Decision–making in unicompartmental knee arthroplasty using radiological parameters in South Asian populations

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ABSTRACT

BACKGROUND: Many patients who visit orthopedic surgeons mainly complained of knee pain, which is often diagnosed as osteoarthritis affecting the medial compartment, whereas the lateral compartment and patello-femoral joint remain relatively unaffected.

AIM: This study aimed to establish criteria for patient selection and validate an evidence-based approach for selecting candidates for unicompartmental knee arthroplasty (UKA). Key considerations in patient selection for UKA include identifying the presence of bone-on-bone osteoarthritis in the medial compartment, ensuring a functionally normal anterior cruciate ligament, maintaining full-thickness cartilage in the lateral compartment, verifying a functionally normal medial collateral ligament, and confirming the absence of severe damage lateral to the patello-femoral joint.

MATERIALS AND METHODS: From a consecutive cohort of 390 patients with medial knee pain, preoperative radiographs of bilateral knee including anteroposterior/lateral/Rosenberg/20° valgus stress views were collected, and results were tabulated. Patients were categorized into appropriate groups. The suitability for UKA was determined based on the Oxford radiological decision aid, history, examination, and radiographic assessment including stress radiographs.

RESULTS: The Oxford radiological decision aid demonstrated 92% sensitivity and 88% specificity. According to the radiographic assessment, 49% of the knees were considered suitable for Oxford UKA (OUKA), whereas 51% were deemed unsuitable. Among the 51 knees identified as unsuitable for OUKA, 40% did not meet one radiographic criterion, 38% did not meet two criteria, 22% did not meet three criteria, and <1% did not meet four criteria.

CONCLUSION: The Oxford radiographic decision aid safely and reliably identifies the appropriate patients for meniscal-bearing UKA and achieves good results in this population. The widespread use of this radiological decision aid should improve the results of UKA.

Keywords: Oxford radiological decision aid; unicompartmental knee arthroplasty; osteoarthritis.

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Принятие решения об однокомпонентном эндопротезировании коленного сустава с использованием рентгенологических параметров в южноазиатской популяции

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АННОТАЦИЯ

Обоснование. Значительное число пациентов обращаются к хирургам-ортопедам с жалобами на боль в колене, которая часто диагностируется как остеоартрит, поражающий медиальный отдел, в то время как латеральный отдел и надколенно-бедренный сустав остаются относительно незатронутыми.

Цель. Установление критериев отбора пациентов и проверка научно обоснованного подхода к отбору кандидатов на одномыщелковое протезирование коленного сустава. Ключевыми моментами при отборе пациентов для одномыщелкового протезирования коленного сустава являются выявление остеоартроза кость в кость в медиальном отсеке, обеспечение функционально нормальной передней крестообразной связки, сохранение полной толщины хряща в латеральном отсеке, проверка функционально нормальной медиальной коллатеральной связки и подтверждение отсутствия серьёзного повреждения пателлофеморального сустава в латеральном направлении.

Материалы и методы. У 390 пациентов с болью в медиальной части коленного сустава были собраны предоперационные рентгенограммы коленных суставов, включая AP/LAT/Rosenberg view/20° valgus stress view, и результаты были сведены в таблицу. Пациенты были распределены по соответствующим группам. Отбор кандидатов на одномыщелковое протезирование коленного сустава определялся с помощью Оксфордской рентгенологической системы принятия решений, анамнеза, осмотра, рентгенографической оценки, включая стресс-рентгенограммы.

Результаты. Оксфордская рентгенологическая система принятия решений продемонстрировала чувствительность 92% и специфичность 88%. По результатам рентгенографической оценки 49% коленных суставов были признаны пригодными для проведения одномыщелкового протезирования коленного сустава, а 51% — непригодными. Среди 51 коленного сустава, признанных непригодными, 40% не соответствовали одному рентгенографическому критерию, 38% не соответствовали двум критериям, 22% — трём и менее 1% — четырём критериям.

Заключение. Оксфордская рентгенологическая система принятия решений безопасно и надёжно определяет подходящих пациентов для проведения одномыщелкового протезирования коленного сустава с менисковой опорой и позволяет достичь хороших результатов в данной популяции. Широкое использование этого рентгенологического пособия по принятию решений должно улучшить результаты одномыщелкового протезирования коленного сустава.

