论著·临床医学

智能云平台随访模式可改善全膝关节置换术后关节活动度并降低随访成本:一项回顾性队列研究

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[摘要] **目的** 探究基于智能云平台的随访模式在全膝关节置换术(total knee arthroplasty, TKA)后随访质量、随访成本及膝关节功能恢复上较传统随访模式是否具备优势。**方法** 回顾性收集2022年10月至2023年9月于陆军军医大学第一附属医院行TKA的患者资料260例,根据术后不同随访方式分为云平台组(130例)与传统组(130例),收集并比较2组患者的基线资料、手术前后膝关节功能评分及随访成本。**结果** 云平台组的随访满意率高于传统组($P<0.05$),且其单次随访时间、单次陪同人数、总随访花费和总随访时间均显著低于传统组($P<0.05$)。术后6周、3月、6月、12月,云平台组的关节活动度(range of motion, ROM)均优于传统组($P<0.05$),2组间的其他膝关节功能评分差异无统计学意义。**结论** 基于云平台随访模式在术后早期(6周至12个月)膝关节ROM方面优于传统随访模式,且具备低随访成本优势,可作为TKA术后随访的有效替代方案。

[关键词] 骨关节炎;膝关节置换术;远程医疗;数字健康

[中图法分类号] R195.4;R473.6;R687.4 [文献标志码] A

Intelligent cloud platform follow-up model improves joint range of motion and reduces follow-up costs after total knee arthroplasty: A retrospective cohort study

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[**Abstract**] Objective To determine whether an intelligerct cloud platform follow-up model demonstrates superiority over conventional methods in enhancing follow-up quality, reducing costs, and improving functional recovery following total knee arthroplasty(TKA). Methods A retrospective cohort study was conducted on 260 patients undergoing TKA at our hospital from October 2022 to September 2023. According to the different postoperative follow-up methods, they were divided int a cloud platform group (n=130) and a traditional group (n=130). The baseline data, pre- and postoperative knee function scores, and follow-up costs were collected and compared between the 2 groups. Results The cloud platform group exhibited significantly higher rate of follow-up satisfaction, reduced resource utilization, shorter per-follow-up duration,

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fewer accompanying persons per visit, lower total follow-up expenditures, and decreased cumulative follow-up time when compared with the traditional group (P<0.05). At 6 weeks, 3, 6, and 12 months postoperatively, better range of motion (ROM) was observed in the cloud-based group than the traditional group (P<0.05), but no intergroup differences were seen in other knee function scores. **Conclusion** Cloud platform follow-up enhances early postoperative ROM (6 weeks to 12 months) and demonstrates marked cost-effectiveness when compared to the conventional mode. It represents a viable alternative for post-TKA rehabilitation surveillance.

[**Key words**] osteoarthritis; arthroplasty, replacement, knee; telemedicine; digital health

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当前,以医院门诊为基础的传统随访模式仍是全膝关节置换(total knee arthroplasty, TKA)术后管理的主流方式[1]。然而,该模式正面临多重严峻挑战:患者需承担高昂的经济(如交通、住宿)与时间成本[2-3]、随访效率低下导致医疗资源紧张、患者依从性不足影响治疗连续性[4],以及受限于短暂的门诊交互,随访质量难以得到充分保障[5]。在传统随访模式下,TKA术后患者的不满意率近20%[6]。

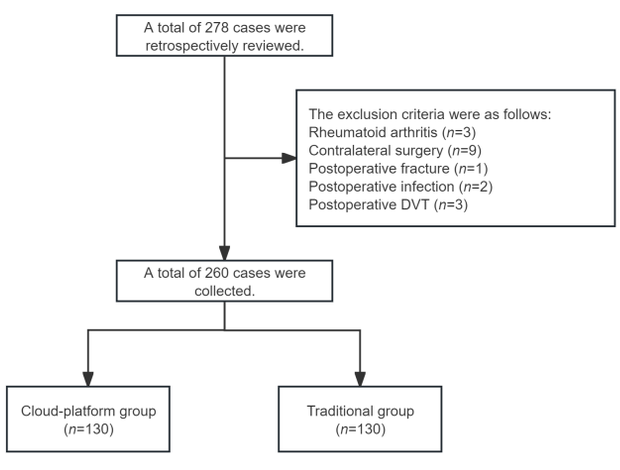
以云平台为载体的术后远程随访技术正日益普及,其底层技术(如云计算、大数据)已高度成熟[7-8]。国内外医疗实践表明,基于云平台构建的健康管理系统能够为患者提供直接、便捷的医患互动通道[9],有效辅助患者获取并应用术后康复知识与技能,从而促进积极健康结局。这类患者参与平台不仅能增强患者在随访过程中的参与感和依从性[4],还展现出降低整体医疗成本的潜力。

