

不同程度膝内翻患者初次全膝关节置换术后下肢力线分布与近期临床疗效的关系

刘磊¹, 徐石庄¹, 杨冠杰¹, 郑力¹, 李大地¹, 郭开今¹, 赵凤朝²

(1. 徐州医科大学附属医院骨科, 江苏 徐州 221002; 2. 徐州医科大学, 江苏 徐州 221004)

【摘要】 目的: 探讨不同程度膝内翻畸形患者行初次全膝关节置换术后下肢力线分布与近期临床疗效之间的关系。方法: 自 2016 年 12 月至 2018 年 3 月行初次全膝关节置换术治疗的膝骨性关节炎患者 87 例(101 膝), 男 21 例(25 膝), 女 66 例(76 膝); 年龄 51~85(67.6±7.0) 岁。根据患者全膝关节置换术后下肢髌膝踝角(hip-knee-ankle angle, HKA)不同分为 4 组: 中立位组(A 组), $-3^{\circ} \leq \text{HKA} \leq 3^{\circ}$, 50 膝; 轻度内翻组(B 组), $3^{\circ} < \text{HKA} < 6^{\circ}$, 20 膝; 严重内翻组(C 组), $\text{HKA} \geq 6^{\circ}$, 20 膝; 外翻组(D 组), $\text{HKA} < -3^{\circ}$, 11 膝。比较 4 组患者术前性别、年龄、体质量指数、手术侧别、术前及术后膝关节活动度, 美国特种外科医院膝关节评分(Hospital for Special Surgery Knee Score, HSS), 美国膝关节协会评分(Knee Social Score, KSS), 并分别比较术后股骨、胫骨假体力线分布与近期临床疗效的关系。结果: 所有病例获得随访, 时间(18.4±4.0)个月。4 组患者术后末次随访膝关节活动度、HSS、KSS 评分均较术前提高($P < 0.001$)。4 组患者术后末次随访 HSS、KSS 评分组间比较差异具有统计学意义($P < 0.05$); A 组评分优于 C、D 两组($P < 0.05$), B 组评分优于 C、D 两组($P < 0.05$), A、B 两组间以及 C、D 两组间比较差异无统计学意义($P > 0.05$); 4 组患者术后膝关节活动度组间比较差异无统计学意义。股骨假体力线在 $\pm 3^{\circ}$ 以内组评分优于 3° 以外组($P < 0.05$), 胫骨假体力线在 $\pm 3^{\circ}$ 以内组评分较 3° 以外组差异无统计学意义($P > 0.05$)。结论: 膝内翻型骨关节炎患者初次全膝关节置换术后近期临床疗效与下肢力线分布有关, 力线轻度内翻分布可获得与中立位相似的近期临床疗效, 股骨假体力线分布与初次膝关节置换术后近期临床疗效有关。

【关键词】 膝关节; 全膝关节置换术; 下肢; 膝内翻

中图分类号: R687.4

DOI: 10.12200/j.issn.1003-0034.2020.06.008

开放科学(资源服务)标识码(OSID):



Relationship between lower limb alignment distribution and short-term clinical results after primary total knee arthroplasty in patients with varying degrees of knee varus LIU Lei, XU Shi-zhuang, YANG Guan-jie, ZHENG Li, LI Da-di, GUO Kai-jin, and ZHAO Feng-chao*. *Xuzhou Medical University, Xuzhou 221004, Jiangsu, China

