Knee Surgery, Sports Traumatology, Arthroscopy
https://doi.org/10.1007/s00167-017-4817-y

KNEE

Larger range of motion and increased return to activity, but higher revision rates following unicompartmental versus total knee arthroplasty in patients under 65: a systematic review

Laura J. Kleeblad[1] · Jelle P. van der List[2] · Hendrik A. Zuiderbaan[2] · Andrew D. Pearle[1]

Received: 8 September 2017 / Accepted: 21 November 2017

Abstract

Purpose Due to the lack of comparative studies, a systematic review was conducted to determine revision rates of unicompartmental and total knee arthroplasty (UKA and TKA), and compare functional outcomes, range of motion and activity scores in patients less than 65 years of age.

Methods A literature search was performed using PubMed, Embase, and Cochrane systems since 2000. 27 UKA and 33 TKA studies were identified and included. Annual revision rate (ARR), functional outcomes, and return to activity were assessed for both types of arthroplasty using independent *t* tests.

Results Four level I studies, 12 level II, 16 level III, and 29 level IV were included, which reported on outcomes in 2224 UKAs and 4737 TKAs. UKA studies reported 183 revisions, yielding an ARR of 1.00 and extrapolated 10-year survivorship of 90.0%. TKA studies reported 324 TKA revisions, resulting in an ARR of 0.53 and extrapolated 10-year survivorship of 94.7%. Functional outcomes scores following UKA and TKA were equivalent, however, following UKA larger ROM (125° versus 114°, $p = 0.004$) and higher UCLA scores were observed compared to TKA (6.9 versus 6.0, n.s.).

Conclusion These results show that good-to-excellent outcomes can be achieved following UKA and TKA in patients less than 65 years of age. A higher ARR was noted following UKA compared to TKA. However, improved functional outcomes, ROM and return to activity were found after UKA than TKA in this young population. Comparative studies are needed to confirm these findings and assess factors contributing to failure at the younger patient population. Outcomes of UKA and TKA in patients younger than 65 years are both satisfying, and therefore, both procedures are not contraindicated at younger age. UKA has several important advantages over TKA in this young and frequently more active population.

Level of evidence IV.

Keywords Age · Survivorship · Annual revision rate · Functional outcomes · Range of motion · Unicompartmental knee arthroplasty · Total knee arthroplasty

✉ Laura J. Kleeblad
kleebladl@hss.edu

Jelle P. van der List
jpjvanderlistmd@gmail.com

Hendrik A. Zuiderbaan
aernoutzuiderbaan@hotmail.com

Andrew D. Pearle
pearlea@hss.edu

[1] Department of Orthopaedic Surgery, Sports Medicine and Shoulder Service, Hospital for Special Surgery, Weill Medical College of Cornell University, 535 East 70th St, New York, New York 10021, USA

[2] Department of Orthopaedic Surgery, Noordwest Hospital, Alkmaar, The Netherlands

Introduction

Medial unicompartmental knee arthroplasty (UKA) and total knee arthroplasty (TKA) are both effective treatment options for medial compartment knee osteoarthritis (OA). However, in younger patients with end-stage OA, the most suitable surgical option remains controversial. Surgical concerns include accelerated failure rates due to higher activity levels as well as increased likelihood of need for multiple subsequent revision surgeries [1–3].

Recent studies have shown good long-term survivorship and functional outcomes following TKA in younger patient cohorts [2–4]. Over the last decade, UKA has gained popularity as a viable alternative for TKA in the case of isolated medial OA [5–8]. In the general knee arthroplasty population, increased postoperative range of motion (ROM) and greater bone stock preservation were noted following UKA compared to TKA. These benefits are of special interest for younger patients with higher sports participation rates, and increased risk for multiple revisions due to longer life expectancy [9–15]. Based on registry data, however, survival rates of medial UKA tend to be lower than TKA in young patients [16–18]. To our knowledge, comparative studies assessing overall UKA and TKA survivorship in younger patient cohorts are lacking. Outcomes of prior non-comparative cohort studies are difficult to generalize to the younger patient population, as only a low percentage of patients undergoing knee arthroplasty are generally aged less than 65 years. This is the first study to systematically review the literature on outcomes of UKA and TKA in patients under 65.

To gain more insight in the younger population, a systematic review was conducted to assess survivorship, functional outcomes and activity levels of medial UKA and TKA in patients less than 65 of age. The study aims were to (1) determine revision rates of both arthroplasty types in cohort studies, and (2) compare functional outcomes and activity scores following UKA and TKA in younger patients. The hypothesis was that good-to-excellent outcomes were achieved after both arthroplasty types in patients less than 65 years, and therefore, young age should not be considered a contraindication for either procedures.