本研究旨在应用一种整合膝关节置换智能随访系统、智能影像评估系统及大数据平台分析系统的随访云平台(以下简称云平台),对接受初次TKA的患者实施术后管理,分析相较于传统的医院门诊随访模式,该云平台模式在随访质量、随访成本、膝关节功能恢复上是否展现出显著优势。

1 资料与方法

1.1 研究对象及分组

本研究采用回顾性队列研究,收集2022年10月至2023年9月于陆军军医大学第一附属医院行TKA的患者资料。纳入标准:①患者年龄≥50岁;②诊断为膝关节重度骨性关节炎克-劳分级法(Kellgren-Lawrence grading scale, K-L)Ⅳ期;③首次接受单侧TKA的患者;④手术均由同一名高年资的外科医师采用传统TKA手术工具执行;⑤术后进行门诊随访或使用云平台随访,术后随访时间达到1年以上且资料完整。排除标准:①需行膝关节翻修手术;②有任何影响下肢力线的疾病的患者,如既往骨折、畸形、先天畸形等;③存在炎症性疾病,如强直性脊柱炎和类风湿性关节炎;④术中出现严重并发症(严重骨折、神经血管损伤等)影响术后康复计划;⑤术后膝关节感染;⑥伴多关节病变或功能评估受限的患者;⑦计划90 d内接受对侧膝关节手术。最终共纳入260例患者,其中130例患者术后基于医院门诊进行随访即为传统组,130例患者基于云平台进行随访即为云平台组(图1)。本研究方案获陆军军医大学第一附属医院伦理委员会批准[(A)KY2022145]。



DVT: Deep vein thrombosis

图1 患者入组流程

Figure 1 Flowchart of patient enrollment

1.2 手术技术

入组患者的TKA均由同一名高年资外科医师进行,术后由同一护理团队进行护理。手术采用椎管内麻醉联合神经阻滞麻醉。术中使用下肢止血带;屈膝位采用膝前正中切口经髌旁内侧入路切开皮肤及关节囊,切除滑膜及部分髌下脂肪垫,伸膝并向外侧翻转髌骨;屈膝,切除交叉韧带、内外侧半月板及骨赘等;胫骨侧髓外定位垂直于机械轴截骨,股骨侧髓内定位行股骨远端截骨,根据术前规划外翻角进行股骨

远端截骨[10],股骨后髁外旋3°截骨[11];选择合适型号假体安装试模,检查伸直与屈曲过程中内外侧软组织张力和稳定性,确保软组织平衡和下肢力线恢复正常;冲洗伤口,调制骨水泥,安装正式假体;冲洗、缝合伤口,放置引流管。术后3天内给予抗生素预防感染;术后常规抗凝治疗;术后2天嘱患者行功能康复锻炼,并指导患者下床锻炼及行走,逐渐增加活动量;术后给予非甾体抗炎镇痛药减轻疼痛,在达到出院指征后出院居家康复[12]。