ABSTRACT Objective: To analyze the relationship between the distribution of lower limb alignment and short-term clinical efficacy in patients with varus-type osteoarthritis after primary total knee arthroplasty (TKA). **Methods:** From December 2016 to March 2018, 87 patients (101 knees) with knee osteoarthritis were treated with the first total knee arthroplasty by the same medical group, including 21 males (25 knees) and 66 females (76 knees), ranging in age from 51 to 85 years old, with a mean of (67.6±7.0) years old. According to the difference of hip knee ankle angle (HKA) after total knee arthroplasty, the patients were divided into 4 groups: neutral position group (group A), $-3^{\circ} \leq \text{HKA} \leq 3^{\circ}$, 50 knees; slight varus group (group B), $3^{\circ} < \text{HKA} < 6^{\circ}$, 20 knees; severe varus group (group C), $\text{HKA} \geq 6^{\circ}$, 20 knees; valgus group (group D), $\text{HKA} < -3^{\circ}$, 11 knees. The preoperative sex, age, body mass index, operative side, preoperative and postoperative knee joint activity, HSS score, KSS clinical and functional score were compared among the 4 groups, and the relationship between the force line distribution of femoral and tibial prosthesis and the recent clinical effect was compared. **Results:** All the patients were followed up with a mean duration of (18.4±4.0) months. The range of motion of knee joint, HSS and KSS scores at the latest follow-up after operation in the 4 groups were higher than those before operation, and the difference was statistically significant ($P < 0.001$). There were significant differences in HSS and KSS scores among the 4 groups at the latest follow-up ($P < 0.05$); and the results in group A were better than those in group C and group D ($P < 0.05$); the results in group B were better than those in group C and group D ($P < 0.05$); there was no significant difference between group A and group B or group C and group D ($P > 0.05$). There was no significant difference in knee joint activity among the 4 groups. The score of femoral prosthesis force line within $\pm 3^{\circ}$ was better than that of the other group ($P < 0.05$), and the score of tibia prosthesis force line had no significant difference between within $\pm 3^{\circ}$

通讯作者: 赵凤朝 E-mail: zhjianzh@vip.sina.com

Corresponding author: ZHAO Feng-chao E-mail: zhjianzh@vip.sina.com

group and other group ($P>0.05$). **Conclusion:** The short-term clinical efficacy of patients with knee varus osteoarthritis after primary total knee arthroplasty is related to the distribution of lower limbs alignment. The short-term clinical efficacy of slight inversion position can be similar to that of neutral position. The force line distribution of femoral prosthesis is related to the short-term clinical efficacy after primary knee arthroplasty.

KEYWORDS Knee joint; Total knee arthroplasty; Lower extremity; Genu varum

全膝关节置换术(total knee arthroplasty, TKA)是缓解终末期膝骨性关节炎患者疼痛并改善功能的有效方法,手术目的之一是恢复患者正常的下肢力线分布^[1-2]。目前多数学者认为术后保证下肢机械轴中立位(机械力学对齐)可获得良好的临床疗效并可减少聚乙烯衬垫磨损,降低早期发生假体无菌性松动的风险^[3]。但 Abdel 等^[4]对 398 例患者进行长达 20 年的随访研究发现 TKA 术后下肢力线对位不良的患者并没有表现出更高的假体失败率,并且随着膝关节假体设计和聚乙烯衬垫工艺的不断提高,国内外一些学者开始质疑机械力学对线方式^[5-8]。目前关于膝关节置换术后下肢力线选择仍有争议^[9-10]。本研究回顾性分析 2016 年 12 月至 2018 年 3 月行初次全膝关节置换术的膝内翻 87 例患者,通过比较术前、术后下肢力线分布情况,探讨解决以下 2 个问题,即膝内翻患者初次全膝关节置换术后下肢力线不同分布与近期临床疗效的关系;膝内翻患者术后股、胫骨假体力线与近期疗效的关系。

1 资料与方法

1.1 病例选择

纳入标准:(1)行初次全膝关节置换术的骨性关节炎患者。(2)术前术后均拍摄负重位下肢全长 X 线片。(3)术前存在膝内翻畸形。排除标准:(1)膝关节翻修或行同侧髌关节手术者。(2)接受双侧同期置换者。(3)术后失访或随访时间<1 年。(4)术前伴有腰椎或髌关节疼痛者。

1.2 临床资料

回顾性分析 2016 年 12 月至 2018 年 3 月行初次 TKA 手术的患者,共 87 例(101 膝)符合本研究标准,男 21 例(25 膝),女 66 例(76 膝);年龄 51~85(67.6±7.0)岁;体质量指数(body mass index, BMI) 19.2~39.1(26.8±4.0) kg/m²;左膝 51 例,右膝 50 例。按 TKA 术后下肢髌膝踝角(hip-knee-ankle angle, HKA)大小将患者分成 4 组:中立位组(A 组, 50 膝), $-3^{\circ} \leq HKA \leq 3^{\circ}$;轻度内翻组(B 组, 20 膝), $3^{\circ} < HKA < 6^{\circ}$;严重内翻组(C 组, 20 膝), $HKA \geq 6^{\circ}$;外翻组(D 组, 11 膝), $HKA < -3^{\circ}$ 。分组标准见文献^[11]。4 组患者年龄、BMI、性别、手术侧别比较,具有可比性(表 1)。