Materials and methods

Search strategy and criteria

A systematic literature search was performed in PubMed, EMBASE and Cochrane Library databases to identify studies reporting survivorship, functional outcomes and/or activity scores of TKA and UKA. Search terms consisted of "unicompartmental", "unicondylar", "partial", "UKA", "UKR", "PKA", "PKR", or "total" "TKA", combined with "knee arthroplasty", "knee replacement" or its Mesh term. Other keywords were "young", "younger", "middle-aged", "outcomes", "prosthesis failure" and its Mesh terms. Results were filtered for retrieval of only English language studies published since 2000. After removal of duplicates, two authors (LJK and JPL) independently screened all entries by both title and abstract. Subsequently, all eligible studies were scanned for full texts against the inclusion and exclusion criteria. Survivorship studies were screened for differentiation of age groups or young patients. Additionally, references of scanned articles were checked for any missed studies. The third author (HAZ) was consulted in case of disagreement. Consensus was achieved with regards to inclusion and exclusion of all reviewed articles.

Inclusion criteria consisted of cohort studies that (1) reported survivorship, revision rates or functional outcomes in TKA and/or medial UKA patients aged < 65 years, (2) regarded primary OA as the main indication (> 70% of study cohort), (3) only included patients with intact ACLs for UKA, and (4) had minimum follow-up of 2 years. Exclusion criteria consisted of studies that (1) not reported cohort size and/or revisions separately for young patients or per age group, (2) assessed revision or complex primary procedures (e.g., bicondylar UKA, TKA in > 15° valgus knees), (3) assessed specific subgroups (e.g., ACL-deficient and obese patients), (4) were performed using the same database, or (5) were case reports or systematic reviews.

Methodological quality assessment

Level of evidence was determined for all studies using the adjusted Oxford Centre for Evidence-based Medicine [19]. Methodological Index for Non-randomized Studies (MINORS) instrument was used to determine the methodological quality of studies and assess the risk of bias [20]. Mean scores and percentage of the maximum score were reported.

Data extraction

PRISMA guidelines were used to perform this systematic review. The following data were collected in Excel 2016; study type, authors, year of publication, type of implant, age group and mean age, number of TKA or UKA, number of failures, mean follow-up, functional outcomes, ROM, and activity scores. Outcomes of this study included survivorship, revision rates, annual revision rate (ARR), patient-reported outcomes, ROM, and activity scores following UKA and TKA. ARR was defined as "revision rate per 100 observed component years", which provides an average failure rate per follow-up year. This metric corrects for varying follow-up intervals between populations, allowing direct comparison between studies with different follow-up lengths [21–24]. All outcome scores were reported as a percentage of the maximum score, which enabled comparison of different functional outcome scores. Collected outcome scores included Knee Society Score (KSS), Oxford Knee Score (OKS), Hospital for Special Surgery (HSS) Score, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) Score, and Visual Analog Scale for pain (VAS). Raw scores were used for ROM, University of California at Los Angeles (UCLA) Activity Score, and Tegner Activity Score. Satisfaction was recorded using Likert scales and reported as percentage of patients that scored good/excellent.

Statistical analysis

Follow-up, age, revision rates of UKA and TKA were calculated using a weighted-mean to correct for different cohort sizes. Total number of revisions and observed component years were extracted to calculate the ARR for each study. Log-transformed ARRs were pooled separately for UKA and TKA studies using Poisson-normal models with random effects. Pooled log-transformed ARRs were exponentiated to obtain pooled ARRs with 95% confidence intervals (CI). Between-study heterogeneity was tested using the χ^2 test and quantified using the I^2 statistic. These statistical analyses were performed using the Metafor package Version 2.0–0 (Maastricht University, Maastricht, the Netherlands) implemented in R-software Version 3.3.1 (R Foundation for Statistical Computing, Vienna, Austria). Additionally, functional outcomes and activity scores following UKA and TKA were assessed using independent *t* tests.

Results

Search results

After full-text review of 757 articles, a total of 61 cohort studies [3, 4, 7, 10, 25–81] were selected for inclusion. Only two comparative studies assessing functional outcomes after UKA and TKA were identified [10, 43]. Twenty-four non-comparative UKA studies [7, 26, 27, 29, 31–33, 35, 37, 39, 48, 50–52, 59, 64, 66, 67, 71–73, 76, 78, 81] and 35 TKA studies [3, 4, 25, 28, 30, 34, 36, 38, 40–42, 44–47, 49, 53–58, 60–63, 65, 68–70, 74, 75, 77, 79, 80] reported revision rates and/or functional outcomes (Fig. 1).

Quality of studies and risk of bias

Four level I randomized controlled trials were included [34, 36, 54, 61]. Twelve studies were level II prospective studies [40, 41, 45–47, 52, 56, 69, 70, 74, 81]. The majority of studies were either level III retrospective observational studies [3, 7, 10, 28, 33, 35, 39, 42–44, 57, 58, 62, 64, 76, 79] or level IV case series [4, 25–27, 29, 31, 32, 37, 38, 48–51, 53, 55, 59, 60, 63, 65–68, 71–73, 75, 77, 78, 80]. Using the MINORS instrument, a mean score of 15.5 (standard deviation, SD 0.5) was observed for the two comparative studies, while 59 non-comparative studies scored 10.1 (SD 1.8), corresponding to 64.6% and 63.1% of the maximum, respectively. None of the included studies were blinded and only 5% reported power calculations. Heterogeneity mainly existed in type of prosthesis and surgical indication.