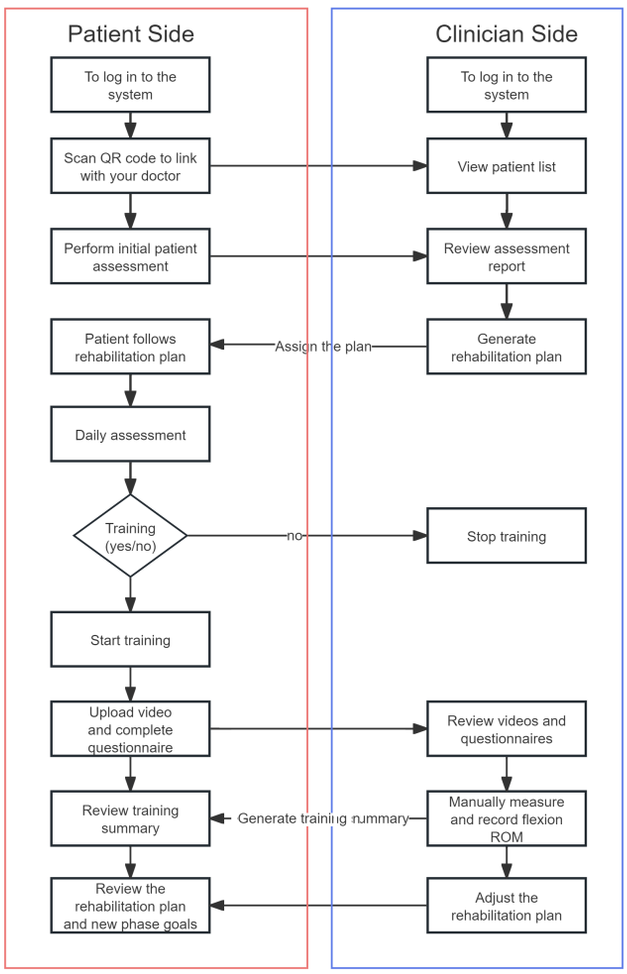
1.3 随访方法

1.3.1 传统组 患者在出院前由外科医师提供康复指导及功能锻炼方案。患者按照指导进行居家康复,并于术后6周、3月、6月、12月分别进行门诊随访,评估康复效果,包括膝关节活动度(range of motion, ROM)、膝关节功能评分及术后并发症等,并指导下一步康复治疗。

1.3.2 云平台组 使用由陆军军医大学、解放军总医院及北京欧应科技有限公司共同开发的膝关节置换智能随访云平台,该云平台包含智能随访、智能影像评估及随访大数据分析功能,区分患者端和医师端,可通过电脑网页或移动智能设备APP操作(图2)。

患者端:患者需于出院前注册云平台账号,完善个人信息,签署知情同意书,通过扫码关联主治医师。首次登录后云平台会对患者进行初次评估,包含基本疾病信息、主观功能评估及客观功能评估。全部完成后,智能生成个性化的初始默认随访和康复计划,经过医师确认后方可开始训练。患者在训练前需通过云平台进行评估,评估身体状态,排除常见的训练禁忌,并在必要时暂停或调整训练强度和训练内容。在训练中,患者可以通过云平台观看跟练视频,了解每个动作的作用和训练步骤,并进行训练。完成阶段性康复训练后,云平台会对患者进行阶段性评估,评估当前阶段的康复结果是否达到相应康复目标。云平台将于患者术后6周、3月、6月、12月分别通过微信公众号或短信提醒其进行线上随访。患者可于当地医院拍摄下肢X光片,并使用云平台骨科相机功能拍摄或上传复查X光影像资料,同时上传患肢手术区域照片及功能活动视频。此外,患者需在线上填写膝关节功能评估量表。

医师端:医师需在云平台确认患者的评估报告,并根据患者病情及手术情况调整患者的康复计划,通过医师确认后患者才能开始训练。医师可通过云平台实时获取患者每日训练情况及评估报告,并可及时调整患者的康复计划。医师可通过云平台查阅患者术后6周、3月、6月、12月随访资料,包括患肢X光片、手术区域照片、功能活动视频及膝关节功能评分等资料,评估患者恢复情况,并通过云平台给予指导和建议。



QR code: Quick response code; ROM: Range of motion

图2 云平台随访流程

Figure 2 Follow-up process on our intelligont cloud platform

1.4 统计指标

1.4.1 基线资料 收集患者年龄、性别、左右侧、身高、体质量、体质量指数(body mass index, BMI)、住院时间、手术时间、止血带时间、出血量、国产假体或进口假体的基线资料。