1.3 手术方法

全身应用抗生素及氨甲环酸并麻醉完成后,患

表 1 各组膝内翻骨关节炎患者一般资料比较

Tab.1 Comparison of clinical data of patients with varus knee osteoarthritis among 4 groups

组别	膝数	年龄 ($\bar{x} \pm s$, 岁)	BMI($\bar{x} \pm s$, kg/m ²)	性别(例)		手术侧别(膝)	
				男	女	左	右
中立位组	50	66.3±6.9	26.9±4.2	11	35	30	20
轻度内翻组	20	65.7±7.1	27.5±4.1	6	12	9	11
严重内翻组	20	69.0±6.5	26.6±3.5	4	15	7	13
外翻组	11	70.7±5.6	25.6±3.3	3	8	5	6
检验值		$F=2.049$	$F=0.513$	0.249*		4.081	
P 值		0.113	0.674	0.969*		0.253	

注:*表示采用似然比检验

Note: * Means likelihood ratio test

者取仰卧位,经膝关节前正中切口,髌旁内侧入路,依次切开皮肤、皮下组织、关节囊,切除增生滑膜组织,将髌骨翻向外侧,暴露髌股关节,常规修整髌股关节面,屈膝暴露胫股关节,切除残余半月板、交叉韧带,去除胫骨平台内侧骨赘。通过髓外定位法垂直于胫骨机械轴完成胫骨近端截骨,股骨远端截骨按髓内定位法,常规 6°外翻截骨,相对于股骨后髁连线 3°外旋截骨,截骨完成后依次完成伸直、屈曲间隙测试,模拟膝关节伸屈活动评估稳定性。最后彻底冲洗关节腔,安放胫骨、股骨假体及聚乙烯衬垫。再次检查膝关节伸直及屈曲稳定性,去除充气止血带压力,待骨水泥凝固确认切口无活动性出血后再次冲洗关节腔,于膝关节外上方常规放置引流管 1 根,逐层关闭手术切口。术后 24~48 h 视引流情况(<50 ml)拔除引流管,当天嘱患者扶助行器下床活动,并行膝关节伸屈功能锻炼。所有患者术后进行相同的康复过程,为减少切口并发症及更好的功能锻炼,所有患者统一住院治疗至切口拆线。

1.4 观察项目与方法

1.4.1 下肢全长 X 线片的拍摄与测量 患者术前及术后 2 周均拍摄站立位下肢全长 X 线片(摄片机器型号为 PHILIPS Digital Diagnost 3),摄片时要求患者双足并立,髌骨朝向正前方^[11]。测量由我科医师运用影像归档和通信系统(picture archiving and communication systems, PACS)中角度测量工具完成。根据 Cooke 等^[12]的标准定义股骨及胫骨机械轴,股骨头中心由同心圆法标出,取股骨髁间窝顶点与胫骨

表 3 各组膝内翻骨关节炎患者全膝关节置换手术前后观察指标比较($\bar{x}\pm s$)

Tab.3 Comparison of observation indexes before and after total knee arthroplasty in four groups of patients with knee varus osteoarthritis($\bar{x}\pm s$)

组别	膝数	术前				术后			
		HSS(分)	KSS 临床评分(分)	KSS 功能评分(分)	ROM(°)	HSS(分)	KSS 临床评分(分)	KSS 功能评分(分)	ROM(°)
中立位组(A组)	50	50.1±13.4	36.8±15.4	33.7±17.6	93.7±22.8	88.8±4.3	92.5±4.6	80.4±10.2	106.6±7.3
轻度内翻组(B组)	20	51.2±13.8	38.4±13.2	37.8±12.0	88.1±25.2	88.2±2.9	91.8±5.0	79.2±11.6	105.5±8.1
严重内翻组(C组)	20	46.6±14.0	31.0±16.4	27.8±16.7	84.0±22.9	85.4±4.4	89.0±3.6	72.2±6.4	103.9±6.1
外翻组(D组)	11	41.1±15.3	28.3±14.7	30.4±15.9	76.6±28.8	85.1±7.7	87.7±7.3	70.0±8.9	103.2±5.9
F 值		1.680	1.772	1.378	1.904	3.795	4.398	5.753	1.118
P 值		0.176	0.158	0.254	0.134	0.013*	0.006*	0.001*	0.346