Revision rates of UKA and TKA

Twenty-one cohort studies reported data on 2224 UKAs at a mean age of 54.7 years, stating 182 revisions, yielding a revision rate of 8.18% and ARR of 1.00 (95% CI 0.77–1.30) (Table 1; Fig. 2). This ARR corresponds to an extrapolated 5-, 10-, and 15-year survivorship of 95.0, 90.0 and 85.0%, respectively. Thirty-three cohort studies reported data on 4737 TKAs at a mean age of 51.7 years, reporting 324 revisions, which results in a revision rate of 6.95% and ARR of 0.53 (95% CI 0.36–0.78) (Table 1; Fig. 3). This corresponds to an extrapolated 5-, 10-, and 15-year survivorship of 97.4, 94.7 and 92.1%, respectively. The revision rates and follow-up intervals of all individual cohort studies were plotted (Fig. 4).

Functional outcomes

Functional outcomes were reported by 49 cohort studies, which included scores of 2012 UKAs at mean follow-up of 7.2 years (range 2.0–17.2) and 8664 TKAs at mean follow-up of 6.7 years (2.0–25.1). Overall, no significant differences were observed in any outcome scores between UKA and TKA (Table 2; Fig. 5). At long-term follow-up (9.7 years for UKA and 11.1 years for TKA), only KSS total scores were significantly higher following UKA compared to TKA (88.1 ± 4.5 and 85.8 ± 5.7, respectively, $p = 0.04$) (Fig. 6).

Range of motion and activity scores

A total of 35 studies reported ROM and/or activity scores, including 1590 UKAs and 2487 TKAs. Eleven UKA studies [26, 27, 31–33, 43, 48, 50, 64, 67, 72, 76, 81], 14 TKA studies [4, 30, 38, 43, 45, 46, 53–55, 57, 58, 61, 63, 68, 74] and two comparative studies [10, 43] reported larger ROM following UKA compared to TKA (125° and 114°, respectively, $p = 0.004$). A similar trend was observed with regard to UCLA scores, six UKA studies [10, 26, 32, 66, 72, 78] reported higher overall scores at each follow-up interval than five TKA studies [10, 46, 58, 62, 63] (6.9 and 6.0, respectively, n.s.). In eight studies [7, 35, 52, 53, 55, 63, 78, 81], similar Tegner scores were observed after both arthroplasty types (Table 3).

Discussion

The most important finding of this study was that good–to-excellent outcomes can be achieved with UKA and TKA in patients less than 65 years of age. More specifically, the ARR of medial UKA was higher compared to TKA (1.00 and 0.53, respectively). On the contrary, significantly larger ROM and higher activity scores were observed following