Ключевые слова: Оксфордская рентгенологическая система принятия решений; односуставная артропластика коленного сустава; остеоартрит.

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BACKGROUND

Most commonly found in older individuals, knee osteoarthritis (OA), which results from the wear and tear of knee joint, is a degenerative joint disease that leads to articular cartilage loss [1]. OA is a progressive disease that can lead to disability. The intensity of clinical symptoms may differ among individuals; however, they generally become more severe, frequent, and debilitating with time [1]. The progression rate also varies individually. Common clinical symptoms encompass gradual onset of knee pain aggravated by activity, knee stiffness, swelling, pain after prolonged sitting or resting, and worsening pain. Treatment for knee OA is initiated with conservative methods and advanced to surgical options if conservative treatment proves ineffective [2].

Many patients who visit orthopedic surgeons complained of knee pain, which is often diagnosed as OA affecting the medial compartment, whereas the lateral compartment and patello-femoral joint remain relatively unaffected [3]. Total knee arthroplasty (TKA) has been the conventional treatment of choice; however, this procedure involves removing healthy joint surfaces. Recently, a trend has developed toward less invasive surgery with unicompartmental knee replacement (UKR) gaining a high popularity [3].

Compared with TKA, patients who underwent UKA experience faster recovery, achieve superior functional outcomes, face lower morbidity and mortality rates, and report higher levels of satisfaction. Moreover, UKA was reported to be more cost-effective than TKA in both the short and long terms. UKA has been in existence since the 1950s; however, the initial designs were plagued with complications [4]. With the evolution of component designs and instrumentation, the survivorship of UKA has significantly improved. In the United States, the utilization rates of UKA from 2002 to 2008 had steadily increased, followed by a subsequent decline [3]. According to data from the 2018 Australian National Joint Replacement Registry, partial knee replacement constituted 8.6% of primary knee arthroplasties in 2017, showing a decline from its previous representation of 16.9% in 2003 [5]. The National Joint Registry of England and Wales also reported a similar UKA use rate of 8.9% in 2017, which has remained consistent over the past decade [6].

Since the establishment of the Indian Joint Registry in 2016, a similar trend of UKA use has been observed. UKA utilization has steadily increased, starting from 0.33% of TKAs in 2016, to 2.85% in 2019. However, the trend declined in 2020, with UKA accounting for 1.67% of TKAs.

However, not all arthroplasty surgeons perform UKA, and a small percentage of surgeons perform most of these procedures. In addition, attitudes toward UKA tend to be quite rigid among surgeons, with some being strong advocate, whereas others are vocal critics [7].

Aim: this study aimed to establish the criteria for patient selection and validate an evidence-based approach for selecting candidates for UKA. Key considerations in the patient selection for UKA include identifying bone-on-bone OA in the medial compartment, ensuring a functionally normal anterior cruciate ligament, maintaining full-thickness cartilage in the lateral compartment, verifying a functionally normal medial collateral ligament, and confirming the absence of severe damage laterally to the patello-femoral Joint.

MATERIALS AND METHODS
Research design

From a consecutive cohort of 390 patients with medial knee pain, preoperative radiographs of both knees including standing anteroposterior (AP), true lateral, posteroanterior (PA) view with 20° flexion, valgus stress view with 20° flexion, and skyline view were taken (Fig. 1), and results were tabulated. UKA suitability was determined using the Oxford Radiological Criteria (decision aid), history, examination, and radiographic assessment including stress radiographs.

The X-ray knee instability and degenerative scoring system (X-KIDS) is currently being used as a tool to determine the optimal treatment choice between UKA or TKA for an individual knee.

Regarding UKA, the X-KIDS scoring system lacks robust evidence to support its application.

Consequently, a novel atlas-based radiographic Oxford decision aid has been developed. This new tool is tailored for medial Oxford UKA (OUKA) within the context of anteromedial OA (AMOA).

The Oxford decision aid (Fig. 2) comprises five distinct sections, each dedicated to evaluating one of the five criteria: standing AP, true lateral, PA view with 20° flexion, valgus stress view with 20° flexion, and skyline view. Within these sections, radiographic views are presented alongside illustrative radiographs that showcase instances where the criteria are fulfilled. Conversely, exemplar radiographs were also included to illustrate situations where the criteria are not satisfied. The assessment of each criterion was conducted through a binary, yes-or-no question format, characterized by a polar response. Importantly, all five criteria must be met collectively to warrant the consideration of OUKA as a suitable intervention for AMOA.

