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全髋关节置换术后下肢不等长研究进展

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摘　要

下肢不等长是全髋关节置换术后最常见的并发症之一。尽管下肢不等长的幅度是可变的，但一般 > 10 mm通常是不可接受的，因此应尽一切努力将其最小化。因此，了解下肢不等长的分类、发生率、测量方式、发生因素、影响、预防和治疗措施是必要的。本文就全髋关节置换术下肢不等长关于上述内容进行综述，希望可以帮助骨科医生更加了解和认识全髋关节置换术下肢不等长的研究进展，以期更好地防治下肢不等长，使患者获得良好的下肢功能与满意度。

关键词

全髋关节置换术，真实性(结构性)下肢不等长，感知性下肢不等长

Research Progress on Leg Length Discrepancy after Total Hip Arthroplast

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Abstract

Leg length discrepancy (LLD) is one of the most common complications following total hip arthroplasty (THA). Although the degree of LLD varies, a discrepancy exceeding 10 mm is generally considered unacceptable, and every effort should be made to minimize it. Therefore, it is essential to understand the classification, incidence, measurement methods, contributing factors, clinical impact, and preventive and corrective measures for LLD. This article provides a comprehensive review of LLD after THA, focusing on the aforementioned aspects. The aim is to enhance orthopedic surgeons' understanding of current research advancements in post-THA LLD, thereby improving its

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prevention and management to achieve optimal lower limb function and patient satisfaction.

Keywords

Total Hip Arthroplasty, True (Structural) Leg Length Discrepancy, Perceived Leg Length Discrepancy

1. 引言

全髋关节置换术(total hip arthroplasty, THA)是治疗老年股骨颈骨折，中重度髋关节骨关节炎，中晚期股骨头坏死的有效可靠手段，可减轻疼痛并改善髋关节功能[1] [2]。THA 在全世界范围内广泛开展，被誉为 20 世纪最成功的手术。随着手术技术的成熟、假体的更新以及功能康复计划的完善，越来越多的 THA 术后患者髋关节功能得以恢复，生活质量明显提高。在不影响髋关节稳定性的情况下纠正肢体长度不等是 THA 的主要术中挑战之一[3]。骨科医生在术中控制良好的股骨偏移量和腿长恢复髋关节生物力学可以使患者获得更好的步态和功能[4]。通常，实现疼痛缓解和提高稳定性优先于恢复等腿长[5]。肢体不等长(leg length discrepancy, LLD)是 THA 术后的常见问题，显著的 LLD 会导致跛行、腰痛、步态障碍和神经功能障碍，其是 THA 后引起患者诉讼和不满的主要原因之一[5]-[7]。LLD 包括影像学 LLD (radiological leg length discrepancy, RLLD)和感知性 LLD (perceived leg length discrepancy, PLLD)。通常来说，医生更加关注术前及术后骨盆片上的 RLLD，并且根据 RLLD 的情况来制定平衡肢体等长的手术计划，而患者更加关注 PLLD。RLLD 和 PLLD 是二种不同概念，骨科医生要清楚地认识到二者的区别和联系，做到综合分析 LLD 的危险因素、术前 LLD 程度以及运用术前、术中技术，选择合适的假体，调整最终的腿长，最大限度地减少术后 RLLD 和 PLLD 的发生。

2. LLD 的分类

LLD 可以分为真实性(结构性) LLD 和感知性(功能性) LLD。真实性 LLD 定义为两肢长度的解剖学差异，可由自身疾病导致，如终末期骨关节炎或解剖异常如先天性畸形和髋关节发育不良[8]。对于行 THA 的患者，真实性 LLD 还可以由假体头颈距离延长和部件错位引起的[9]。在研究中，真实性 LLD 通常用影像学检查上的肢体差异来替代，即影像学 LLD (RLLD)。感知性 LLD (PLLD)是髋关节生物力学改变的结果，由于髋关节软组织挛缩、骨盆倾斜或脊柱侧弯等因素，导致患者肢体长度不一致的主观感觉[8] [10]。