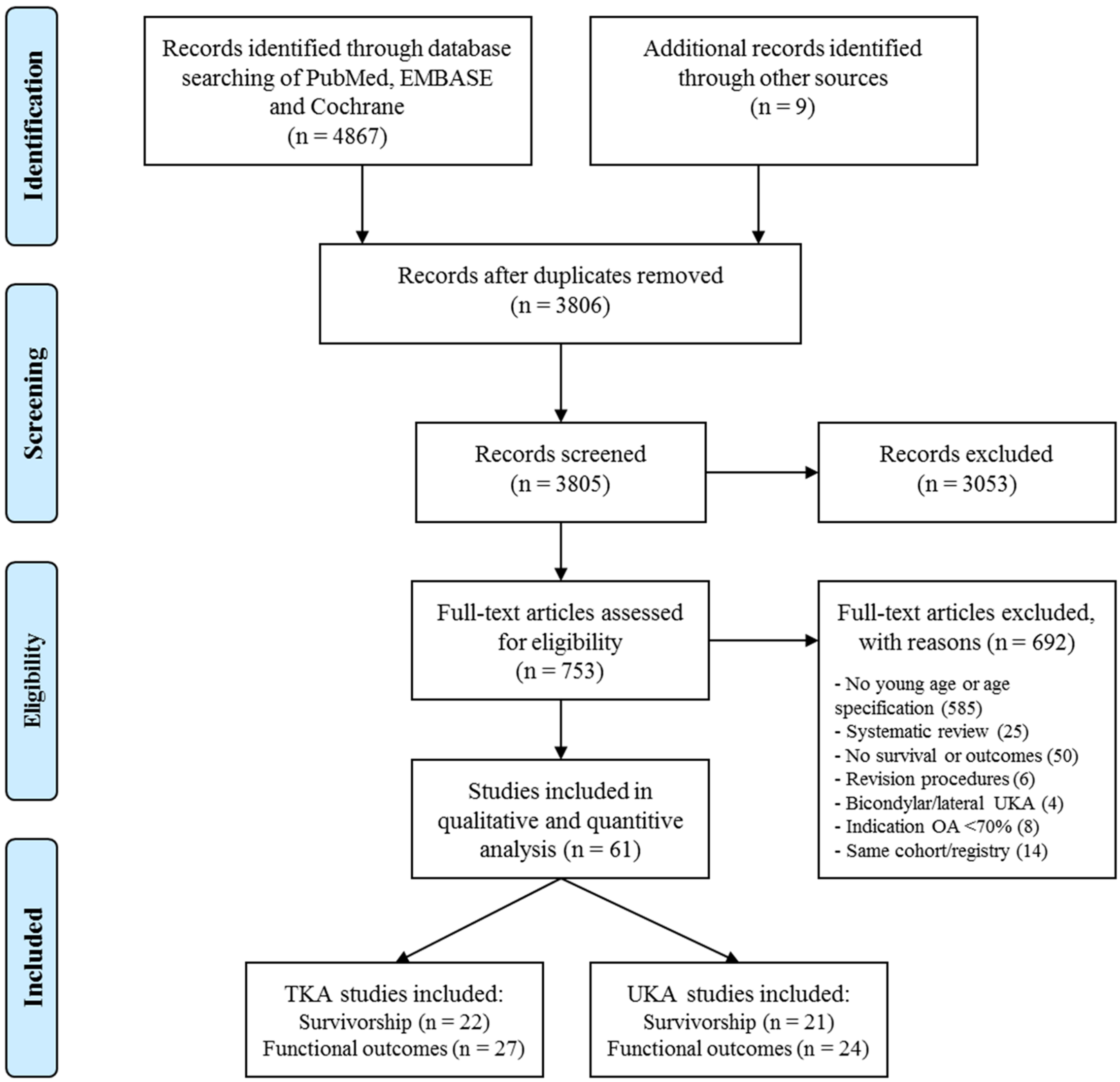

Fig. 1 PRISMA flow diagram of study inclusion process. *TKA* total knees arthroplasty, *UKA* unicompartmental knee arthroplasty

Table 1 Revision rates of unicompartmental and total knee arthroplasty of all studies and registries

Type of arthroplasty	No. of studies	Mean age (years)	No. of arthroplasties	No. revisions	Revision rate (%)	Mean follow-up (years)	Observed component years	Annual revision rate
UKA	21	54.7	2224	182	8.18	8.41	18,696.0	1.00
TKA	22	51.7	4737	324	6.95	9.77	46,245.9	0.53

Annual revision rate is the revision rate corrected for follow-up interval (observed years)

No. number *TKA* total knee arthroplasty, *UKA* unicompartmental knee arthroplasty

UKA at mid- to long-term follow-up. Overall functional outcome scores were equivalent after both procedures in this patient population. This study emphasizes the importance of assessing these outcomes using a systematic approach, as the number of younger patients is often small in individual cohort studies, particularly for UKA. Furthermore, a corresponding increase in knee OA is expected as surges in obesity and sport-related injuries are anticipated to continue [82]. Therefore, higher demand for knee arthroplasty is predicted in the younger population [83, 84]. Finally, this

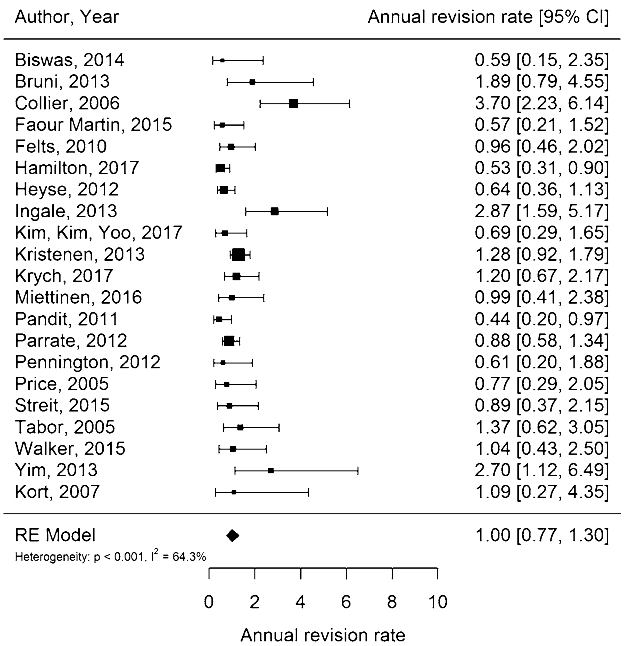

Fig. 2 Forest plot of UKA studies reporting annual revision rates in younger patients. *ARR* annual revision rate; *95% CI* confidence interval

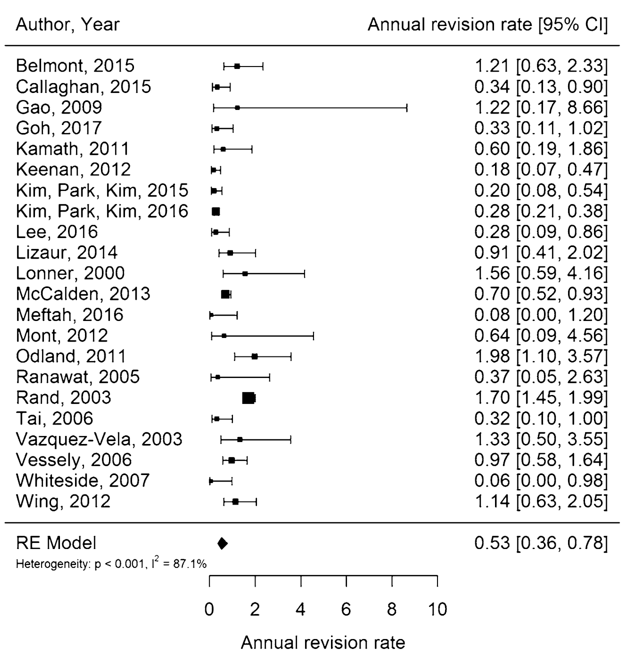

Fig. 3 Forest plot of TKA studies reporting annual revision rates in younger patients. *ARR* annual revision rate; *95% CI* confidence interval

review stresses the need for comparative clinical studies to assess outcomes of UKA and TKA, as they are currently lacking.