1.4.2 疗效指标 主要疗效指标:ROM。其他疗效指标:西安大略和麦克马斯特大学骨关节炎指数评分(Western Ontario and McMaster Universities Osteoarthritis Index, WOMAC)、膝关节学会评分(Knee Society score, KSS)、特种外科医院评分(Hospital for Special Surgery knee score, HSS)以及疼痛视觉模拟评分(Visual analogue scale, VAS)、术后并发症及术后不良事件发生情况。

1.4.3 随访资料 收集患者1年内随访中的随访满意率、单次随访时间、单次随访陪同人数、总随访花费、总随访时间。

1.5 统计学分析

所有数据采用SPSS 27.0进行统计分析。计量资料经Shapiro-Wilk检验证实符合正态分布,以$\bar{x}\pm s$表示,组间比较采用独立样本t检验;非正态分布资料以$M(P_{25},P_{75})$表示,组间比较采用Mann-Whitney U检验。计数资料以例(%)表示,组间比较采用χ^2检验。为评估结局指标(膝关节ROM、VAS评分、WOMAC评分、KSS评分、HSS评分)的动态变化,采用2(假体类型:国产/进口)×2(随访方式:云平台/传统)×4(时间:术后6周/3月/6月/12月)的三因素混合重复测量方差分析。其中时间为被试内因素,假体类型和随访方式为被试间因素。对违反球形假设的效应采用Greenhouse-Geisser校正,并对显著的主效应或交互作用进行Bonferroni法事后比较。以$P<0.05$为差异有统计学意义。

2 结果

2.1 患者基本情况

本研究共纳入260例患者,其中传统组130例,云平台组130例。2组患者的基本情况、术前膝关节功能、住院期间手术及治疗情况差异均无统计学意义(表1)。

2.2 随访满意率及随访成本对比

云平台组的随访满意率高于传统组,且其单次随访时间、单次陪同人数、总随访花费和总随访时间均显著低于传统组($P<0.05$,表2)。

表1 云平台组与传统组基线资料比较($\bar{x}\pm s$, n=130)

Table 1 Comparison of baseline data between the cloud platform group and the traditional group ($\bar{x}\pm s$, n=130)

Items	Cloud platform group	Traditional group
Baseline characteristics		
Gender(male:female)	30:100	27:103
Age/years	67.3±7.3	67.1±7.4
Affected side (left:right)	65:65	60:70
Height/cm	155.8±7.1	156.1±7.2
Weight/kg	63.4±9.4	62.5±9.4
BMI/(kg/m^2)	26.1±3.6	25.6±3.3
Preoperative knee function		
ROM/(°)	83.4±22.2	85.9±21.9
VAS	6.0±1.5	6.0±1.4
WOMAC	67.0±9.2	67.1±9.5
Pain	12.6±2.2	12.5±2.3
Stiffness	4.5±1.7	4.8±1.8
Function	49.9±6.7	50.0±6.7
KSS	67.8±29.8	68.8±30.4
Knee score	31.6±16.3	31.6±16.1
Function score	36.1±17.8	37.1±18.2
HSS	50.2±12.1	48.9±12.5
Perioperative outcomes		
Operative time/min	101.4±19.2	100.7±21.9
Blood loss/mL	172.1±32.4	170.7±29.8
Tourniquet time/min	82.2±15.4	81.2±17.6
Prosthesis(Domestic:Imported)	65:65	65:65
Length of hospital stay/d	6.3±1.5	6.4±1.5
ROM at discharge /(°)	73.5±13.0	74.9±13.5

ROM: Range of motion; VAS: Visual analogue scale; WOMAC: Western Ontario and McMaster Universities osteoarthritis index; KSS: Knee Society score; HSS: Hospital for Special Surgery knee score; BMI: Body mass index

表2 云平台组与传统组随访资料对比($\bar{x}\pm s$, n=130)

Table 2 Comparison of follow-up outcomes between the cloud platform and traditional groups ($\bar{x}\pm s$, n=130)

Follow-up parameters	Cloud platform group	Traditional group	*P*
Patient satisfaction rate/%	93.8	83.8	<0.05
Duration per follow-up/min	55.8±12.4	73.4±16.1	<0.05
Number of companions per visit	0.5±0.3	1.3±0.3	<0.05
Total follow-up cost/Yuan	2 177.4±711.0	3 822.6±732.1	<0.05
Total follow-up period/d	2.1±1.7	7.5±3.3	<0.05

