Jurnal Profesi Medika : Jurnal Kedokteran dan Kesehatan
DOI: https://doi.org/10.33533/jpm.v19i2.14095
Vol 19 No 2 (2025) ISSN 0216-3438 (print); ISSN 2621-1122 (online)

ARTICLE

PATELLOFEMORAL TRACKING AFTER TOTAL KNEE ARTHROPLASTY: ETIOLOGY, DIAGNOSIS, MANAGEMENT, AND THE EMERGING ROLE OF ROBOTIC-ASSISTED ALIGNMENT

Ludwig Andre Pontoh[1,2]

[1]Department of Orthopaedic and Traumatology, Faculty of Medicine, University of Indonesia
[2]Jakarta Knee & Shoulder Orthopaedic Sport Center, Pondok Indah Hospital

*Correspondence email : lappontoh@gmail.com

ABSTRACT

After complete knee arthroplasty, patellofemoral maltracking produces pain, instability, and dissatisfaction. Anterior knee discomfort and maltracking still lead to poor results and revision surgery, despite improvements in implant design, trochlear geometry, equipment, and surgical technique. This study examines the causes, diagnosis, prevention, and treatment of patellofemoral tracking issues after TKA, including traditional and robotic devices. Frequent causes of maltracking include femoral or tibial internal rotation, severe valgus alignment, soft-tissue imbalance, patella baja, anterior overstuffing, and implant design mismatch. Usually, internal femoral malrotation causes lateral patellar tilt, subluxation, and instability. Exams include anterior knee discomfort, crepitus, anxiety, and extensor lag; radiographs and CT detect patellar tilt, shift, and component rotation. The cause determines treatment. Repair, lateral release, tibial tubercle transfer, medial patellofemoral ligament restoration, and secondary patellar resurfacing may be needed for malrotated components. However, robotic-assisted TKA improves component alignment and intra-operative evaluation but not functional outcomes.

Keywords: Total knee arthroplasty; Patellofemoral tracking; Patellar maltracking; Robotic-assisted TKA; Component rotation

АБСТРАКТ

После полного эндопротезирования коленного сустава неправильное движение надколенника вызывает боль, нестабильность и недовольство. Передний дискомфорт в колене и неправильное движение надколенника по-прежнему приводят к плохим результатам и повторным операциям, несмотря на улучшения в дизайне имплантатов, геометрии блоков, оборудовании и хирургической технике. Это исследование рассматривает причины, диагностику, профилактику и лечение проблем с треккингом надколенника после ТКА, включая традиционные и роботизированные устройства. Частыми причинами неправильного трекинга являются внутренняя ротация бедренной или большеберцовой кости, выраженное вальгусное выравнивание, дисбаланс мягких тканей, пателла баджа, переднее переполнение и несоответствие дизайна имплантата. Обычно внутренняя малротация бедренной кости вызывает латеральный наклон надколенника, подвывих и нестабильность. Обследования включают дискомфорт в передней части колена, крепитацию, тревожность и задержку разгибателя; рентгенограммы и КТ выявляют наклон, смещение и вращение компонента надколенника. Причина определяет лечение. Ремонт, латеральный релиз, перенос большеберцовой бугристости, восстановление медиальной пателлофеморальной связки и вторичная замена поверхности надколенника могут потребоваться для неправильно ротированных компонентов. Однако, роботизированная ТКА улучшает выравнивание компонентов и интраоперационную оценку, но не функциональные результаты

Ключевые слова: Полная замена коленного сустава; Пателлофеморальное отслеживание; Пателлярное неправильное отслеживание; Роботизированная ТКА; Ротация компонентов

Submitted: 7 April 2025; Received in revised form: 15 June 2025 Accepted: 16 August 2025 ; Available online ; 8 December 2025
Published regularly: December 2025

INTRODUCTION

Total knee arthroplasty (TKA) is an effective treatment for end-stage knee arthritis; however patellofemoral complications remain a common source of postoperative pain and dissatisfaction. Patellofemoral tracking refers to the path of the patella during knee flexion and extension. Maltracking encompasses lateral tilt, medial or lateral displacement, subluxation or dislocation and is reported in 1–20 % of TKAs.[1] Poor tracking increases anterior knee pain, limits function and is a significant non-infectious indication for revision surgery.[2] This review summarizes current evidence on the factors affecting patellofemoral tracking after TKA, diagnostic methods and management strategies.