In this systematic review, an ARR of 1.00 following UKA and 0.53 following TKA were noted in patients less than 65 years of age, corresponding to an extrapolated 10-year survivorship of 90.0% and 94.7%, respectively. Many studies have found similar survivorship differences between UKA and TKA in the typical arthroplasty population (> 65 years), and therefore may be attributed to the following factors [85, 86]. First, UKA survival is highly sensitive to technical parameters, including lower leg alignment and component position [87–89]. However, the role of alignment in the setting of TKA is currently debated, as several authors showed good results for both kinematically and mechanically aligned knees [90, 91]. The window for optimal postoperative alignment in UKA is relatively small (1°–4° of varus). Since undercorrection is associated with accelerated polyethylene wear, and overcorrection induces OA progression of the contralateral compartment [87, 89, 92, 93]. Therefore, it can be argued that coronal alignment might be even more important in younger active patients, as they impart increased stresses along the knee joint for longer durations [10, 15, 78]. A second potential explanation for higher UKA revision rates compared to TKA relates to surgical thresholds. Several authors have suggested a lower threshold may exist for revising an UKA to a TKA, due to relative ease of the procedure [21, 94]. Moreover, surgical inexperience of low-volume surgeons and the preserved bone stock after UKA surgery might contribute to the lower threshold [86, 94, 95]. Additionally, UKA are more often revised for unexplained pain compared to TKA (23% and 9% of all revisions, respectively) [96].

Numerous registry studies and systematic reviews have assessed survivorship in the general arthroplasty population (> 65 years) [21, 97, 98]. Compared to the most recent Finish registry study, our extrapolated 10-year UKA survivorship was higher than their survival rate in the general population with a mean age of 63.5 years (90.0 versus 80.6%) [98]. A systematic review by Rodriguez reported a survival rate at 10 years of 88% for UKA and 94% for TKA, which findings were similar to our results in a younger population (90.0 and 94.7%, respectively) [99]. Another recent systematic review has compared UKA with TKA in the general OA population (mean age 67.4 and 68.6 years, respectively) using ARR. The authors found a lower ARR (0.46) for TKA, but surprisingly, an equivalent ARR for UKA (1.04) was found compared to our results [21]. In summary, TKA survivorship was higher relative to UKA, but UKA survivorship seems not to be negatively affected by age at the time of surgery. More recent cohort studies by Pandit and Kristenen et al. showed comparable results between the general and younger arthroplasty population, which matches our findings as well as those of a systematic review by Chawla et al. [7, 21, 51]. However, future studies are needed to confirm these findings.

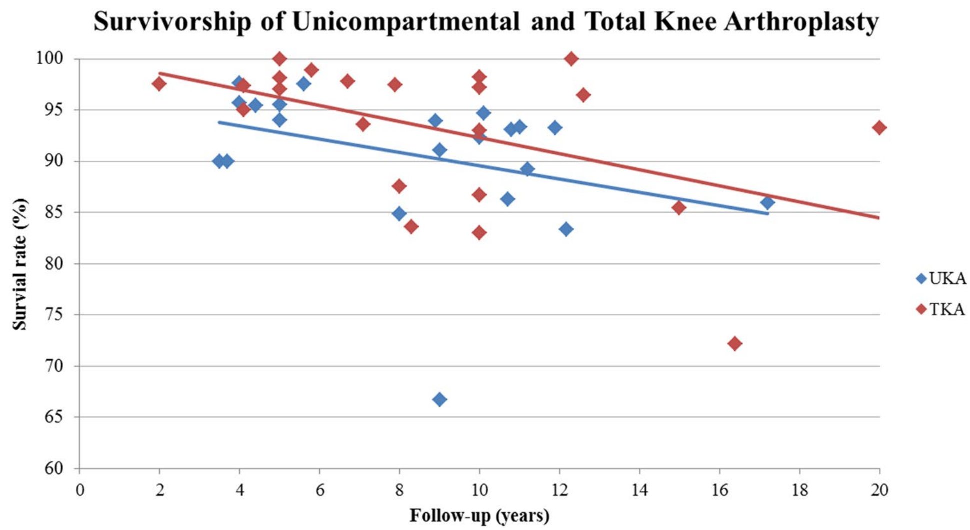

Fig. 4 All included studies reporting survivorship of UKA and TKA in young patients