To evaluate the effectiveness of this decision aid, its sensitivity, specificity, positive predictive value, negative predictive value, and accuracy in identifying cases suitable for OUKA were determined (Fig. 3, 4). This evaluation was conducted solely through radiographic assessment.

Conformity criteria

Inclusion criteria:
- patient with knee pain, aged >30 years.

Exclusion criteria:
- age <30 years;
- fractures around the knee and tibia;
- ligamentous injury of the knee;
- tumors;

Fig. 1. Patient positioning for X-rays.

- Charcot's disease;
- skeletally immature knees.

Research facilities

Chettinad Hospital and Research Institute, Chennai, India.

Research duration

Two years.

The main research outcome

In this section, the primary endpoints were described. They could be "true" (lethal outcome, serious adverse effects, etc.) or "substitute" finishing point (biochemical parameters and quality of life assessment scores). Usually, the main research outcome is characterized by safety, efficiency, and affordability.

Ethical review

Ethical committee approval was obtained from Chettinad Academy of Higher Education — Institutional Human Ethics Committee for Student Research (CARE IHEC-I) with ID no. IHEC-I/1219/22 approved on 06/09/2022.

Statistical analysis

Principles of samples size calculating: sample size cross-sectional study.

$$N=z^2 SD^2/e^2,$$

$$n=1.64^2 \times 0.6 \times (1-62)/0.05^2 = 390 \sim 400,$$

where $z=1.64$ (I.e) 90% CI, SD=0.6%.

RESULTS

Research sample (participants / respondents)

A total of 390 knees were subjected to assessment based on the Oxford decision aid criteria. The use of the radiographic decision aid led to the identification of 49% (191 knees) of the knees as suitable candidates for OUKA, whereas the remaining

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Radiographic Assessment for Medial Oxford® Partial Knee Replacement (PKR)

- See the package insert for complete indications, contraindications and patient selection criteria
- Recommended X-rays: AP weight bearing, true lateral, valgus stress & skyline. (Varus stress or Rosenberg/standing PA 20° flexion if bone-on-bone not seen on AP X-ray)
- Only proceed if **all** criteria are satisfied†

Patient Name:

Date of Birth:　　　Hospital Number:

Which Knee:

Comments:
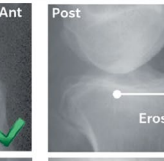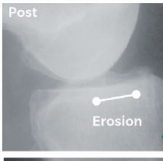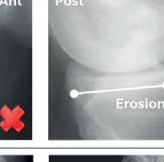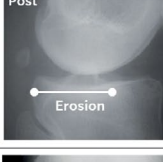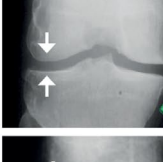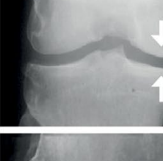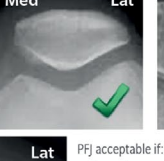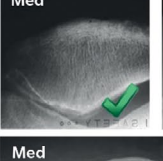
| Criterion	Example X-rays	Conclusion
(1) Medial Bone-on-bone X-ray: • AP weight bearing • Varus stress *(20° flexion)* or Rosenberg/ standing PA 20° flexion		Bone-on-bone *(or bone loss)* Meets criteria
	If bone-on-bone is not seen on AP weight bearing view perform varus stress or Rosenberg/standing PA 20° flexion X-ray. If these do not show bone-on-bone consider arthroscopy. Only perform PKA if there is exposed bone on both the femur and tibia in the medial compartment.	No Bone-on-bone Does not meet criteria
(2) Functionally Intact ACL X-ray: • True lateral *(femoral condyles overlapping)*	Post / Ant — Erosion	Functional ACL *(preserved posterior tibia)* Meets criteria
	Post / Ant — Erosion	Absent ACL *(posterior erosion/ subluxation)* Does not meet criteria
(3) Full Thickness Lateral Cartilage X-ray: • Valgus stress *(20° flexion)*		Full thickness *(ignore osteophytes)* Meets criteria
	Repeat if inadequately stressed or X-ray not parallel to joint surface.	Lateral narrowing Does not meet criteria
(4) Functionally Normal MCL *(correctable intra-articular deformity)* X-ray: • Valgus stress *(20° flexion)*		Correctable deformity *(Normal medial opening)* Meets criteria
	Repeat if inadequately stressed or X-ray not parallel to joint surface.	Not correctable *(Incomplete medial opening)* Does not meet criteria
(5) Acceptable Patellofemoral Joint X-ray: • Skyline	Med / Lat	Meets criteria
	Med / Lat — PFJ acceptable if: • Normal • Medial facet OA, with or without bone loss • Lateral facet OA, **without** bone loss. PFJ not acceptable: • Lateral facet OA, **with** bone loss, grooving & subluxation	Does not meet criteria