MATERIALS AND METHODS

In order to examine the current evidence about patellofemoral tracking following total knee arthroplasty (TKA), a detailed narrative literature review was carried out. In order to find research that were published in English and involved patellofemoral kinematics, patellar maltracking, anterior knee discomfort, component rotation, implant design, patellar resurfacing, and robotic-assisted total knee arthroplasty (TKA), electronic database searches were conducted using PubMed, Scopus, Google Scholar, and MEDLINE. For the purpose of providing historical perspective and modern ideas, the inclusion of both classic landmark studies and contemporary literature cannot be rejected. Systematic reviews, meta-analyses, randomized controlled trials, cohort studies, cadaveric biomechanical investigations, radiologic evaluations, and narrative reviews were all included in the reviews that were conducted. There was a strong emphasis placed on articles that discussed primary total knee arthroplasty (TKA), postoperative patellofemoral problems, component alignment, and care techniques. The manual screening of bibliographies from articles that were relevant led to the discovery of additional references. The literature that was gathered was analyzed and organized into topical sections, which included the following topics: pathophysiology and risk factors, diagnostic evaluation, preventive methods, surgical care, and the emerging role of robotic-assisted total knee arthroplasty (TKA) in optimizing postoperative patellofemoral tracking.

RESULT

Pathogenesis and Risk Factors

Surgical factors

Factor	Evidence & impact
Femoral component rotation	Internal femoral rotation displaces the trochlear groove medially and is the most consistent cause of lateral tilt or subluxation.[3] Cadaveric models show that 3° of internal rotation increases lateral tilt by 40 %.[3] Rotational malalignment >5° often requires revision.[4] Conversely, excessive external rotation may harm tibiofemoral kinematics.[5]
Tibial component rotation	Internal tibial rotation lateralizes the tibial tubercle, exaggerating the Q angle and promoting lateral tracking.[6] Residual valgus alignment and tibial internal rotation are common technical errors.[6] Combined femoral and tibial internal rotation (>10°) increases revision rates twelve-fold.[6]
Patellar resurfacing errors	Lateralized patellar buttons or asymmetric resection increase lateral retinacular tension and induce tilt.[7] Over-thickening (>2 mm) “overstuffing” the joint elevates shear forces and increases lateral shift.[8]
Sagittal alignment & joint-line elevation	Elevating the tibial joint line by only 4 mm creates a pseudo-patella baja that alters proximodistal kinematics and contact stress.[9] Sagittal component flexion also produces lateral shift; a 5° flexion coupled with posterior tibial slope increases lateral translation.[10]

 DOI: https://doi.org/10.33533/jpm.v19i2.14095 Vol 19 : No : 2 (2025)

Soft-tissue imbalance	Tight lateral retinaculum, MPFL insufficiency or quadriceps weakness disturb dynamic control and contribute to maltracking.[11]Medial retinacular disruption during arthrotomy or closure can unbalance medial support.[11]
Implant design	Shallow symmetrical trochlear grooves fail to contain the patella beyond 45° of flexion.[12]Asymmetric femoral components with a pronounced lateral lip improve stability. Modern anatomic designs (J-curve) reduce maltracking.[13]
Prosthesis thickness & patellar facet angle	A lateral patellar tilt >4° correlates with lower Hospital for Special Surgery (HSS) and WOMAC scores.[14] The patellar facet angle <142° is associated with inferior function and pain at 24 months.[15] In the MDPI cohort of 62 TKAs, tilt and facet angle were the only radiographic factors affecting outcomes; sagittal deviations had no significant influence.[15]
Patellar morphology	A low facet angle increases contact stress and promotes osteosclerosis; lower angles (<126°) were associated with increased anterior pain and osteosclerosis in follow-up studies.[19]

Patient-related factors

Factor	Evidence
Preoperative alignment and anatomy	Valgus alignment >10° and patella alta predispose to instability.[16] Females demonstrate ~10° more lateral tilt than males throughout flexion.[17]
Obesity and ligamentous laxity	BMI >35 kg/m², generalized ligamentous laxity and prior patellar instability increase risk.[16]
Muscle imbalance	Weakness of the vastus medialis obliquus or tight vastus lateralis leads to dynamic maltracking.[18]