注: * $P<0.05$, A 组与 C、D 组间比较, $P<0.05$; B 组与 C、D 两组比较, $P<0.05$

Note: * $P<0.05$. Significant difference between group A and group C or D($P<0.05$). Significant difference between group B and group C or D ($P<0.05$)

($P>0.05$); 4 组患者术后 ROM 组间比较差异无统计学意义($P=0.346$), 详见表 3。

2.3 TKA 术后假体力线组间比较

根据患者 TKA 术后 mMPTA、mLDFA 角度大小, 以 $(90\pm 3)^\circ$ 为标准^[15], 将其分组。胫骨侧: $-3^\circ \leq \text{mMPTA} \leq 3^\circ$ 组术后末次随访时 HSS、KSS 临床及功能评分、术后 ROM 较 mMPTA $>3^\circ$ 或 mMPTA $<-3^\circ$ 组差异无统计学意义 ($P>0.05$); 股骨侧: $-3^\circ \leq \text{mLDFA} \leq 3^\circ$ 组术后末次随访时 KSS 临床评分、术后 ROM 较 mLDFA $>3^\circ$ 或 mLDFA $<-3^\circ$ 组差异有统计学意义 ($P<0.05$), 术后 HSS、KSS 功能评分差异无统计学意义 ($P>0.05$)。详见表 4-5。

表 4 膝内翻骨关节炎患者全膝关节置换术后 mMPTA 以 $(90\pm 3)^\circ$ 为标准分组时两组观察指标比较($\bar{x}\pm s$)

Tab.4 Comparisons of observational indexes between mMPTA within $(90\pm 3)^\circ$ group and mMPTA not within $(90\pm 3)^\circ$ group after total knee arthroplasty in patients with knee varus osteoarthritis($\bar{x}\pm s$)

组别	膝数(n)	HSS 评分	KSS 临床评分	KSS 功能评分	ROM (°)
$\pm 3^\circ$ 以内组	80	87.8±4.7	91.5±5.3	77.9±10.4	105.1±6.9
$\pm 3^\circ$ 以外组	21	86.8±5.0	89.8±4.1	75.7±10.8	106.8±7.9
t 值		0.903	1.328	0.842	-0.926
P 值		0.369	0.187	0.402	0.357

2.4 术后并发症

2 例出现 TKA 术后切口并发症, 1 例予加强换药, 另一例予以床边清创缝合、定期换药后切口均愈合良好, 门诊随访未见明显膝关节周围红肿、发热等情况; 另有 1 例术后出现术侧胫后动脉血栓, 予抗凝治疗后复查彩超血栓明显减少。3 例均为严重内翻

表 5 膝内翻骨关节炎患者全膝关节置换术后 mLDFA 以 $(90\pm 3)^\circ$ 为标准分组时两组观察指标比较($\bar{x}\pm s$)

Tab.5 Comparisons of observational indexes between mMPTA within $(90\pm 3)^\circ$ group and mMPTA not within $(90\pm 3)^\circ$ group after total knee arthroplasty in patients with varus knee osteoarthritis ($\bar{x}\pm s$)

组别	膝数	HSS 评分	KSS 临床评分	KSS 功能评分	ROM (°)
$\pm 3^\circ$ 以内组	68	88.1±4.3	92.0±4.8	78.1±10.4	106.6±6.9
$\pm 3^\circ$ 以外组	33	86.6±5.4	89.3±5.4	76.1±10.6	103.2±7.2
t 值		1.559	2.603	0.913	2.293
P 值		0.122	0.011	0.363	0.024