Fig. 2. Oxford radiological decision aid.
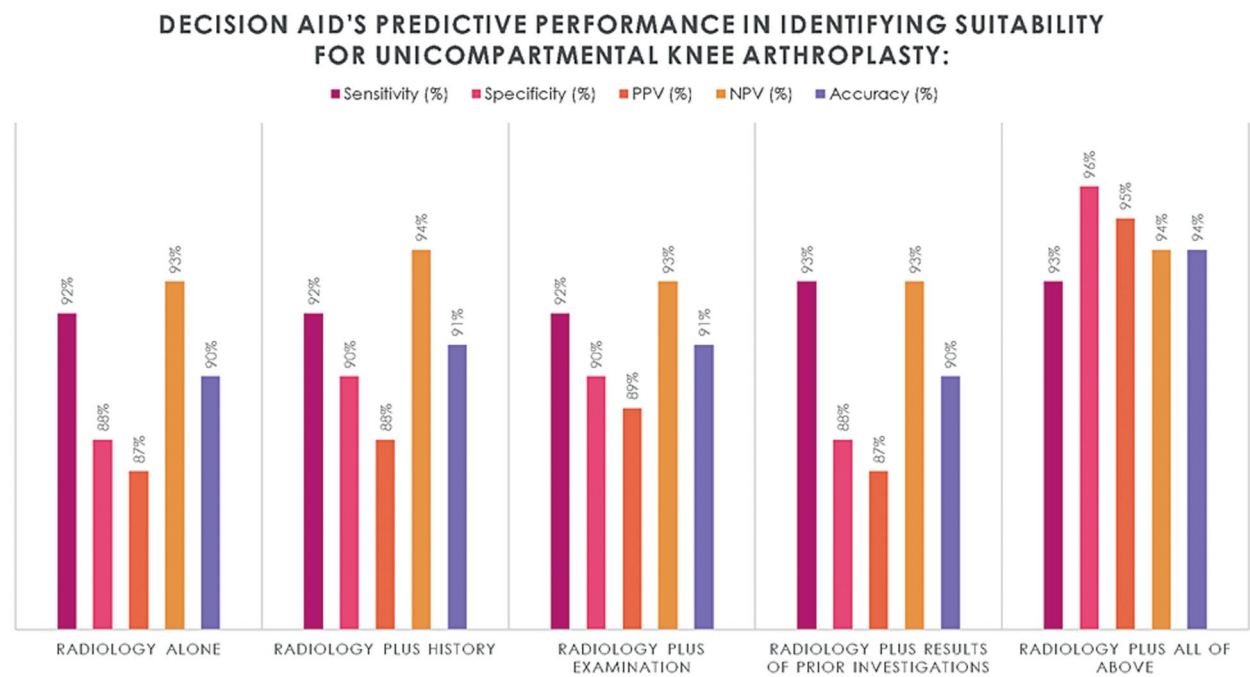
Fig. 3. Decision aid's predictive performance in identifying suitability for unicompartmental knee arthroplasty.
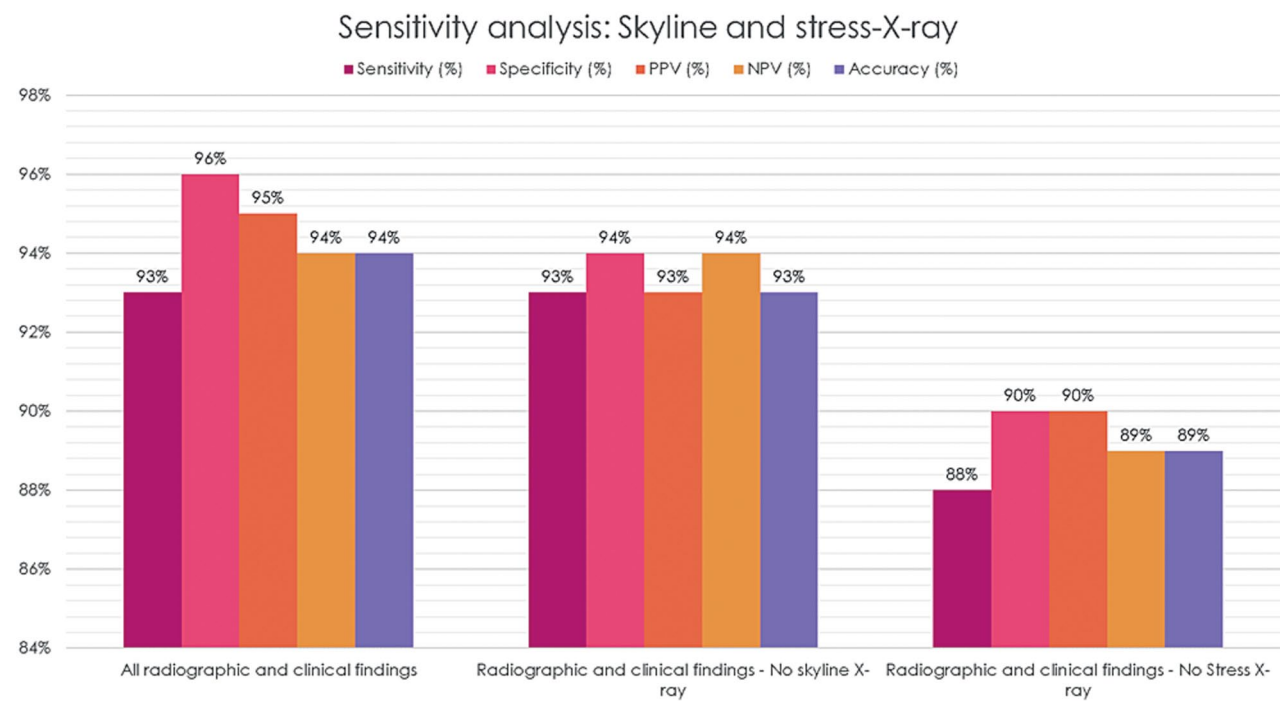