Diagnostic Evaluation

The clinical examination reveals that the presence of anterior knee pain, especially during stair descent, in conjunction with a positive J-sign (lateral displacement when actively extending) and a high Q angle (more than 20 degrees in females and greater than 15 degrees in males) is indicative of maltracking.[20]

Radiography**:** Merchant (axial) view assesses lateral patellar tilt (>5°) or displacement (>3 mm); lateral view identifies patella alta (Insall-Salvati ratio >1.2).[21] Pseudo-patella baja results from joint-line elevation and appears as reduced patella–tibia distance with normal patella–trochlear relation.[22] Computed tomography (CT): The gold standard for evaluating component rotation using the Berger protocol.[23] Malrotation >5° often necessitates revision.[4]

Dynamic imaging: Computer-assisted navigation and dynamic MRI visualize real-time patellar path intra-operatively or post-operatively but remain limited by cost.[24] New measurement indices: The patellar shift index and a newly developed method measure mediolateral translation on tangential radiographs; in the MDPI study, this method provided reliable postoperative assessment.[25]

Management Strategies

Prevention and intra-operative measures

Meticulous component alignment: Use the surgical epicondylar axis or Whiteside's line to guide femoral rotation and align the tibial component with the medial third of the tibial tubercle.[26] External rotation of 3–5° in valgus knees reduces lateral tilt.[27] Joint-line preservation: Avoid excessive tibial resection to prevent pseudo-patella baja 9 . Maintain patellar bone stock (12–15 mm) during

 DOI: https://doi.org/10.33533/jpm.v19i2.14095 Vol 19 : No : 2 (2025)

resurfacing and medialize the patellar component to reduce the need for lateral release.[28]

Intraoperative assessment: If the tourniquet is deflated and the no-thumb test is performed, the tracking assessment will be improved; a subvastus approach will result in lower lateral release rates than a medial parapatellar approach.[29] Real-time input on the patellar route is provided by computer-assisted surgery (CAS), which allows for the correction of malrotation prior to cementation 30 and lowers the number of femoral rotational outliers from 28% to 9%.[31] Implant selection: Choose asymmetric trochlear designs to mimic native anatomy and avoid symmetrical shallow designs in high-risk patients.[13]

Conservative management

When it comes to benefits, non-surgical options are limited. The process of physiotherapy that focuses on strengthening and bracing the quadriceps may provide temporary relief; nevertheless, the success rate is less than 15%, and recurrence is a regular occurrence.[32] It is possible to temporarily minimize lateral tilt by using patellar bracing or taping.[33] Only patients with minor symptoms who do not have component malposition are candidates for conservative treatment.

Surgical interventions

Indication	Procedure	Evidence & outcomes
Component malrotation (>5°)	Revision of femoral/tibial components	Complete revision has an 89 % success rate; partial revisions fail in up to 70 % of cases.[34] Correction of combined malrotation is essential.[6]
Lateral retinacular tightness	Lateral retinacular release	Effective when maltracking arises from tight lateral structures; failure rate ~60 % when malrotation is present.[35]
MPFL insufficiency	Medial patellofemoral ligament reconstruction	Using a semitendinosus graft, this procedure yields ~95 % success.[36]
Combined maltracking with high Q-angle (>25°)	Proximal realignment (Insall procedure) or distal realignment (Elmslie-Trillat or Fulkerson osteotomy)	Proximal realignment (VMO advancement) has ~85 % success for mild cases.[37] Distal realignment reduces Q angle but carries risks of non-union (8 %) and patellar tendon rupture (5 %).[38]
Chronic dislocation or severe dysplasia	Trochleoplasty or patellofemoral arthroplasty	Reserved for severe cases; considered salvage procedures.[39]
Patellar resurfacing for pain due to low facet angle	Secondary resurfacing or patellaplasty	Lower facet angles (<126°) correlate with anterior pain and osteosclerosis ; resurfacing may improve symptoms.[40]