3. LLD 的发生率

术前 LLD 通常发生在髋关节疾病的中晚期，此时股骨头变形，软骨磨损严重，甚至出现髋关节脱位。如中晚期的股骨头坏死、髋关节骨性关节炎，先天性髋关节发育不良(Crowe III 或 IV 型)。Gurney B 报道了一般人群中 LLD 的发病率为 90%，差异范围从 2.4 mm 到 6. 8 mm (平均差异幅度为 5.2 mm) [11]。Konyves A 等发现 90 例行 THA 患者术前有 83 例存在 RLLD，其中 65 名患者感到患肢缩短[12]。一篇综述经过广泛的文献回顾，THA 术前 LLD 的范围从−70 mm 到+14 mm 不等，平均术前 LLD 从−0.5 mm 到−7.5 mm 不等[13]。

术后 LLD 在文献报道的发生率有所不同。García-Juárez JD 等发现 252 例 THA 术后有 45.63%患者

LLD 小于 10 mm，28.17%患者 LLD 大于 10 mm，其中 6 例 LLD 大于 20 mm [14]。一篇关于 191 例接受标准化 THA 术后的研究发现 8.9%患者患肢缩短，90.6%患者患肢延长，其中 21.5%患者变长超过 10 mm [15]。一篇综述报道，初次 THA 术后 LLD 的范围从 1%到 27%不等，从 3 到 70 mm 不等，平均从 3 到 17 mm 不等。短缩比延长更常见，≥1 cm 的 LLD 在有 LLD 的病例中高达 50% [6]。

PLLD 可能存在于解剖学上相等长度的肢体中。LLD 的两种病因共同作用形成患者对其肢体长度的最终感知[8]。因此 RLLD 与 PLLD 往往存在着不一致性。已有众多文献报道，Wylde V 等对 1114 名初次行 THA 手术患者进行调查，发现约 30%的患者存在感知 LLD，但经过影像学分析发现在存在感知 LLD 患者中仅 36%存在真实 LLD [16]。Pakpianpairoj C 等对 151 例 THA 术后双下肢不等长的患者进行调查，发现 79 例术后存在真实 LLD，其中 41 例存在 PLLD，下肢不等长平均差别为 14 mm 的患者中只有 30%能感觉到双下肢不等长的存在[17]。Lazennec 等报道，无论手术侧和非手术侧股骨解剖长度的差异如何，大约 50%~60%的患者存在 PLLD，即使差异只有 1 mm 也是如此[18]。Kawakami 等发现 25.6%的患者在 THA 术后 1 年出现下肢不等长，其中 57.1%的患者 RLLD 小于 5 mm [19]。Konyves A 等也报道了一些存在感知 LLD 患者并没有真实 LLD [12]。

4. LLD 的测量方式

4.1. 临床测量方式

临床上测量 LLD 一般用卷尺来完成，真实肢体长度和表观肢体长度是临床评估 LLD 的 2 种方法[20]。真实肢体长度为髂前上棘到内踝的距离。表观肢体长度为脐到内踝的距离。真实肢体长度代表肢体的长度，而表观肢体长度考虑了导致不同腿长的所有因素，如骨盆倾斜或软组织挛缩。表观肢体长度包括了真实的肢体长度差异，以及所有导致腿长不平等的因素。卷尺测量评估 LLD 简单直接，但因其存在定位困难、测量误差较大及易受体位和下肢畸形影响，卷尺测量的准确性和重复性较低。在患肢下放置不同高度的木块测试有助于量化明显的腿长差异，以此来测定 PLLD [21]。具体方法为患者用感知较短的下肢踩踏木垫，记录当患者感知双下肢等长时木垫的厚度。检查时嘱患者站立，不扶扶手，背部伸直，双膝伸直。Badii 等比较卷尺测量、木块测量和影像学方法的可靠性，他们发现木块测量优于卷尺测量，但不如影像学测量[22]。

4.2. 影像学测量方式

前后位骨盆片是目前临床上及文献报道最常用的影像学测量方式，测量时一般在骨盆片上选取几个相对稳定骨盆和股骨标记。股骨标记点有：股骨头中心、小转子顶点、股骨大转子顶点。骨盆的参考线有：髋臼泪滴最低点的连线、坐骨结节的连线、髂嵴最高点连线。两侧股骨标记点到骨盆参考线的距离差即为 RLDD。Williamson 等描述的方法中测量了坐骨结节连线与小转子顶点之间的距离[23]，而在 Woolson 等描述的方法中测量了髋臼泪滴最低点连线与小转子顶点之间的距离[24]。以上二种方法在文献中占主导地位，并在临床实践中广泛应用。但 Meermans 等进一步报道股骨头中心比小转子顶点更适合作为股骨参考点[25]。