Fig. 4. Sensitivity analysis of skyline and stress X-rays.

51% (199 knees) were not deemed suitable. Remarkably high levels of agreement were observed, both within observers (intraobserver agreement with Cohen's kappa of 0.90) and between different observers (interobserver agreement with Cohen's kappa of 0.85).

Among the knees identified as unsuitable for OUKA (51%), 40% (79 knees) failed to meet a single radiographic criterion, 38% (75 knees) fell short of meeting two criteria, 22% (43 knees) did not meet the three criteria, and an

insignificant portion <1% (1 knee) did not fulfill the four criteria (Fig. 5).

In knees that did not meet the radiographic criteria, observations were as follows: 67 knees (46%) showed partial-thickness cartilage loss in the medial compartment, 69 (45%) exhibited posterior bone loss on true lateral radiographs, signifying ACL insufficiency, 113 (67%) displayed evidence of lateral compartment disease, 21 (11%) demonstrated signs of MCL shortening, and 31 (16%)
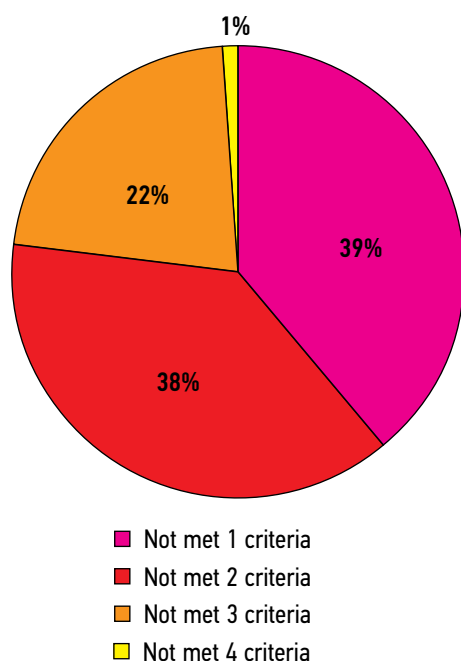
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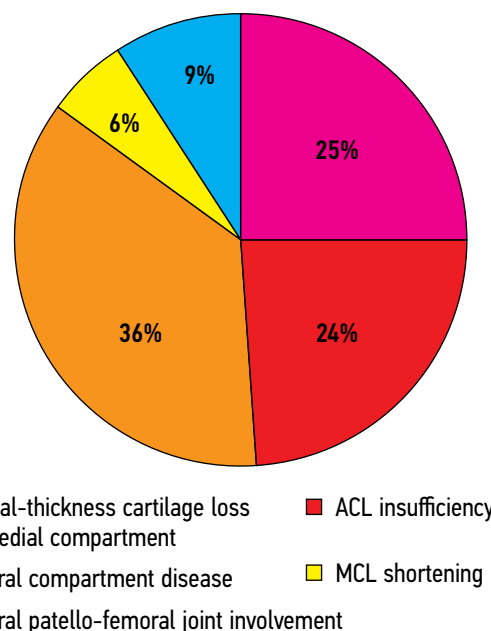**Fig. 5.** Radiographic assessment of X-rays.