表3 重复测量方差分析中ROM的主体内效应检验结果

Table 3 Results of the within-subjects effects test from the repeated-measures ANOVA for knee ROM

Source	SS	df(G-G)	MS	*F*	*P*
Time	273 282.423	1.951	140 107.019	865.651	<0.001
Time×Prosthesis	427.192	1.951	219.014	1.353	>0.05
Time×Follow-up mode	3 108.577	1.951	9.847	9.847	<0.001
Time×Prosthesis×Follow-up mode	43.654	1.951	0.138	0.138	>0.05
Error	80 818.154	499.335	161.852		

ROM: Range of motion; SS: sum of squares; df(G-G): Degrees of freedom, when the sphericity assumption was violated, the degrees of freedom were corrected using Greenhouse-Geisser; MS: Mean square

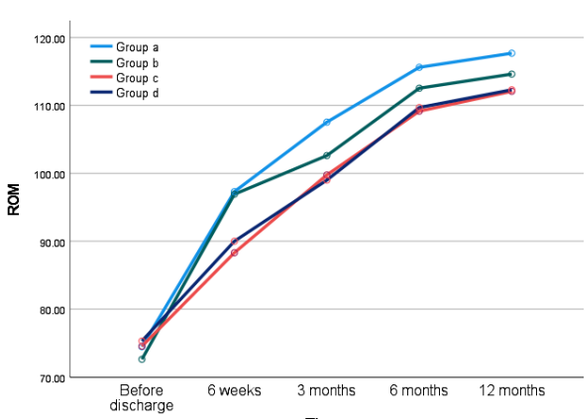
2.3 随访膝关节功能评估对比结果

2.3.1 关节活动度对比结果 采用三因素混合重复测量方差分析对因变量(ROM、VAS评分、WOMAC评分、KSS评分、HSS评分)进行分析,结果显示:二阶"时间×随访"方式存在显著的交互作用(F=9.847,P<0.001),然而二阶"时间×假体"和"假体×随访"均无显著交互作用;三阶"时间×假体×随访"无显著交互作用(表3、4)。再进行简单效应分析,结果表明:术后6周、3、6、12个月,云平台组国产假体的ROM均优于传统组国产假体(P<0.05,图3),术后6周,云平台组进口假体的ROM优于传统组进口假体(P<0.05),术后3、6、12个月云平台组进口假体与传统组进口假体差异无统计学意义;而云平台组内、传统组内的不同假体之间差异无统计学意义(表5)。

2.3.2 膝关节功能评分对比结果 术后6周、3月、6月、12月,云平台组和传统组间的VAS评分、WOMAC评分、KSS评分、HSS评分差异均无统计学意义,国产假体和进口假体之间的膝关节功能评分差异无统计学意义(表6)。

2.4 术后并发症对比结果

在2组患者术后1年时间内,发生的疼痛、髌骨弹响、关节僵硬的并发症差异无统计学意义(表7)。



ROM: Range of motion; Group a: Comprised patients who received domestic prostheses within the cloud platform group; Group b: Comprised those who received imported prostheses within the cloud platform group; Group c: Comprised patients who received domestic prostheses within the traditional group; Group d: Comprised those who received imported prostheses within the traditional group

图3 不同随访方式下国产/进口假体患者膝关节活动度随时间变化

Figure 3 Knee ROM over time in patients with domestic/imported prostheses under different follow-up modes

3 讨论

本研究通过为期1年的随访,对比基于云平台的随访模式与传统随访模式在TKA患者术后康复中的临床疗效,结果显示,与传统组相比,云平台组患者对该模式的满意度更高,且其随访所需的时间、人力及经济成本显著降低。在术后膝关节早期功能评估中,云平台组患者自术后6周起表现出优于传统组的膝关节活动度,而2组在其他膝关节功能评分上未见显著差异。

表4 重复测量方差分析中ROM的主体间效应检验结果

Table 4 Results of the between-subjects effects test from the repeated-measures ANOVA for knee ROM