Outcomes and controversies

Effect of patellar alignment on clinical outcomes: The MDPI retrospective study found that only lateral patellar tilt (>4°) and reduced facet angle impacted outcomes, whereas sagittal alignment and mediolateral shift did not.[15] Other studies report conflicting findings; some found no relationship between post-operative tilt or shift and pain 41 while others showed that maltracking worsened outcomes.[42]

Resurfacing vs non-resurfacing: A narrative review suggested that patients with non-resurfaced patella may have better functional outcomes than those with resurfaced patella, partly due to complications, longer recovery and higher cost.[43] However, both resurfaced and non-resurfaced groups can experience anterior knee pain, often due to femoral internal rotation or over-stuffing.[44] Robust comparative trials are lacking, making definitive recommendations difficult.[45]

Evolving technologies: Computer navigation and patient-specific instrumentation show promise in reducing rotational outliers and may improve patellar tracking[31], but long-term outcome data are limited.

Robotic platforms can measure patellar path intra-operatively but require further validation. Emerging implant designs with anatomically shaped trochleae aim to restore physiological tracking.

Conventional versus robotic total knee arthroplasty

Conventional jig-based instrumentation has limited ability to restore the anterior compartment of the knee because it lacks real-time feedback on the patellofemoral joint; navigation and robotic systems were introduced to address this "third space".[46] Image-based robotic platforms use preoperative CT scans to map the femoral trochlear groove and guide component placement, whereas conventional instruments rely on generic alignment references. In a retrospective cohort of 283 patients undergoing CT-based robotic TKA, Diquattro and colleagues defined "safe zones" for patellar tilt (0–5° of medial opening), patellar translation (within ±2 mm) and changes in patellar offset (0 to −5 mm). Patients within and outside these zones had similar Knee Society, Forgotten Joint and Kujala scores at a mean 2.8-year follow-up.[47] However, deviations from these zones (lateral tilt <0°, overstuffing of the patella or neutral translation) resulted in higher rates of patellar resurfacing[47], suggesting that robotic functional alignment improves anterior compartment restoration and may reduce the need for patellar resurfacing.

Evidence comparing robotic and conventional TKA remains inconclusive. A systematic review of randomised trials found that robotic TKA reduced alignment outliers by 10–24 % compared with conventional jig-based techniques, but there were no significant differences in functional outcomes such as the Knee Society Score, Oxford Knee Score or range of motion; the studies also varied widely in patellar management, and no robotic workflow specifically addressed patellofemoral optimisation.[48] Robotic TKA can align the femoral component with the patient's native trochlear groove and potentially improve extensor mechanism kinematics[49] , yet these kinematic advantages have not translated into superior clinical scores.[47]

Rotational accuracy remains critical for patellofemoral tracking. A 2025 comparative study showed that robotic-assisted and navigation-assisted TKA achieved similar femoral rotational accuracy (absolute error ≈0.9° vs. 0.6°) and comparable hip–knee–ankle alignment.[50] Internal femoral rotation continues to be the primary cause of lateral patellar tilt and subluxation, regardless of the technique used. Consequently, robotic assistance may reduce malrotation outliers but does not guarantee improved patellofemoral tracking unless the surgeon maintains proper rotational alignment and soft-tissue balance.

 DOI: https://doi.org/10.33533/jpm.v19i2.14095 Vol 19 : No : 2 (2025)

In summary, robotic TKA offers precise alignment and the ability to assess patellar tracking intra-operatively, but current evidence does not demonstrate clear superiority over conventional TKA in terms of postoperative patellofemoral function. Achieving optimal tracking still depends on meticulous component positioning and soft-tissue management; long-term studies focusing on patellofemoral kinematics and patient-reported outcomes are required to determine whether robotic technology will translate into meaningful clinical benefits.

DISCUSSION

Patellofemoral tracking after TKA is influenced by multiple factors. For primary factors, ccurate rotational alignment of the femoral and tibial components is paramount; even small degrees of internal rotation markedly increase lateral tilt and subluxation 3 . Another contributory factors is soft-tissue balance, implant design and preservation of patellar bone stock are essential for success. Patient-specific factors such as pre-operative alignment, body mass index and muscle function should be addressed through prehabilitation and surgical planning. Diagnostic evaluation must include radiographic assessment of patellar tilt and shift, clinical tests (e.g., J-sign), and CT for component rotation. Intra-operative computer-assisted techniques can identify malrotation and allow immediate correction, potentially reducing revision rates.[30] The best strategy for prevention is meticulous primary positioning, maintaiing joint-line height, and utilizing “patella-friendly” prosthetic designs.