Fig. 6. Specific findings in X-rays of patients that failed to meet the criteria.

exposed evidence of bone loss with grooving affecting the lateral patello-femoral joint (Fig. 6).

Undesirable phenomena

No undesirable phenomenon was observed in this study.

DISCUSSION

The X-KIDS was conducted based on the evaluation of five radiographic views, namely, standing AP, lateral, PA, varus, and valgus stress views. The knees were assessed for narrowing, presence of osteophytes, and subluxation in the coronal and sagittal planes [7].

The evaluation for joint space narrowing included examining both the medial and lateral compartments. A compartment is deemed narrowed when bone-on-bone arthritis is detected in standing AP, standing PA 15° flexion, or varus and valgus stress views. Upon identifying the bone-on-bone arthritis compartment, 3 points were credited, provided that the opposite knee compartment maintains a joint space width of ≥5 mm on all views. However, if the joint space width in the other compartment is <5 mm, it was scored 6 points [1].

Osteophytes are assigned a score of 1 point for the presence of either a medial or lateral osteophyte. Subluxation is evaluated using both standing AP and lateral views. In the AP view, 1 point is allotted for subluxation; however, this point is deducted if the subluxation is corrected on varus or valgus stress views. Subluxation observed in the lateral view credited 2 points, with a maximum total of 3 points achievable if uncorrectable subluxation is evident on both AP and lateral views [6].

Overall, knees can accumulate a maximum of 10 points. A score of 3–4 indicates that UKA is the preferred treatment. A score of 5 suggests that UKA might be suitable pending clinical findings and surgical correlation, while a score exceeding 5 points indicates that TKA is the more appropriate choice [6].

However, in clinical practice, the standing radiographs of some patients exhibit bone-on-bone arthritis, particularly in the medial compartment. In such cases, the value of conducting standing AP view in 15° flexion and varus stress views in 20° flexion to further evaluate the medial compartment appears limited because it does not alter the knee scores.

The X-KIDS score raises additional concerns, one of which pertains to the incorporation of osteophytes as a predictive factor for outcomes. However, these osteophytes do not affect functional outcomes or likelihood of surgery failure. Moreover, X-KIDS falls short in its evaluation of the patello-femoral joint. Lastly, inherent problems occurred in the calculation of scores using the X-KIDS system. Given its reliance on a points-based framework, a risk of misinterpretation associated with X-KIDS utilization is possible [7].

Collectively, these findings imply that the Oxford decision aid holds valuable utility in identifying suitable candidates for OUKA among individuals who fulfill the criteria for joint arthroplasty.

Summary of the primary research results

The Oxford radiological decision aid has shown high sensitivity and specificity in predicting the suitability of medial OUKA. Its use is expected to be associated with improved implant durability and better functional outcomes.

Research limitations

The functional outcome of patients selected for UKA was not evaluated in the study.

CONCLUSION

The Oxford radiological decision aid demonstrates high sensitivity and specificity in forecasting the appropriateness of medial OUKA. Its application is anticipated to correlate with superior implant longevity and favorable functional results. Furthermore, the decision aid maintains a low false-positive rate. Given that surgeons meticulously assess the knee during the surgical procedure, any false positives can be promptly recognized, thus averting the occurrence of OUKA in any patients.