Source	SS	df(G-G)	MS	*F*	*P*
Intercept	12 768 044.020	1	12 768 044.020	31 088.165	<0.001
Prosthesis	382.327	1	382.327	0.931	>0.05
Follow-up mode	5 670.173	1	5 670.173	13.806	<0.001
Prosthesis×Follow-up mode	808.173	1	808.173	1.968	>0.05
Error	105 140.308	256	410.704		

ROM: Range of motion; SS: Sum of squares; df(G-G): Degrees of freedom, when the sphericity assumption was violated, the degrees of freedom were corrected using Greenhouse-Geisser; MS: Mean square

表5 云平台组与传统组术后关节活动度对比($\bar{x}\pm s$, n=65)

Table 5 Comparison of postoperative ROM between the cloud platform and traditional groups ($\bar{x}\pm s$, n=65)

ROM/(°)	Cloud platform group			Traditional group			P^a	P^b	P^c
	Domestic	Imported	*P*	Domestic	Imported	*P*			
Before discharge	74.4±12.1	72.6±13.8	>0.05	74.5±12.7	75.3±14.3	>0.05	>0.05	>0.05	>0.05
6 Weeks	97.3±8.0	96.9±9.7	>0.05	88.3±13.0	90.0±14.1	>0.05	<0.05	<0.05	<0.05
3 Months	107.5±9.0	102.6±10.1	>0.05	99.7±11.9	99.0±13.6	>0.05	<0.05	>0.05	<0.05
6 Months	115.6±9.3	112.5±9.3	>0.05	109.1±13.0	109.6±15.2	>0.05	<0.05	>0.05	<0.05
12 Months	117.6±9.4	114.6±9.4	>0.05	112.0±12.8	112.3±15.1	>0.05	<0.05	>0.05	<0.05

ROM: Range of motion; P^a: Comparison between the cloud platform and traditional groups for patients using domestic prostheses; P^b: Comparison between the cloud platform and traditional groups for patients using imported prostheses; P^c: Overall comparison between the cloud platform and traditional groups

表6 云平台组与传统组术后1年功能指标对比($\bar{x}\pm s$, n=65)

Table 6 Comparison of functional outcomes at 1 year postoperatively between the cloud platform and traditional groups ($\bar{x}\pm s$, n=65)

Functional scores	Cloud platform group		Traditional group	
	Domestic	Imported	Domestic	Imported
6 weeks				
VAS	3.0±1.3	3.1±1.3	2.7±1.1	3.2±1.3
WOMAC	48.1±8.0	47.9±8.7	47.8±7.3	49.0±8.2
Pain	10.4±2.2	10.3±2.3	10.5±2.0	10.5±2.2
Stiffness	3.8±1.9	3.7±2.4	3.4±2.3	4.1±2.2
Function	33.9±5.8	33.9±6.2	33.8±5.6	34.4±5.9
KSS	104.9±26.6	107.1±26.7	107.0±28.2	104.3±25.1
Knee score	53.1±15.2	55.7±14.9	54.3±16.7	52.8±15.4
Function score	51.7±13.8	51.3±14.4	52.6±14.5	51.5±12.5
HSS	66.4±10.0	68.9±9.6	68.1±10.6	67.2±9.6

(表6续下页)

续表6 云平台组与传统组术后1年功能指标对比($\bar{x}\pm s$, n=65)

Table 6(Continued) Comparison of functional outcomes at 1 year postoperatively between the cloud platform and traditional groups ($\bar{x}\pm s$, n=65)