下肢全长片在测量 LLD 也发挥着重要的作用[26]-[28]，尤其是在对于存在明显 LLD 时，如先天性髋关节发育不良(Crowe III 或 IV 型)等。Tipton 等报道在骨盆的 AP 片上计算的 LLD 与在下肢全长片上计算的 LLD 不具有可比性，因此仅使用骨盆片来评估 LLD 是不充分的[29]。确定真正的 LLD 之前需要考虑除骨盆以外的下肢来源。由于 THA 术后 LLD 唯一的相对变化是在髋关节内，因此使用骨盆片作为 THA 术前与术后的比较是可以接受的，但不建议使用骨盆正位片来预测真正的术前 LLD。

CT 检查来测量 LLD 在临床上无疑是一种精确和可靠的方法。Sariali 等认为在全髋关节置换术计划

中，基于计算机断层扫描的三维技术比二维测量具有更高的可靠性[30]。但 CT 因其价格昂贵，放射性较大，在临床上的使用远不及 X 线。

5. LLD 发生的因素

真实性(结构性) LLD 具体表现为患者双下肢长度的解剖学差异，是客观存在的，任何导致构成下肢长度部分的结构畸形均会导致。PLLD 的发生因素通常包括了真实性(结构性) LLD 发生的因素。故下面主要将对导致患者发生 PLLD 的危险因素做一总结。

5.1. 脊柱活动度和骨盆倾斜

髋-骨盆-脊柱的代偿关系与 THA 术后 PLLD 的发生也起着关键作用，当存在 LLD 时，患者的骨盆通常会在冠状位发生旋转，来代偿这种肢体差异，即使在轻微的 LLD [31]。这种骨盆补偿取决于脊柱骨盆复合体在冠状面的足够活动性。当脊柱发生相关病变或有脊柱手术史，脊柱的活动度会下降，导致这种调节机制能力的降低。Pheasant MS 报道既往有脊柱融合病史的患者似乎更有可能在 THA 后出现 PLLD、跛行报告和腰痛恶化，即使在较小的 RLLD [32]。Koga D 等发现术前骨盆倾斜和腰椎灵活性与 THA 后的 P-LLD 有关，骨盆倾斜向患侧而且腰椎活动度较差的患者往往更倾向于感知 LLD [21]。Takemoto G 探究了发育不良髋关节骨关节炎患者术前 RLLD 与 PLLD 不一致性的原因，发现其独立危险因素是骨盆倾斜角度和较长的 RLLD [33]。随后，Takemoto G 又调查了术后 PLLD 发生影响因素，他们发现尽管没有 RLLD (≤5 mm)，25%的患者经历了 PLLD，与 THA 术后 PLLD 相关的独立危险因素是术前较大的 POA 和骨盆向手术侧倾斜[34]。Omichi Y 还报道发现术后骨盆倾斜也是术后 PLLD 的重要指标[35]。

5.2. 关节假体位置与股骨形态

旋转中心(COR)和股骨偏心距(FO)是髋臼假体常用的位置参数。有研究表明，髋关节的 COR 越高，相应的患肢长度就越低[20] [36]。FO 重建不足会导致外展肌的臂力降低，最终也会导致 LLD 和跛行[37]。髋关节外展肌群也可能与 THA 术后 PLLD 的发生有关。Kinoshita K 发现术前髋关节外展肌弹性模量是影响 THA 后一个月 PLLD 的术前因素，如果患者弹性模量的值越高，表明肌肉越僵硬，其术后发生 PLLD 概率越高[38]。Huang Z 等研究表明，股骨近端形态(CFI)和术后髋臼假体位置(VCOR)影响 LLD，而股骨假体填充对 LLD 无影响。高 CFI 是术后 RLLD 和 PLLD 的独立危险因素，较低 VCOR 是术后 RLLD 的独立危险因素[39]。高 CFI 的患者，骨科医生在植入股骨假体时，因为股骨髓腔较小，而股骨假体型号有限，有时最小号仍难以进入骨髓腔，难免导致肢体的延长。

5.3. 其他因素

Mavčič B 指出 BMI < 26 kg/m^2、身高 < 1.75 m 的身体综合尺寸是 THA 术后主观感知 LLD 的独立危险因素[40]。还有文献报道 LLD 的感知与双膝关节畸形(屈曲/反曲角度差异)以及双侧胫骨平台中部到地面的距离差异相关[18]。LLD 的感知可能还与年龄相关，老年患者不太容易出现 PLLD [41]。