组患者。所有患者术后随访期间未发现感染、假体周围骨折、无菌性松动等情况, 未发现须行翻修手术者。

3 讨论

3.1 膝内翻患者 TKA 术后下肢力线不同分布与近期临床疗效

本研究最重要的发现是术前存在膝内翻畸形的患者行初次膝关节置换术后下肢残留力线固定在内翻 6° 以内, 其近期临床疗效与中立位组相似, 均明显优于内翻 6° 以外组。同样地, Bilgin 等^[16]对 51 例行初次膝关节置换患者(70 膝)进行至少 5 年的随访, 发现术后下肢力线在 $\pm 6^\circ$ 以内的患者术后功能评分明显优于 $\pm 6^\circ$ 以外组, 但在临床评分方面两者相似。Vanlommel 等^[13]对 132 例内翻膝患者平均随访 7.2 年, 发现术后下肢力线轻度内翻患者临床疗效优于中立位及重度内翻患者, 且各组随访期间均无感染、无菌性假体松动、假体周围骨折等情况。然而其研究缺乏比较各组间术前术后下肢 HKA 变化对术后关节功能及临床预后的影响。本研究通过比较各组间术前术后 HKA 角度变化发现术后外翻组患

者 dHKA 明显增大,与 Zhang 等^[17]的研究一致,这可能与术中内侧软组织松解过多及截骨不准确有关。有研究表明^[18]过多的软组织松解和截骨是引起膝关节置换术后近期疗效差的原因,柴伟等^[19]认为 TKA 术中采用电刀松解膝关节内侧软组织可降低术后膝前痛发生率。

目前关于膝骨性关节炎患者 TKA 术后残留轻度畸形与患者术后临床预后关系的研究主要集中在早、中期,且残留畸形主要为内翻位,多篇文献认为 TKA 术后残留轻度内翻畸形(6°以内)其早期临床预后与中立位力线患者相似^[20-23]。这可能与以下原因有关:(1)TKA 术中残留部分内翻畸形可减少术中截骨及软组织松解,更多地保护原有的韧带,一定程度上减少了手术创伤。(2)Matsumoto 等^[24]对 60 例随机对照研究认为实际正常步态下单足着地时下肢力线较传统髌膝踝力线更加外翻,而残余内翻力线可获得相对中立位分布。(3)Lozano 等^[25]认为采取运动力学对线的患者其假体的股骨髁间窝位置更接近正常生理膝关节。而本研究中 B 组患者即残留轻度内翻畸形,在一定程度上符合运动力学对线理念。(4)将膝内翻患者下肢力线矫正至中立位时则会导致 Q 增大,这可能是动力学力线患者髌股关节并发症发生率低的原因^[26]。

3.2 膝内翻患者 TKA 术后假体力线分布与近期疗效的关系

进一步比较膝内翻患者 TKA 术后胫骨、股骨侧假体力线不同分布范围与近期疗效的关系,发现术后股骨假体力线分布在(90±3)°范围内可获得更好的术后 KSS 临床评分及 ROM,差异具有明显统计学意义,笔者认为初次 TKA 术中保证股骨侧假体中立位置能提高患者术后近期临床疗效,与 Nishida 等^[23]研究结果一致。术前预设的股骨外翻角度、术中进髓点选择、髓内定位杆的长度及旋转均会对股骨远端截骨面造成影响^[27-30]。因此,术前测量股骨外翻角,术中合理选择进髓点可能是保证股骨假体冠状面对齐的方法。本研究虽然没有发现胫骨假体位置对近期临床疗效的影响,但 Ritter 等^[31]认为 TKA 术后胫骨假体内翻(<90°)会增加假体无菌性松动的风险,因此笔者建议术中安放假体时应避免股骨假体内外翻、胫骨假体内翻。

本研究存在的不足:(1)首先本研究属于回顾性研究,必然存在设计局限。(2)本研究只关注冠状位下肢力线分布与近期临床预后的关系,并未考虑矢状位及假体旋转的影响。(3)本研究随访时间较短,无法对中、远期预后及假体使用寿命做出评估,也无法评价残留内翻力线对假体生存率的影响,还需进

一步随访研究,尤其是术后残留部分内翻畸形对假体远期生存率的影响。另外,如术前中立位力线患者术后力线矫正为轻度内翻位的情况、术前外翻力线患者术后是否也需残留部分外翻,这些问题有待今后的研究进一步解决。