Functional scores	Cloud platform group		Traditional group	
	Domestic	Imported	Domestic	Imported
3 months				
VAS	2.4±1.1	2.4±1.0	2.3±0.9	2.4±1.0
WOMAC	40.1±7.6	40.0±8.4	39.2±7.1	41.0±8.1
Pain	7.7±1.8	7.8±2.2	7.6±1.8	7.9±2.1
Stiffness	2.8±1.9	2.6±2.0	2.8±1.9	3.2±1.9
Function	29.5±5.9	29.5±6.2	28.7±5.4	29.8±6.1
KSS	126.7±25.1	127.5±27.3	130.2±27.3	125.3±26.6
Knee score	63.7±13.5	64.8±14.8	66.1±14.7	63.0±15.1
Function score	63.0±12.4	62.7±13.2	64.1±13.5	62.3±12.9
HSS	72.6±9.5	73.0±9.4	73.5±10.0	72.9±8.7
6 months				
VAS	1.6±1.3	1.6±1.3	1.5±1.2	1.7±1.0
WOMAC	26.5±8.1	25.5±8.5	24.2±7.1	26.7±7.8
Pain	4.8±1.8	4.7±2.1	4.6±1.7	5.1±2.0
Stiffness	1.8±1.6	1.7±1.6	1.8±1.7	1.9±1.7
Function	19.8±6.1	19.0±6.2	17.6±5.7	19.6±5.8
KSS	157.3±21.2	156.6±24.6	159.0±21.1	152.7±23.0
Knee score	79.0±10.7	79.2±12.4	79.7±10.5	76.6±12.5
Function score	78.3±11.7	77.3±13.3	79.2±11.9	76.0±12.0
HSS	82.3±8.2	82.1±8.6	81.9±7.4	80.7±7.8
12 months				
VAS	1.1±0.7	0.7±0.8	0.7±0.6	0.8±0.7
WOMAC	17.4±7.9	17.2±7.8	14.8±6.5	17.8±6.2
Pain	2.2±1.3	2.1±1.7	2.0±1.5	2.6±1.5
Stiffness	1.7±1.4	1.5±1.3	1.5±1.3	1.7±1.4
Function	13.4±6.7	13.5±5.9	11.2±5.5	13.4±5.3
KSS	171.2±22.2	170.7±20.2	175.6±17.2	166.9±20.0
Knee score	87.6±7.2	88.2±8.1	87.6±7.6	84.7±9.3
Function score	83.6±17.7	82.5±14.3	88.0±12.0	82.1±14.8
HSS	86.8±6.3	86.8±6.2	87.7±6.4	85.8±7.1

表7 云平台组与传统组术后并发症对比[n(%)]

Table 7 Comparison of postoperative complications between the cloud platform and traditional groups [n(%)]

Postoperative complications	Cloud platform group(n=130)	Traditional group(n=130)
Pain	6(4.6)	7(5.3)
Patellar clunk syndrome	11(8.4)	10(7.6)
Joint stiffness	3(2.3)	5(3.8)

ROM是评估TKA术后康复效果的关键指标,直接反映关节功能恢复水平[13]。本研究观察到术后6周云平台组ROM的优势,这与CORREIA等[14]的结果部分一致,其远程生物反馈系统发现实验组在术后8周的ROM较对照组得到近2倍的改善。CRAWFORD等[15]利用智能手表与应用程序发现远程康复组在术后4周ROM优于传统组,但差异在12周时消失。NUEVO等[16]通过远程随访平台的干预虽未显示ROM的组间差异,但术后4周时股四头肌力量较对照组增强了36%。在上海的一家教学医院,WANG等[17]利用康复APP进行远程指导,患者术后6周的生活质量、身体机能均优于对照组;然而诸多研究通过居家远程康复发现ROM并未有明显差异[18-20]。本研究中发现云平台组早期ROM改善,可能与云平台组采用的"居家康复联合远程云平台指导"模式有关,其随访间隔(术后6周、3月、6月、12月)相对较长,随访频次低于既往研究[14-16,18-19]。早期的康复锻炼有助于膝关节功能的恢复[21],本研究采用云平台模式的创新之处在于整合了线上康复训练指导、实时评估与反馈,这一机制有效提升了患者的康复依从性与主动性[4]。医师端管理平台能够基于上传数据,对屈曲挛缩高风险患者自动触发预警,提示临床医师及时干预,这可能是云平台组获得更优早期ROM的关键机制。

本研究通过三因素混合方差分析发现,在TKA术后的功能恢复过程中,随访方式与时间存在显著的交互作用,而假体类型的主效应及其相关交互作用均未达到统计学差异。本研究还发现云平台随访模式在改善术后ROM方面优于传统随访模式,且这一优势在国产假体患者群体中表现得尤为持久。假体类型在本研究中并未显示出对膝关节功能恢复的独立影响,可能是因为现代制造工艺使得主流国产假体与进口假体在假体设计、材料学等方面已趋于接近,所以在术后功能恢复方面无明显差异[22]。