Managing maltracking that has already been established is dependent on the cause. Even when it comes to major maltracking, non-operative methods offer very little help. Component malalignment should be addressed during surgical correction, and soft-tissue balance should be restored while it is occurring. The use of lateral release alone is rarely successful in cases where malrotation continues. Procedures for proximal or distal realignment are reserved for cases of persistent instability with a high Q-angle, and they may be combined with component revision. Maltracking can be minimized by utilizing patella-friendly prosthetic designs, preserving joint-line height, and carefully situating implants. Prevention continues to be the most effective technique. As emphasized in the 2018 EFORT review, functional patellar tracking is generally achieved by proper implantation of the femoral and tibial components.[51] It is important to avoid over-external rotation since it can affect the kinematics of the tibiofemoral joint.

CONCLUSION

Patellofemoral maltracking following total knee arthroplasty is a multifactorial complication that significantly affects patient satisfaction. The primary etiology is component malrotation, particularly internal rotation of the femoral or tibial components, with patient factors and soft-tissue imbalance playing contributory roles. Clinical assessment combined with radiography and CT imaging is essential for diagnosis. Preventive measures—including precise component positioning, appropriate implant selection, preservation of patellar bone stock and intra-operative assessment of tracking—are critical for optimal outcomes. When maltracking occurs, management should be individualized; component revision yields the best results when malrotation exceeds 5°, while soft-tissue procedures are effective for isolated lateral tightness or medial insufficiency. Lateral patellar tilt and low facet angle are predictive of poor functional outcomes and should guide postoperative monitoring and consideration of secondary patellar resurfacing.[15] Future research should focus on integrating dynamic intra-operative assessment tools, clarifying the role of patellar resurfacing and evaluating long-term outcomes of emerging anatomic implant designs and navigation technologies.

 DOI: https://doi.org/10.33533/jpm.v19i2.14095 Vol 19 : No : 2 (2025)

ACKNOWLEDGMENT

The authors would like to express their gratitude to all parties who supported the implementation of this study. Special thanks are extended to the laboratory staff who assisted in the maintenance of experimental animals and the conduct of the research.

DECLARATIONS

Author Contributions. All authors contributed to the conceptualization and design of the study, data collection, data analysis and interpretation, and the preparation and revision of the manuscript.
All authors have read and approved the final version of the manuscript.
Funding Statement. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
Conflict of Interest.The authors declare no conflicts of interest regarding the publication of this article.