综上所述,本研究结果说明术前膝内翻患者 TKA 术后下肢力线分布于轻度内翻位可获得与中立位力线相似的近期临床疗效,膝内翻患者术中保证股骨假体对齐可获得更好的近期临床疗效。

参考文献

- [1] Manjunath KS, Gopalakrishna KG, Vineeth G. Evaluation of alignment in total knee arthroplasty: a prospective study[J]. Eur J Orthop Surg Traumatol, 2015, 25(5): 895-903.
- [2] Riviere C, Iranpour F, Auvinet E, et al. Alignment options for total knee arthroplasty: a systematic review[J]. Orthop Traumatol Surg Res, 2017, 103(7): 1047-1056.
- [3] Cip J, Widemschek M, Luegmair M, et al. Conventional versus computer-assisted technique for total knee arthroplasty: a minimum of 5-year follow-up of 200 patients in a prospective randomized comparative trial[J]. J Arthroplasty, 2014, 29(9): 1795-1802.
- [4] Abdel MP, Ollivier M, Parratte S, et al. Effect of postoperative mechanical axis alignment on survival and functional outcomes of modern total knee arthroplasties with cement: a concise follow-up at 20 years[J]. J Bone Joint Surg Am, 2018, 100(6): 472-478.
- [5] Bellemans J, Colyn W, Vandenuecker H, et al. The chitranjan ranawat award: is neutral mechanical alignment normal for all patients The concept of constitutional varus[J]. Clin Orthop Relat Res, 2012, 470(1): 45-53.
- [6] Eckhoff D, Hogan C, DiMatteo L, et al. Difference between the epicondylar and cylindrical axis of the knee[J]. Clin Orthop Relat Res, 2007, 461: 238-244.
- [7] Eckhoff DG, Bach JM, Spitzer VM, et al. Three-dimensional mechanics, kinematics, and morphology of the knee viewed in virtual reality[J]. J Bone Joint Surg Am, 2005, 87(Suppl 2): 71-80.
- [8] 张国栋, 杨晨, 杨光, 等. 膝关节表面置换术中运动力学对线的应用与发展[J]. 中国骨伤, 2015, 28(12): 1162-1165. ZHANG GD, YANG C, YANG G, et al. Application and development of kinematical alignment during total knee arthroplasty [J]. Zhongguo Gu Shang/China J Orthop Trauma, 2015, 28(12): 1162-1165. Chinese with abstract in English.
- [9] Bonner T, Eardley W, Patterson P, et al. The effect of post-operative mechanical axis alignment on the survival of primary total knee replacements after a follow-up of 15 years[J]. J Bone Joint Surg Br, 2011, 93(9): 1217-1222.
- [10] Magnussen RA, Weppe F, Demey G, et al. Residual varus alignment does not compromise results of TKAs in patients with pre-operative varus[J]. Clin Orthop Relat Res, 2011, 469(12): 3443-3450.
- [11] Rames RD, Mathison M, Meyer Z, et al. No impact of under-correction and joint line obliquity on clinical outcomes of total knee arthroplasty for the varus knee[J]. Knee Surg Sports Traumatol Arthrosc, 2018, 26(5): 1506-1514.
- [12] Cooke T, Sled E, Scudamore R. Frontal plane knee alignment: a call for standardized measurement[J]. J Rheumatol, 2007, 34(9):