术后12个月,2组患者在VAS评分、WOMAC评分、KSS评分及HSS评分等指标上均未显示出统计学差异,ALEXANDER等[18,23-24]通过智能手机/手表护理平台指导患者康复,经过1年的随访发现平台组与传统组的膝关节功能也有着相似的结果,本研究结果与既往多数研究结论一致。本研究所采用云平台系统实现了个体化随访计划与康复方案的制定,并辅以训练过程的实时监控与指导[25]。患者状态数据及评估结果可即时上传至医师端平台,便于进行动态监测和精准干预。患者端的良好依从性是实现康复目标的基础,本研究通过云平台系统自动发送随访提醒短信;对未按时完成随访者启动电话督促流程;必要时辅以微信或电话人工督导[26],该多重保障机制提升了患者的随访依从性。

本研究明确证实了云平台随访模式在降低医疗成本方面的显著优势,云平台组随访相关花费和时间均显著低于传统组,这一成本优势源于多个层面:①患者直接成本降低:住院康复或定期到康复机构就诊的费用可能比居家康复高3倍或3倍以上[3],云平台随访模式大幅减少了患者往返医院复诊所需的交通、住宿费用及误工损失[27-28]。②医疗资源利用效率提升:优化了医护人员的工作流程,减少了用于常规线下随访的时间成本,使其能更专注于复杂病例处理和预警干预;同时也降低了医院在随访空间、设备和管理上的间接成本。③预防性干预的潜在节约:云平台的风险预警功能有助于早期识别并发症风险[29-30],及时干预可能避免后续更复杂的治疗和更高的费用支出[31]。

除了成本优势,云平台随访模式在临床应用中的价值也已得到多项实践验证。厦门某医院通过云平台随访系统开展TKA术后管理,结果显示该组患者满意率显著高于传统管理模式[32],与本研究结果一致。云平台的应用场景并非局限于TKA术后管理,而是在多领域医疗场景中展现出广泛适配性与实用价值,在其他场景中远程随访对肝移植患者的应用效果与常规随访的满意度持平[33],国内某医院通过远程药房平台开展肿瘤患者随访,更实现了88%~95%的高患者满意度[34];云平台能够通过个性化指导与动态监测,有效提升慢病患者治疗依从性[35],云平台的术后伤口感染诊断的辅助功能,为并发症早期识别与干预提供高效支持[36],这些跨领域实践进一步印证,云平台随访模式不仅能为TKA术后管理提供有力支撑,更能成为推动多场景医疗服务数字化升级的重要工具。

本研究仍存在局限与不足:本研究在单一医疗中心开展,样本量相对有限。未来需要在多中心、更大样本量的研究中进一步验证云平台随访模式的普适性。虽然本研究已完成了1年随访,但评估TKA假体的长期生存率和功能状态需要更长时间的观察,本研究尚未能提供云平台模式对长期疗效影响的证据。本研究云平台组患者接受了更密集的远程指导和监

控,而传统组为标准门诊随访,这种干预强度的差异本身可能影响结果。本研究为回顾性研究,且受干预性质限制,患者和评估者均无法实施盲法,可能引入测量偏倚。未来需要更加科学的前瞻性设计进行进一步研究。云平台的有效使用依赖于患者拥有智能手机、稳定的网络连接和一定的数字素养。这可能限制了其在老年人群或资源匮乏地区患者中的应用,存在潜在的选择偏倚和公平性问题。本研究未详细分析不同年龄、教育背景人群对平台接受度和使用效果的差异。

综上,基于云平台的全膝关节置换术后随访模式在术后早期(6周至12个月)膝关节ROM方面优于传统随访模式,而在VAS评分、WOMAC评分、KSS评分及HSS评分等功能指标方面与传统模式无差异。此外,云平台模式在降低随访成本方面具备显著优势,可作为TKA术后随访的有效替代方案。

利益冲突 本文所有作者声明不存在利益冲突

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