Table 2 Functional outcome scores reported by 49 cohort studies

	Mean or % of maximum (range)		*p* value	References
	UKA	TKA		
OKS	40.8 (40.0–41.4)	36.4 (29.0–42.9)	n.s	[3, 7, 27, 35, 42, 44, 49, 70, 72]
HSS	94.0	89.3 (85.3–93.2)	n.s	[45, 55, 61, 66, 67]
WOMAC	84.6% (79.6–89.2)	76.5% (69.5–83.9)	n.s	[27, 46, 48, 50, 54, 58]
KSS total	87.5% (77.6–95.5)	87.7% (74.8–96.5)	n.s	[3, 4, 7, 27, 30–32, 35, 37–39, 45, 46, 48, 50, 53–55, 57–61, 63, 64, 68, 71, 73, 74, 76, 79]
Satisfaction	93.8% (83.0–100)	90.3% (81.0–95.6)	n.s	[3, 31, 32, 43, 46, 48, 49, 53, 62, 65, 66, 71, 72, 78]
VAS	2.1 (1.6–3.0)	2.3 (1.9–2.6)	n.s	[27, 43, 44, 72]

Satisfaction was defined as % of patients that scored a good to excellent rate

HSS Hospital for Special Surgery Score, *KSS* Knee Society Score, *OKS* Oxford Knee Score, *VAS* Visual Analog Pain Scale, *WOMAC* Western Ontario and McMaster Universities Osteoarthritis Index Score

When reviewing functional outcomes, it was found that OKS, HSS, and WOMAC scores were higher following UKA than TKA, although equivalent KSS scores were observed. At mid- and long-term follow-up, these patient-reported outcome scores continued to favor UKA (Fig. 6). This might be explained by the nature of UKA surgery including increased preservation of bone stock, larger ROM, maintenance of proprioception, and restoration of native knee kinematics [100, 101]. These factors likely allow patients to 'forget' their artificial joint more often [102, 103]. This may influence postoperative satisfaction rates, as our data suggests that UKA patients were more satisfied overall (good to excellent satisfaction in 94% of UKA versus 90% of TKA) [32, 43, 78]. Interestingly, only KSS scores were equivalent for both UKA and TKA. The sensitivity of the KSS has been questioned by authors [104, 105]. According to Na et al., the KSS fails to differentiate between moderate and high functional levels, which is of special interest in younger patients as they require increased motion and strength [105].

Additionally, this systematic review showed increased ROM and UCLA scores following UKA, indicating young patients return to high level activities compared moderate levels after TKA [106]. Several studies have similarly showed higher and often quicker return to activity following UKA [12, 15, 107]. Naal et al. showed a 95% return to activity rate and the majority the patients (90.3%) maintained or improved their ability to participate in sports [12]. The review by Witjes et al. found that TKA patients were also able to return to low- and high-impact sports, although to a lesser extent (36–89%) [15]. Finally, the comparative study by Ho et al. demonstrated a difference in timing, UKA patients were able to return to sports more quickly following surgery [10].

This study has several limitations. First, indications for UKA and TKA differ, as both types of arthroplasty can

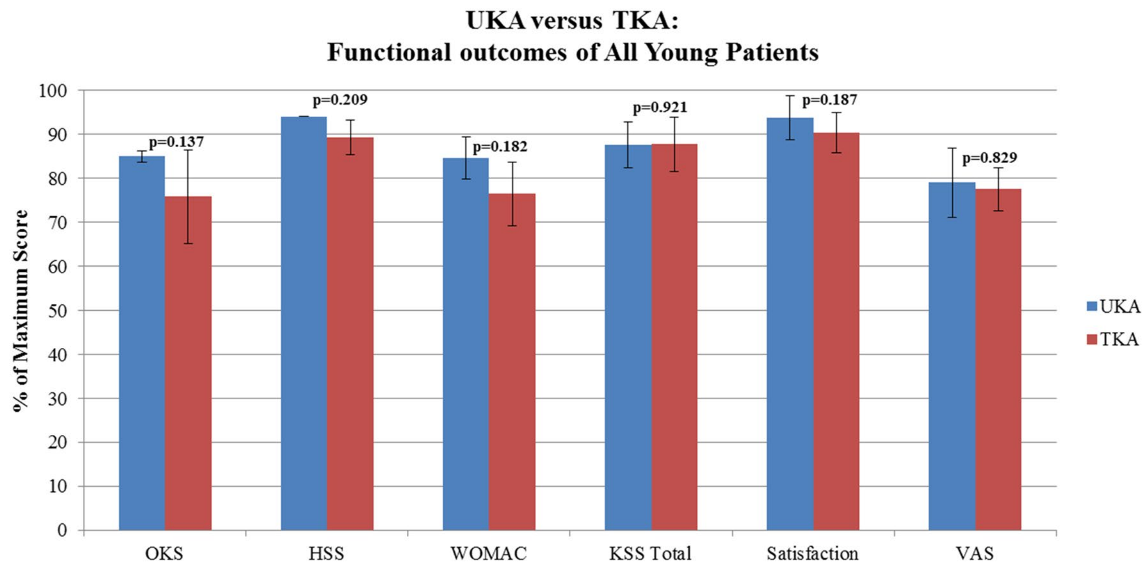

Fig. 5 Functional outcomes of all studies at mean follow-up was 7.4 years for UKA, and 6.7 years for TKA. *OKS* Oxford Knee Score, *HSS* Hospital for Special Surgery score, *WOMAC* Western Ontario and McMaster Universities Osteoarthritis Index score, *KSS* Knee Society Score, *VAS* Visual Analog Scale

