斜有关。同时，由于膝关节在接近伸直时会出现生理性的胫骨外旋现象，扭转角过大，髌骨在运动时更容易脱位。

2.18. 家族基因遗传

复发性髌骨脱位的遗传性是已知的，但其易感基因尚未明确。有研究[65]报道 HOXB9 基因、SLC26A2 基因为髌骨脱位的可能致病基因或相关基因。有学者[66]通过外显子测序发现羧肽酶 D (CPD)基因根据其基因功能和组织表达与髌骨脱位显示出较高的相关性。同时 Parikh [9]等发现滑车发育不良的所有线性测量值(髌高度、滑车高度、滑车隆起)均随着年龄的增长而增加。然而，滑车发育不良的形状，如沟角和 Dejour 分类所反映的，并没有随着年龄的增长而改变。滑车发育不良的形状很可能是一种遗传倾向，在骨骼生长过程中不一定会改变[67]。髌骨脱位是一个发育性疾病，涉及下肢骨软组织的发育，基因的显性及外部因素都可能影响研究，造成研究差异。

2.19. 第一次脱位年龄

研究发现当存在不成熟的骨骺和滑车发育不良时，首次髌骨脱位患者转变为复发性髌骨脱位的发生率为 69%，这意味着低年龄患者中发生 RPI 的可能性高出 3.3 倍[68]。Pruneski [62]等研究发现髌骨高度 (Caton-Deschamps 指数)、外侧髌骨倾斜角、滑车高度、滑车沟深度、滑车沟角和胫骨结节-滑车沟(TT-TG)距离都发生者显著的年龄相关变化。一般来说，髌骨不稳定的大多数解剖学风险因素随着成熟度的变化而朝着有助于降低髌骨不稳定和/或脱位风险的方向发展。唯一的异常值是 TT-TG 值，它随着年龄的增长而增加，这强调了年龄在解释受伤风险方面的重要性，特别是第一次脱位年龄，年龄越小，维持髌骨稳定结构越差，更容易影响后续发育完善。

2.20. 脱位的次数

与初次髌骨脱位者相比，有髌股不稳定病史的髌骨脱位者随后发生髌骨不稳定的风险更大[1]。髌股脱位事件数量的增加与滑车和髌骨/滑车软骨联合损伤的发生率更高以及损伤严重程度更高相关[69]。髌骨与股骨滑车软骨的损伤会破坏髌股关节的匹配性及髌骨周围软组织的生物力学功能，更易造成髌骨脱位。第一次脱位后保守治疗，第二次脱位的概率从 17%~66%不等，第三及更多次脱位可达到 80%以上[70]-[72]。反复的脱位，严重损耗了骨、软组织的限制，提高了后续脱位的风险。

2.21. 髌骨轨迹异常(J 征)

髌骨轨迹异常也是复发性髌骨脱位的危险因素之一，最常见的异常轨迹表现为“J 征”[6]。髌骨轨迹不良是骨软组织异常的综合表现。高度滑车发育不良会增加髌股关节压力并降低膝关节伸展扭矩，使髌骨在运动过程中位置改变，从而导致髌骨轨迹不良[19]。胫股旋转角度增大与髌骨轨迹异常有关，胫股旋转角度增大的患者髌骨轨迹异常通常更严重。研究表明术前高度的髌骨轨迹不良会导致更低的术后临床效果，同时会遗留更多的移植物松弛及髌骨异常轨迹，甚至导致手术失败[32]。

3. 治疗

目前复发性髌骨脱位以内侧髌股韧带重建手术作为基本手术,同时具体结合危险因素增加其他手术,如外侧支持带松解术。有些学者建议当 TT-TG 值大于 20 时,同时行胫骨结节截骨术;滑车严重发育不良(B、D 型)时,可伴行滑车成形术或滑车沟槽加深术;股骨前倾角增大时,可行股骨去旋转截骨术。当合并多种畸形时,手术技术结合病人具体情况实行。

4. 结语

复发性髌骨脱位的危险因素是多样的。他们直接或间接地导致“Q 角”或 TT-TG 值增大,改变了髌骨正常的力学环境,增加外侧应力,导致髌骨外侧脱位的发生。也有学者研究发现年龄、性别、体重指数和高髌骨与复发不稳定没有统计学相关性[68],但该研究纳入患者年龄太小(9~18 岁),很多混杂因素不确定,且终末随访年龄小,可能会降低再次复发率,影响结论的真实性。所以充分地理解及掌握其高危因素,给病人制定具体化、个体化的治疗方案是很有必要的。目前认为,滑车发育不良、TT-TG>20 mm、内侧髌股韧带异常是复发性髌骨脱位的主要影响因素,各种手术也是围绕它们展开。这也就导致了对其其他相对影响较小的高危因素研究的缺乏。有些高危因素或许需要通过手术去平衡,但有些或许不适用。无需实施外科干预的高危因素,或许需要加强功能锻炼去平衡。因为髌骨的动力稳定因素也是重要的。在复发性髌骨脱位的病例中,我们发现,除了扁平足,部分病人还合并高弓足。足弓形态对下肢力线、髌骨脱位的影响又是什么,这就需要进行进一步观察研究。我们只有深入地去研究其高危因素,才能针对具体的病人制定针对性的个体化手术方案及功能康复方案,使病人获得满意的临床治疗结果。

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