ADDITIONAL INFO

ДОПОЛНИТЕЛЬНО

REFERENCES

1. Hsu H, Siwiec RM. Knee Osteoarthritis. In: *StatPearls* [Internet]. Treasure Island (FL): StatPearls Publishing; 2023. Available from: https://www.ncbi.nlm.nih.gov/books/NBK507884/
2. Lundgren Nilsson Å, Dencker A, Palstam A, et al. Patient-reported outcome measures in osteoarthritis: a systematic search and review of their use and psychometric properties. *RMD Open.* 2018;4(2):e000715. doi: 10.1136/rmdopen-2018-000715
3. McCormack DJ, Puttock D, Godsiff SP. Medial compartment osteoarthritis of the knee: a review of surgical options. *EFORT Open Rev.* 2021;6(2):113–117. doi: 10.1302/2058-5241.6.200102
4. Ode Q, Gaillard R, Batailler C, et al. Fewer complications after UKA than TKA in patients over 85 years of age: A case-control study. *Orthop Traumatol Surg Res.* 2018;104(7):955–959. doi: 10.1016/j.otsr.2018.02.015

5. Shlomo YB, Blom A, Boulton C, et al. *The National Joint Registry 16th Annual Report 2019* [Internet]. The National Joint Registry. 2019. Available from: https://www.semanticscholar.org/paper/The-National-Joint-Registry-16th-Annual-Report-2019-Ben-Shlomo-Blom/e73d48948fb87c3830e881c6f2061dd60b531179
6. Clement ND, Afzal I, Liu P, et al. The Oxford Knee Score is a reliable predictor of patients in a health state worse than death and awaiting total knee arthroplasty. *Arthroplasty.* 2022;4(1):33. doi: 10.1186/s42836-022-00132-9
7. Oosthuizen C, Burger S, Vermaak D, et al. The X-Ray Knee instability and Degenerative Score (X-KIDS) to determine the preference for a partial or a total knee arthroplasty (PKA/TKA). *SA Orthopaedic Journal.* 2015;14(3):61–69. doi: 10.17159/2309-8309/2015/v14n3a7

СПИСОК ЛИТЕРАТУРЫ

1. Hsu H., Siwiec R.M. Knee Osteoarthritis. B: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing, 2023. Режим доступа: https://www.ncbi.nlm.nih.gov/books/NBK507884/
2. Lundgren Nilsson Å., Dencker A., Palstam A., et al. Patient-reported outcome measures in osteoarthritis: a systematic search and review of their use and psychometric properties // RMD Open.

2018. Vol. 4, № 2. P. e000715. doi: 10.1136/rmdopen-2018-000715
3. McCormack D.J., Puttock D., Godsiff S.P. Medial compartment osteoarthritis of the knee: a review of surgical options // EFORT Open Rev. 2021. Vol. 6, № 2. P. 113–117. doi: 10.1302/2058-5241.6.200102
4. Ode Q., Gaillard R., Batailler C., et al. Fewer complications after UKA than TKA in patients over 85 years of age: A case-control

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study // Orthop Traumatol Surg Res. 2018. Vol. 104, № 7. P. 955–959. doi: 10.1016/j.otsr.2018.02.015

5. Shlomo Y.B., Blom A., Boulton C., et al. The National Joint Registry 16th Annual Report 2019 [Internet]. The National Joint Registry. 2019. Режим доступа: https://www.semanticscholar.org/paper/The-National-Joint-Registry-16th-Annual-Report-2019-Ben-Shlomo-Blom/e73d48948fb87c3830e881c6f2061dd60b531179

6. Clement N.D., Afzal I., Liu P., et al. The Oxford Knee Score is a reliable predictor of patients in a health state worse than death and awaiting total knee arthroplasty // Arthroplasty. 2022. Vol. 4, № 1. P. 33. doi: 10.1186/s42836-022-00132-9

7. Oosthuizen C., Burger S., Vermaak D., et al. The X-Ray Knee instability and Degenerative Score (X-KIDS) to determine the preference for a partial or a total knee arthroplasty (PKA/TKA) // SA Orthopaedic Journal. 2015. Vol. 14, № 3. P. 61–69. doi: 10.17159/2309-8309/2015/v14n3a7

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