- 1796–1801.
- [13] Vanlommel L, Vanlommel J, Claes S, et al. Slight undercorrection following total knee arthroplasty results in superior clinical outcomes in varus knees[J]. *Knee Surg Sports Traumatol Arthrosc*, 2013, 21(10):2325–2330.
- [14] Insall JN, Ranawat CS, Aglietti P, et al. A comparison of four models of total knee-replacement prostheses[J]. *J Bone Joint Surg Am*, 1976, 58(6):754–765.
- [15] 王波, 胡海涛, 潘健, 等. 膝关节骨性关节炎全膝关节置换术后下肢力线与早期临床效果关系的研究[J]. *中国骨与关节损伤杂志*, 2015, 30(10):1044–1048.
WANG B, HU HT, PAN J, et al. Relationship between lower limb alignment and early clinical results after TKA for osteoarthritis[J]. *Zhongguo Gu Yu Guan Jie Sun Shang Za Zhi*, 2015, 30(10):1044–1048. Chinese.
- [16] Bilgin E, Bombaci H, Turgut A, et al. How are clinical outcomes related to the deviation severity of the tibiofemoral mechanical axis on coronal plane following knee arthroplasty[J]. *J Clin Orthop Trauma*, 2019, 10(1):91–95.
- [17] Zhang Z, Liu C, Li Z, et al. Residual mild varus alignment and neutral mechanical alignment have similar outcome after total knee arthroplasty for varus osteoarthritis in five-year follow-up[J]. *J Knee Surg*, 2020, 33(2):200–205.
- [18] An VVG, Twigg J, Leie M, et al. Kinematic alignment is bone and soft tissue preserving compared to mechanical alignment in total knee arthroplasty[J]. *Knee*, 2019, 26(2):466–476.
- [19] 柴伟, 孙长蛟, 倪明, 等. 人工全膝关节置换术后早期胫骨内侧疼痛的病例对照研究[J]. *中国骨伤*, 2014, 27(4):269–273.
CHAI W, SUN CJ, NI M, et al. Case-control study on earlier medial tibial pain after total knee arthroplasty[J]. *Zhongguo Gu Shang/China J Orthop Trauma*, 2014, 27(4):269–273. Chinese with abstract in English.
- [20] Lanting BA, Williams HA, Matlovich NF, et al. The impact of residual varus alignment following total knee arthroplasty on patient outcome scores in a constitutional varus population[J]. *Knee*, 2018, 25(6):1278–1282.
- [21] Howell SM, Howell SJ, Kuznik KT, et al. Does a kinematically aligned total knee arthroplasty restore function without failure regardless of alignment category[J]. *Clin Orthop Relat Res*, 2013, 471(3):1000–1007.
- [22] Almaawi AM, Hutt JRB, Masse V, et al. The impact of mechanical and restricted kinematic alignment on knee anatomy in total knee arthroplasty[J]. *J Arthroplasty*, 2017, 32(7):2133–2140.
- [23] Nishida K, Matsumoto T, Takayama K, et al. Remaining mild varus limb alignment leads to better clinical outcome in total knee arthroplasty for varus osteoarthritis[J]. *Knee Surg Sports Traumatol Arthrosc*, 2017, 25(11):3488–3494.
- [24] Matsumoto T, Takayama K, Ishida K, et al. Radiological and clinical comparison of kinematically versus mechanically aligned total knee arthroplasty[J]. *Bone Joint J*, 2017, 99B(5):640–646.
- [25] Lozano R, Campanelli V, Howell S, et al. Kinematic alignment more closely restores the groove location and the sulcus angle of the native trochlea than mechanical alignment: implications for prosthetic design[J]. *Knee Surg Sports Traumatol Arthrosc*, 2019, 27(5):1504–1513.
- [26] Meding J, Fish M, Berend M, et al. Predicting patellar failure after total knee arthroplasty[J]. *Clin Orthop Relat Res*, 2008, 466(11):2769–2774.
- [27] Mihalko W, Boyle J, Clark L, et al. The variability of intramedullary alignment of the femoral component during total knee arthroplasty[J]. *J Arthroplasty*, 2005, 20(1):25–28.
- [28] Reed S, Gollish J. The accuracy of femoral intramedullary guides in total knee arthroplasty[J]. *J Arthroplasty*, 1997, 12(6):677–682.
- [29] Nuño-Siebrecht N, Tanzer M, Bobyn JD. Potential errors in axial alignment using intramedullary instrumentation for total knee arthroplasty[J]. *J Arthroplasty*, 2000, 15(2):228–230.
- [30] Maderbacher G, Matussek J, Keshmiri A, et al. Rotation of intramedullary alignment rods affects distal femoral cutting plane in total knee arthroplasty[J]. *Knee Surg Sports Traumatol Arthrosc*, 2018, 26(11):3311–3316.
- [31] Ritter MA, Davis KE, Meding JB, et al. The effect of alignment and BMI on failure of total knee replacement[J]. *J Bone Joint Surg Am*, 2011, 93(17):1588–1596.

(收稿日期:2019-10-13 本文编辑:连智华)