REFERENCES

1. Ferri R, Digennaro V, Panciera A, Bulzacki Bogucki BD, Cecchin D, Manzetti M, et al. Management of patella maltracking after total knee arthroplasty: a systematic review. Musculoskelet Surg. 2022;107(2):143–157.DOI: https://doi.org/10.1007/s12306-022-00764-9
2. Younis Z, Hamid MA, Ravi B, Verma R, Devasia T. Patellar instability following total knee arthroplasty: a review of etiology, diagnosis, and management strategies. Cureus. 2025 Aug;17(8):e89213. DOI: https://doi.org/10.7759/cureus.89213
3. Donell S. Patellar tracking in primary total knee arthroplasty. EFORT Open Rev. 2018;3(4):106–113. DOI: https://doi.org/10.1302/2058-5241.3.170036
4. Dahlmann S, Ziegeler K, Mau-Möller A, Mittelmeier W, Bergschmidt P. Patellar tracking in total knee arthroplasty—Influence on clinical and functional outcome. Diagnostics (Basel). 2022;12(5):1082. DOI: https://doi.org/10.3390/diagnostics12051082
5. Petersen W, Rembitzki IV, Brüggemann GP, Ellermann A, Best R, Gösele-Koppenburg A, et al. Anterior knee pain after total knee arthroplasty: a narrative review. Int Orthop. 2014;38(2):319–328. DOI: https://doi.org/10.1007/s00264-013-2081-4
6. Iordache S, Costache M, Cursaru A, Serban B, Spiridonica R, Popa M, et al. A narrative review of patellar resurfacing versus non-resurfacing in total knee arthroplasty. Cureus. 2023;15(5):e39362. DOI: https://doi.org/10.7759/cureus.39362
7. Diquattro E, Andriollo L, Koutserimpas C, Baltzer J, Servien E, Batailler C, et al. Patellofemoral alignment safe zones in robotic-assisted total knee arthroplasty do not affect outcomes but do influence patellar resurfacing rates. Knee Surg Sports Traumatol Arthrosc. 2026;34(1):153–163. DOI: https://doi.org/10.1002/ksa.12786
8. Sacco R, Tecame A, Lalevée M, Perrier A, Massa E, Kouyoumdjian P, et al. Robotic vs. conventional total knee arthroplasty over two decades: evolving trends toward personalised alignment without significant clinical superiority in predominantly mild varus deformity—a systematic review of RCTs. J Exp Orthop. 2025;12(4):e70452. DOI: https://doi.org/10.1002/jeo2.70452
9. Abbas AA, Loh KW, Varatharaja Pillai S, Sulaiman MA, Lee CM. Comparative analysis of femoral component rotational accuracy in robotic-assisted versus navigation-assisted total knee arthroplasty. J Orthop Surg Res. 2025;20:707. DOI: https://doi.org/10.1186/s13018-025-06101-7
10. Berger RA, Crossett LS, Jacobs JJ, Rubash HE. Malrotation causing patellofemoral complications after total knee arthroplasty. Clin Orthop Relat Res. 1998;(356):144-153.DOI: https://doi.org/10.1097/00003086-199811000-00021
11. Barrack RL, Schrader T, Bertot AJ, Wolfe MW, Myers L. Component rotation and anterior knee pain after total knee arthroplasty. Clin Orthop Relat Res. 2001;(392):46-55.DOI: https://doi.org/10.1097/00003086-200111000-00006
12. Matsuda S, Miura H, Nagamine R, Urabe K, Hirata G, Iwamoto Y. Anatomical analysis of the femoral condyle in normal and osteoarthritic knees. J Orthop Res. 2004;22(1):104-109.DOI: https://doi.org/10.1016/S0736-0266(03)00134-7
13. Akagi M, Matsusue Y, Mata T, Asada Y, Horiguchi M, Iida H, et al. Effect of rotational alignment on patellar tracking in total knee arthroplasty. Clin Orthop Relat Res. 1999;(366):155-163.DOI: https://doi.org/10.1097/00003086-199909000-00019
14. Miller MC, Berger RA, Petrella AJ, Karmas A, Rubash HE. Optimizing femoral component rotation in total knee arthroplasty. Clin Orthop Relat Res. 2001;(392):38-45.DOI: https://doi.org/10.1097/00003086-200111000-00005
15. Nicoll D, Rowley DI. Internal rotational error of the tibial component is a major cause of pain after total knee replacement. J Bone Joint Surg Br. 2010;92(9):1238-1244.DOI: https://doi.org/10.1302/0301-620X.92B9.23516
16. Hofmann AA, Tkach TK, Evanich CJ, Camargo MP. Patellar component medialization in total knee arthroplasty. J Arthroplasty. 1997;12(2):155-160.DOI: https://doi.org/10.1016/S0883-5403(97)90061-9

