

# 胫骨平台后倾角在膝关节置换术中的应用

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## 摘要

全膝关节置换术(total knee arthroplasty, TKA)是治疗各类晚期膝关节骨性关节炎疾病的标准手术之一, 术后可以明显缓解患者膝关节疼痛, 恢复膝关节功能, 极大提高生活质量。胫骨平台后倾角(posterior tibial slope, PTS)是TKA中进行胫骨平台截骨和关节假体植入的重要参数, PTS直接决定了下肢体线及关节处力的传导方式, 截骨不当会导致力线恢复不良、屈伸间隙失衡和假体松动, 影响膝关节功能恢复。尽管PTS在TKA中起到关键作用, 但是目前学者和临床医生尚无法确定最佳的截骨角度。因此本文对PTS在TKA中的应用进展进行综述, 为TKA中PTS的选择提供参考。

## 关键词

膝关节, 全膝关节置换术, 胫骨平台后倾角

# The Application of Posterior Tibial Plateau Inclination in Knee Arthroplasty

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## Abstract

Total Knee Arthroplasty (TKA) is one of the standard operations for the treatment of various advanced osteoarthritis diseases of the knee. It can obviously relieve the pain and restore the function of the knee, greatly improve the quality of life. Posterior tibial slope (PTS) is an important

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parameter in TKA for tibial plateau osteotomy and joint prosthesis implantation. PTS directly determines the line of force of lower limbs and the way of force transmission at joints. Improper osteotomy will lead to poor line of force recovery, flexion-extension gap imbalance and prosthesis loosening, affecting the functional recovery of the knee. Although PTS plays a key role in TKA, currently scholars and clinicians are unable to determine the optimal osteotomy angle. Therefore, this paper reviews the application of PTS in TKA, and provides reference for the selection of PTS in TKA.

## Keywords

Knee, Total Knee Arthroplasty, Posterior Tibial Slope

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## 1. 引言

膝关节是人体内最复杂的关节之一，在进行 TKA 期间，需要考虑到各种角度和轴线，冠状位、矢状位或轴状位的微小改变都可能会显著影响术后膝关节的功能[1]。PTS 的改变会改变股骨平移范围、伸肌的力臂以及膝关节最大屈曲的可能[2] [3]。在 TKA 术中植入胫骨组件期间，PTS 是必须要考虑的因素。

## 2. 胫骨平台后倾角的测量方法

### 2.1. PTS 的测量方法

20 世纪 90 年代初 Hofmann [4]证实了人类胫骨上存在这一解剖结构胫骨平台后倾角，胫骨平台后倾角一般定义为胫骨解剖轴线(tibial anatomic axis, TAA)的垂线与胫骨平台前后向切线之间的夹角[5]。由于选择参照轴和检查方式的不同，PTS 的测量方法多达数种。

#### 2.1.1. 测量 PTS 的参照轴

在测量 PTS 时的参照轴线有多种，常用的参照轴包括胫骨近端解剖轴(TPAA)、胫骨骨干解剖轴(TSAA)、腓骨近端解剖轴、腓骨骨干解剖轴、胫骨中上段前侧骨皮质延长线即胫骨前皮质轴、胫骨后侧骨皮质延长线即胫骨后皮质轴[6] [7] [8]。Bao [9]等采用胫骨前皮质轴作为参照轴测量 PTS；Chen [10]等同样以胫骨前皮质轴作为参照轴来测定中国正常成人的 PTS；Karimi [11]等选择以胫骨后皮质轴为参照轴进行 PTS 的测量也顺利完成了研究。Brazier [7]等在 X 线片上测量 PTS，研究发现以胫骨近端解剖轴、骨干解剖轴、后皮质轴作为参照轴测得的 PTS 之间存在相关性。Zhang [12]等分别采用胫骨近端解剖轴、前皮质轴和后皮质轴作为参照轴通过三维 CT 重建来测量 PTS，经对比虽然三种方式测定的 PTS 不同，但是彼此之间存在显著的相关性，故而均可在测量时使用。在 TKA 中，大多临床医生喜欢采用髓外定位测量 PTS，因定位杆接近平行于胫骨前皮质轴，所以操作更方便，相关数据获取也变得容易，故大多学者在研究 TKA 中的 PTS 时也多采用胫骨前皮质轴作为参照轴进行测量。

#### 2.1.2. PTS 的影像学测定

X 线片、CT 和 MRI 常用于测量 PTS，三者各有利弊。选择 X 线片测量 PTS 时，难以对胫骨内外侧平台单独进行评估[13] [14]。在 CT 和 MRI 图像上测量 PTS 虽然更易区分胫骨内外侧平台，但是在大多

数常规扫描中仅观察到胫骨的近端,无法确定胫骨解剖轴[14],同时CT与MRI由于其高昂的成本仍难以被大多数患者所接受。

在膝关节影像学检查方式中X线片因其操作简便、易于获取、成本低廉等优点,临床医生大多倾向于选择在X线片上进行PTS的测量[15]。另外与短侧位膝关节X线片相比,在长侧位膝关节X线片上测量PTS会更加准确,在短侧位膝关节X线片上只能进行PTS的估计[14][16]。

### 3. PTS与种族、性别的关系

大量研究报告证明,PTS存在种族之间的差异。Weinberg [17]通过对Hamann Todd骨科收藏馆(Ohio, USA)捐赠的545具尸体标本(1090个胫骨)建立三维数字化模型进行测量分析,结果显示PTS间存在着种族差异。Pangaud [18]等运用CT建模和分析系统(SOMA; Stryker)测量378例受试者的PTS后分析发现,亚洲人种与白色人种的PTS存在显著差异。Clinger [19]等通过随机选取新墨西哥州后裔成像数据库中250个带有全身CT扫描的数据样本,通过测量PTS并分析得出平均PTS为 $8.92^\circ$ (范围,  $-9.4^\circ$ 至 $14.95^\circ$ ),且与白色人种相比,非裔与亚裔的PTS有所增加,PTS存在种族间差异。