6. LLD 的影响

LLD 的影响在短期内主要为患者关节疼痛、跛行，中远期可因髋－骨盆－脊柱代偿关系出现骨盆扭转、脊柱侧凸，反而引起腰背部疼痛[42]；更有甚者出现神经麻痹、假体松动脱位而需要进行翻修手术[43]。有研究表明出现步态偏差可能从 LLD > 1 cm 的差异开始出现，并且随着 LLD 的增加而增加。最常见的步态偏差出现在踝、膝和髋关节的矢状面，通常表现为较长一侧肢体的踝背屈、屈膝和髋的增加[44]。神经损伤是与肢体长度不等相关的最严重并发症[5]。Edwards BN 等人对 THA 术后发生腓肠神经和坐骨神

经麻痹病例进行了回顾，发现腓骨神经麻痹的平均延长长度为 2.7 cm (1.9~3.7 cm)，而坐骨神经麻痹的平均延长长度为 4.4 cm (4.0~5.1 cm) [45]。Mihalko WM 的研究则认为 THA 术后出现坐骨神经及股骨神经损害的下肢延长阈值为 2.5 cm [46]。

目前也有部分研究探讨了 PLLD 对患者功能的影响。Kawakami T [19]和 Konyves A [12]均发现感知术侧延长患者的功能低于未感知 LLD 和感到短缩的患者。Wylde 等人通过邮件随访了 THA 术后 5 年至 8 年情况，发现感知 LLD 有较差的功能结果[16]。Waibel FWA 还报道了 THA 后 PLLD 与新发下腰痛相关[47]。

7. LLD 的预防

THA 术后 LLD 几乎是不可避免的，不管是 PLLD 还是 RLLD，我们都无法完全消除，但明显的 RLLD 和 PLLD 往往给患者带来不良的功能异常和较差满意度。关于病人对 RLLD 的耐受情况文献报道各不相同，一般来说，<1 cm 的 RLLD 被大多数临床医生和病人认为是可以接受的[18] [23] [48]。因此我们建议通过联合使用术前和术中技术，尽一切努力最大限度地减少术后肢体长度差异。

目前技术主要是通过模板技术来实现，模板的使用是获得可接受的肢体长度临床结果的第一步。行 THA 患者术前进行骨盆片检查，骨科医生通常在骨盆片上测量术前 RLLD，观察患侧的髋臼和股骨形态，同时使用假体模板来预测术后假体的髋关节旋转中心和偏心距，从而来选取最适合患者的假体型号。但需要注意的是在 X 线上测量模板可能会存在不准确性。Hofmann AA 等人评估了模板技术的可靠性，他们发现有 50%的病例术中使用的假体和术前模板测量的不一致[49]。X 线的放大和测量误差使得模板技术的准确性下降，使其成为不可靠的方法[12]。此外，模板技术没有考虑髋关节软组织的张力，软组织张力会改变髋关节旋转中心和股骨柄长度。但是术前模板测量仍是必要的，它可以给骨科医生一个参考范围，方便术中假体型号的备用。但术前模板必须与可靠的术中方法相结合，以获得最佳长度。

目前运用于术中平衡 LLD 的技术众多，大致可分为以下几类：(1) 术中直接手动比较双侧髌骨或足跟的位置[5] [50]。(2) 术中比较大转子尖端与股骨头中心的位置[51]。(3) 将克氏针固定在骨上作为参考点，用尺子或类似装置测量假体安装前后的距离[3] [52]。(4) 测量股骨颈截骨前和假体植入后股骨头中心与小转子顶部的距离[53]-[55]。(5) 术中 X 线透视[56]。(6) 术中使用导航系统或机器人技术[52] [57]-[59]。各类技术都有其优势和缺陷，在临床上得以运用，其使用范围主要受医疗条件限制。

8. LLD 的治疗

在大多数情况下，THA 术后 LLD 是功能性的，继发于灵活的骨盆倾斜和关节周围软组织挛缩，术后自身的代偿机制可以改善轻微的 LLD，一般不需要特殊治疗。患者发生 PLLD 在 THA 术后早期最高，并随着时间的推移而降低[12] [60]。进行髋关节活动范围训练或肌肉拉伸改善骨盆倾斜也可能降低 PLLD [41]。当患者有症状的腿长不等时，用于较短肢体的鞋垫是一种简单有效的治疗策略。对于较大的肢体长度不平等和不能耐受提鞋的患者，可以进行翻修手术[9]。

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