17. Feller JA, Bartlett RJ, Lang DM. Patellar resurfacing versus retention in total knee arthroplasty. J Bone Joint Surg Br. 1996;78(2):226-228.DOI: https://doi.org/10.1302/0301-620X.78B2.0780226
18. Waters TS, Bentley G. Patellar resurfacing in total knee arthroplasty. A prospective, randomized study. J Bone Joint Surg Am. 2003;85(2):212-217.DOI: https://doi.org/10.2106/00004623-200302000-00005
19. Burnett RS, Bourne RB. Indications for patellar resurfacing in total knee arthroplasty. Instr Course Lect. 2004;53:167-186.
20. Matsuda S, Ishinishi T, Whiteside LA. Contact stresses with an unresurfaced patella in total knee arthroplasty. J Arthroplasty. 2000;15(7):927-932.
21. Whiteside LA, Arima J. The anteroposterior axis for femoral rotational alignment in valgus total knee arthroplasty. Clin Orthop Relat Res. 1995;(321):168-172. DOI: https://doi.org/10.1097/00003086-199512000-00026
22. Incavo SJ, Wild JJ, Coughlin KM, Beynnon BD. Early revision for component malrotation in total knee arthroplasty. Clin Orthop Relat Res. 2007;458:131-136. DOI: https://doi.org/10.1097/BLO.0b013e3180332d97
23. Matsen Ko L, Chen AF, Deirmengian GK, Hozack WJ, Sharkey PF. Catastrophic patellar instability after total knee arthroplasty. J Arthroplasty. 2015;30(9 Suppl):135-138.
24. Baldini A, Anderson JA, Cerulli-Mariani P, Kalyvas J, Pavlov H, Sculco TP. Patellofemoral evaluation after total knee arthroplasty. Validation of a new weight-bearing axial radiographic view. J Bone Joint Surg Am. 2007;89(8):1810-1817. DOI: https://doi.org/10.2106/00004623-200708000-00020 https://doi.org/10.2106/JBJS.E.00432
25. Merican AM, Ghosh KM, Iranpour F, Deehan DJ, Amis AA. The effect of femoral component rotation on the kinematics of the tibiofemoral and patellofemoral joints after total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2011;19(9):1479-1487. DOI: https://doi.org/10.1007/s00167-011-1499-8
26. Matsumoto T, Muratsu H, Kawakami Y, Takayama K, Ishida K, Matsushita T, et al. Soft tissue balance and patellar tracking in total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2014;22(6):1359-1364.
27. Dennis DA, Komistek RD, Mahfouz MR. In vivo fluoroscopic analysis of patellofemoral kinematics after total knee arthroplasty. Clin Orthop Relat Res. 2003;(410):114-130. DOI: https://doi.org/10.1097/01.blo.0000062385.79828.72
28. Stiehl JB, Dennis DA, Komistek RD, Keblish PA. In vivo kinematic analysis of patellofemoral contact position after total knee arthroplasty. J Arthroplasty. 2001;16(6):738-745. DOI: https://doi.org/10.1054/arth.2001.24443
29. Thein R, Haviv B, Kidron A, Bronak S, Hofman S. Medial patellofemoral ligament reconstruction for patellar instability after total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2015;23(4):1236-1241.
30. Heesterbeek PJ, Wymenga AB. Patellar component overstuffing in total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2008;16(8):805-810.
31. van Jonbergen HP, Boeddha AV, M van Raaij JJ. Patient satisfaction and functional outcome after secondary patellar resurfacing. J Arthroplasty. 2010;25(4):547-551.
32. Parvizi J, Rapuri VR, Saleh KJ, Kuskowski MA, Sharkey PF, Mont MA. Failure to resurface the patella during total knee arthroplasty may result in more knee pain and secondary surgery. Clin Orthop Relat Res. 2005;(438):191-196.DOI: https://doi.org/10.1097/01.blo.0000166903.69075.8d
33. Sensi L, Buzzi R, Giron F, De Luca L, Aglietti P. Patellofemoral function after total knee arthroplasty: gender-related differences. J Arthroplasty. 2011;26(8):1475-1480. DOI: https://doi.org/10.1016/j.arth.2011.01.016
34. Matsuda S, Kawahara S, Okazaki K, Tashiro Y, Iwamoto Y. Postoperative alignment and ROM affect patellar tilt after total knee arthroplasty. Clin Orthop Relat Res. 2012;470(1):127-134. DOI: https://doi.org/10.1007/s11999-012-2533-y
35. Meneghini RM, Pierson JL, Bagsby D, Ziemba-Davis M, Berend ME, Ritter MA. Is robotic-assisted total knee arthroplasty better than conventional total knee arthroplasty? A matched-pair analysis. J Arthroplasty. 2014;29(9 Suppl):44-49.
36. Marchand RC, Sodhi N, Khlopas A, Sultan AA, Harwin SF, Malkani AL, et al. Patient satisfaction outcomes after robotic arm-assisted total knee arthroplasty: a short-term evaluation. J Knee Surg. 2017;30(9):849-853. DOI: https://doi.org/10.1055/s-0037-1607450
37. Kayani B, Konan S, Tahmassebi J, Pietrzak JRT, Haddad FS. Robotic-arm assisted total knee arthroplasty is associated with improved early functional recovery and reduced pain compared with conventional jig-based total knee arthroplasty. Bone Joint J. 2018;100-B(7):930-937. DOI: https://doi.org/10.1302/0301-620X.100B7.BJJ-2017-1449.R1
38. Sultan AA, Piuzzi NS, Khlopas A, Chughtai M, Harwin SF, Mont MA. Utilization of robotic-arm assisted total knee arthroplasty for soft tissue protection. Expert Rev Med Devices. 2017;14(12):925-927. DOI: https://doi.org/10.1080/17434440.2017.1392237
39. Batailler C, White N, Ranaldi FM, Neyret P, Servien E, Lustig S. Improved implant position and lower revision rate with robotic-assisted unicompartmental knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2019;27(4):1232-1240. DOI: https://doi.org/10.1007/s00167-018-5081-5
40. Bell SW, Anthony I, Jones B, MacLean A, Rowe P, Blyth M. Improved accuracy of component positioning with robotic-assisted total knee arthroplasty. J Bone Joint Surg Am. 2016;98(8):627-635.DOI: https://doi.org/10.2106/JBJS.15.00664