截至目前,对于不同性别之间的PTS是否存在差异尚存在争议。Kacmaz [20]等在膝关节X线片上回顾性测量了1024名土耳其人的PTS,分析发现男性PTS为 $8.57^\circ \pm 3.4^\circ$ (范围 $2.3^\circ \sim 17.4^\circ$ ),女性PTS为 $8.16^\circ \pm 3.2^\circ$ (范围 $2.1^\circ \sim 18.7^\circ$ ),男性PTS高于女性;Misir [21]等同样研究了土耳其人群的PTS,他们回顾分析了1000名健康受试者的MR图像,分析后却得出PTS在两性间没有差异。Medda [22]等在膝关节X线片上来测定印度成年人群的PTS,TPS从 $6^\circ$ 到 $24^\circ$ 变化很大,平均值 $\pm$ 标准差为 $13.6^\circ \pm 3.5^\circ$ ,通过非配对t检验比较男性和女性TPS显示没有性别二态性;然而,Haddad [23]以胫骨近端解剖轴为参照轴在MR图像测量亚洲人群的PTS揭示了PTS的性别差异。Chen [10]等发表的中国健康成人PTS的回顾性队列研究显示,左侧PTS男性( $7.22^\circ \pm 3.89^\circ$ )明显小于女性( $8.05^\circ \pm 3.60^\circ$ ),左右侧PTS差异无统计学意义,Chen等认为中国健康成人的PTS因性别不同存在显著差异。Koh [24]运用三维磁共振成像技术测量患有Kellgren-Lawrence3级和4级骨关节炎患者的PTS,得出了PTS存在性别差异的结论,同时Koh还提醒外科医生应注意接受TKA患者PTS的性别差异性。Bisicchia [25]分别以胫骨后皮质轴和胫骨近端解剖轴为参照轴在X线片上进行PTS的测量,分析认为性别影响导致PTS的差异不足以在临床实践中产生影响。综上所述,不同性别之间是否存在差异尚有待进一步研究。

## 4. PTS在全膝关节置换术中的应用

### 4.1. PTS的变化对膝关节功能的影响

研究发现胫骨平台后倾角度的增加会加大聚乙烯衬垫、胫骨截骨面、胫骨干处的应力峰值,应力峰值过大会增加假体磨损及松动的风险,使术后出现关节疼痛或进行假体翻修的可能性增加[26]。Wang [27]等研究结果显示PTS较大的后交叉韧带替代型全膝关节置换术(PS TKA)会使得股骨后移更多、接触面积更大、接触压力更小,因此适当增加PTS可能有益。Mizu-Uchi [28]提供的生物力学证据证明,在保留后交叉韧带型全膝关节置换术(CR TKA)中较小的PTS合并胫骨内部旋转不良是增加膝关节潜在疼痛的来源。Ismailidis [29]等分别在 $0^\circ$ ,  $3.5^\circ$ ,  $7^\circ$ 和 $10^\circ$ PTS下切除6mm胫骨,通过观察胫骨解剖轴(TAT)位置的变化来研究PTS的变化是否会造成TKA中胫骨组件的旋转对中不良,虽然最后得出的结果有统计学意义,但Ismailidis认为ATA随PTS的变化可以忽略不计。

### 4.2. TKA中PTS的选择

目前,在近端胫骨截骨中最佳角度的选择尚存在争议。国内学者中,李健[30]等认为TKA术中胫骨

截骨应符合髓内参照法 5°或髓外 8°进行截骨,从而恢复合理的后倾角度来获得更好的术后功能。Shi [31]等研究发现增加后稳定型 TKA 的 PTS 可增加膝关节最大屈曲度,即使 PTS 超过 10°也不会影响膝关节的稳定性,同时考虑到 PTS 过大对聚乙烯衬垫的磨损建议选择 5° PTS 以使膝关节活动获得最大屈曲度。

国外学者中,Okamoto [32]等研究发现,在后稳定 TKA 中 PTS 应小于 5°以便获得更好的膝关节稳定度。在后稳定 TKA 中当 PTS 为 7°时 Mizu-Uchi 等观察到股骨前运动异常,但是在 PTS 为 3°处没有观察到,这与 Okamoto 报道的一致[28]。Sinno [33]等以 5°为界限将全膝关节置换术后的患者分为两组即 PTS < 5°和 PTS > 5°,研究发现当进行后稳定 TKA 时,术后 PTS > 5°会获得最佳手术效果(采用术后膝关节功能评分评价手术效果)。Singh [34]等主张恢复解剖学上的 PTS,在膝关节冠状面对齐的前提下,恢复生理 PTS 可最大限度增加后稳定 TKA 术后患者的膝关节运动范围和屈曲角度。

## 5. 总结

综上所述,胫骨平台后倾角是膝关节非常重要的标志,在膝关节手术特别是膝关节置换术中是一个必须要考虑到的因素,胫骨平台后倾角度的变化会对下肢产生很多方面的影响。在膝关节置换术中对于最佳胫骨平台后倾角度的选择尚没有一个较为统一的观点,过大或者过小的胫骨平台后倾角都会对膝关节的活动产生部分积极或者消极的影响,因此在行膝关节置换术时,应充分评估患者,同时考虑冠状位和矢状位的力线,综合优缺点后选择合适的胫骨平台后倾角度,以期获得最佳的疗效。

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