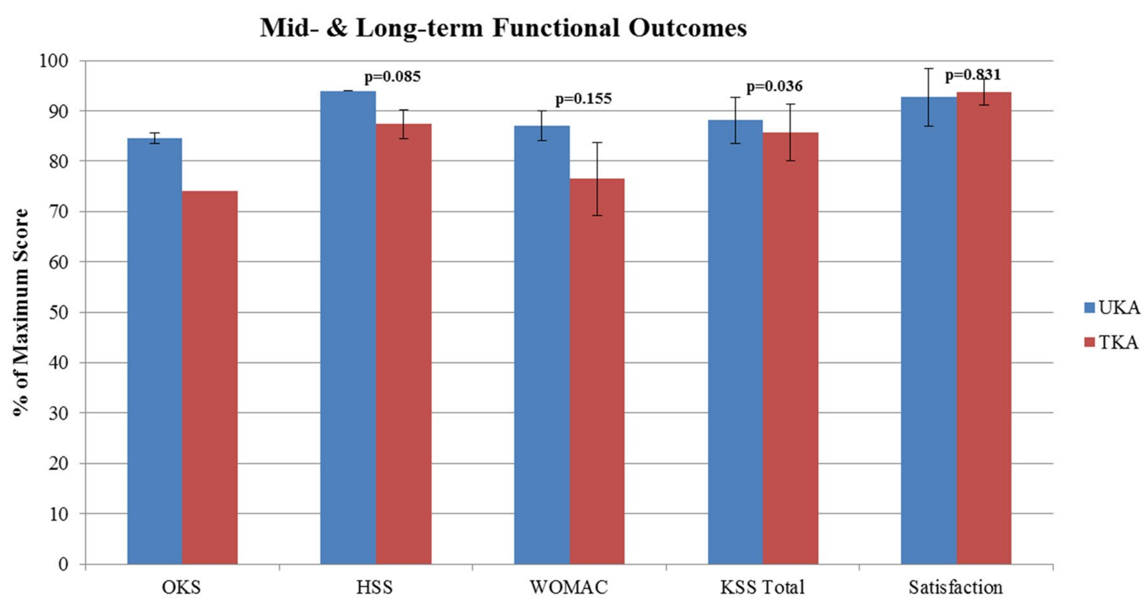

Fig. 6 Mid- to long-term functional outcomes following UKA and TKA (mean follow-up 9.7 and 11.1 years, respectively). *OKS* Oxford Knee Score, *HSS* Hospital for Special Surgery score, *WOMAC* Western Ontario and McMaster Universities Osteoarthritis Index score, *KSS* Knee Society Score

be performed in the setting of medial OA, whereas only TKA is indicated for tricompartmental OA. Although primary diagnosis was OA in at least 70% of patients, this study was limited as most UKA studies report on solely OA patients. Furthermore, based on OA severity, preoperative outcome scores may have been different between UKA and TKA, but few studies specified which knee compartments were involved. This review has focused on cohort studies; therefore, it is likely limited to outcomes in highl or moderately high-volume studies and may not reflect results from low-volume centers. Registry studies that include low-volume centers demonstrate higher revision rates (6.0–21.1%) [2, 108–111]. However, this difference has already been shown by many other studies [21, 95, 112, 113]. Nonetheless, this systematic review stresses the need for comparative studies assessing survivorship and functional outcomes in

Table 3 Activity scores following unicompartmental and total knee arthroplasty, overall and split at five-year follow-up

Type of arthroplasty	No. of arthroplasties	Mean follow-up (years)	Range of motion	UCLA	Tegner activity scale
Overall					
UKA	1590	7.0 (2.0–17.2)	125° (101–138)	6.9 (6.4–7.5)	3.4 (2.6–4.3)
TKA	2487	8.0 (2.0–25.1)	114° (100–132)	6.0 (4.7–7.6)	3.2 (3.0–3.4)
p value			0.004	n.s	n.s
Follow-up ≤ 5 years					
UKA	631	3.7 (2.0–5.0)	122° (101–130)	7.1 (6.8–7.5)	3.6 (2.6–4.3)
TKA	843	3.1 (2.0–5.0)	113° (110–123)	6.2 (6.1–6.3)	–
p value			n.s	0.030	–
Follow-up > 5 years					
UKA	959	9.9 (5.6–17.2)	126° (115–138)	6.5 (6.4–6.5)	3.2 (3.1–3.2)
TKA	1644	11.1 (6.2–25.1)	114° (100–132)	6.0 (4.7–7.6)	3.2 (3.0–3.4)
p value			0.015	n.s	n.s

No. number, *n.s.* non-significant, *TKA* total knee arthroplasty, *UCLA* University of California at Los Angeles Activity Score, *UKA* unicompartmental knee arthroplasty

younger patients for optimal statistical comparison between UKA and TKA [83]. Most studies have used different age cutoff values to define younger patients, and therefore, mean age was calculated and found slightly higher in the UKA group (54.7 years) versus TKA (51.7 years). However, this difference was not considered clinically relevant by the authors. Finally, a possible selection bias exists as non-English articles were excluded.