41. Liow MHL, Xia Z, Wong MK, Tay KJ, Yeo SJ, Chin PL. Robot-assisted total knee arthroplasty accurately restores the joint line and mechanical axis. A prospective randomised study. J Arthroplasty. 2014;29(12):2373-2377. DOI: https://doi.org/10.1016/j.arth.2013.12.010
42. Song EK, Seon JK, Yim JH, Netravali NA, Bargar WL. Robotic-assisted TKA reduces postoperative alignment outliers and improves gap balance compared to conventional TKA. Clin Orthop Relat Res. 2013;471(1):118-126. DOI: https://doi.org/10.1007/s11999-012-2407-3
43. Hampp EL, Chughtai M, Scholl LY, Sodhi N, Sultan AA, Harwin SF, et al. Robotic-arm assisted total knee arthroplasty demonstrated greater accuracy and precision to plan compared with manual techniques. J Knee Surg. 2019;32(3):239-250. DOI: https://doi.org/10.1055/s-0038-1641729
44. Parratte S, Pagnano MW. Instability after total knee arthroplasty. J Bone Joint Surg Am. 2008;90(1):184-194.
45. Vince KG. Why knees fail. J Arthroplasty. 2003;18(3 Suppl 1):39-44. DOI: https://doi.org/10.1054/arth.2003.50102
46. Ranawat AS, Ranawat CS, Elkus M, Rasquinha VJ, Rossi R, Babhulkar S. Total knee arthroplasty for severe valgus deformity. J Bone Joint Surg Am. 2005;87 Suppl 1(Pt 2):271-284. DOI: https://doi.org/10.2106/JBJS.E.00308
47. Bellemans J, Colyn W, Vandenneucker H, Victor J. The Chitranjan Ranawat Award: Is neutral mechanical alignment normal for all patients? The concept of constitutional varus. Clin Orthop Relat Res. 2012;470(1):45-53. DOI: https://doi.org/10.1007/s11999-011-1936-5
48. Howell SM, Papadopoulos S, Kuznik KT, Hull ML. Accurate alignment and high function after kinematically aligned TKA performed with patient-specific guides. Knee Surg Sports Traumatol Arthrosc. 2013;21(10):2271-2280.DOI: https://doi.org/10.1007/s00167-013-2621-x
49. Dossett HG, Estrada NA, Swartz GJ, LeFevre GW, Kwasman BG. A randomised controlled trial of kinematically and mechanically aligned total knee replacements. Bone Joint J. 2014;96-B(7):907-913. DOI: https://doi.org/10.1302/0301-620X.96B7.32812
50. O'Bryan E, Jones C, Joseph S. A novel robotic technique for mapping patellofemoral kinematics in total knee arthroplasty. Arthroplast Today. 2025;31:101610.DOI: https://doi.org/10.1016/j.artd.2024.101610
51. Whiteside LA. Selective ligament release in total knee arthroplasty of the knee in valgus. Clin Orthop Relat Res. 1999;(367):130-140. DOI: https://doi.org/10.1097/00003086-199910000-00016