This study provides an overview of the outcomes of UKA and TKA in a younger patient population, showing good-to-excellent outcomes following both procedures. Improvements in surgical design and techniques have resulted in a decreasing threshold for offering patients UKA and TKA, which in turn, has resulted in younger, more active patients accessing these surgeries. Due to the high number of patients included, this study can be used to guide surgeons, inform patients and manage their expectations with regard to risk of revision, functional outcomes and return to activity. Furthermore, this study shows that comparative studies of UKA versus TKA in younger patients are lacking in the current literature.

Conclusion

This systematic review showed good-to-excellent outcomes are achievable with medial UKA and TKA in the young and often more active patient population. Cohort studies reported ARR of 1.00 for UKA and 0.53 for TKA in patients less than 65 years of age, corresponding to an extrapolated 10-year survivorship of 90 and 94.7%, respectively. Increased ROM and higher activity scores were observed following UKA compared to TKA; however, equivalent functional outcomes were reported. Despite a moderate level of evidence, this review suggests that young age may not be a contraindication for either TKA or UKA.

Acknowledgements We would like to thank Kara Fields from the Healthcare Research Institute for her assistance in the statistical analysis of this study.

Author contributions LK performed the literature search, scanned all abstracts and full texts of the included articles and wrote the manuscript. JL screened all abstracts and full texts as a second author, helped to draft the manuscript. HA determined the quality of all included studies and helped to draft the manuscript. AP coordinated this study, participated in its design and helped to draft the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest Andrew D. Pearle is a consultant and receives research support from Stryker Corp, and has royalties from Zimmer Biomet. The other authors declare that they have no conflict of interests.

Funding No funding has been received for this study.

Ethical approval No ethical approval was obtained, because this study was a systematic review using de-identified data from other cohort studies.

Informed consent Informed consent was not applicable for this study.

References

1. Diduch DR, Insall JN, Scott WN, Scuderi GR, Font-Rodriguez D (1997) Total knee replacement in young, active patients. Long-term follow-up and functional outcome. J Bone Joint Surg Am 79(4):575–582
2. Gioe TJ, Novak C, Sinner P, Ma W, Mehle S (2007) Knee arthroplasty in the young patient: survival in a community registry. Clin Orthop Relat Res 464(464):83–87

3. Goh GS-H, Liow MHL, Bin Abd Razak HR, Tay DK-J, Lo N-N, Yeo S-J (2017) Patient-reported outcomes, quality of Life, and satisfaction rates in young patients aged 50 years or younger after total knee arthroplasty. J Arthroplasty 32(2):419–425
4. Lonner JH, Hershman S, Mont M, Lotke PA (2000) Total knee arthroplasty in patients 40 years of age and younger with osteoarthritis. Clin Orthop Relat Res 380:85–90
5. Kozinn SC, Scott R (1989) Unicondylar knee arthroplasty. J Bone Joint Surg Am 71(1):145–150
6. Liddle AD, Pandit H, O'Brien S, Doran E, Penny ID, Hooper GJ, Burn PJ, Dodd CAF, Beverland DE, Maxwell AR, Murray DW (2013) Cementless fixation in Oxford unicompartmental knee replacement: a multicentre study of 1000 knees. Bone Joint J 95–B(2):181–187
7. Pandit H, Jenkins C, Gill HS, Smith G, Price a J, Dodd C a Murray F DW (2011) Unnecessary contraindications for mobile-bearing unicompartmental knee replacement. J Bone Joint Surg Br 93(5):622–628
8. Pearle AD, O'Loughlin PF, Kendoff DO (2010) Robot-assisted unicompartmental knee arthroplasty. J Arthroplasty 25(2):230–237
9. Bolognesi MP, Greiner MA, Attarian DE, Watters TS, Wellman SS, Curtis LH, Berend KR, Setoguchi S (2013) Unicompartmental knee arthroplasty and total knee arthroplasty among Medicare beneficiaries, 2000 to 2009. J Bone Joint Surg Am 95(22):e174
10. Ho JC, Stitzlein RN, Green CJ, Stoner T, Froimson MI (2016) Return to sports activity following UKA and TKA. J Knee Surg 29(3):254–259
11. Hopper GP, Leach WJ (2008) Participation in sporting activities following knee replacement: total versus unicompartmental. Knee Surg Sport Traumatol Arthrosc 16(10):973–979
12. Naal FD, Fischer M, Preuss A, Goldhahn J, von Knoch F, Preiss S, Munzinger U, Drobny T (2007) Return to sports and recreational activity after unicompartmental knee arthroplasty. Am J Sports Med 35(10):1688–1695
13. Vorlat P, Putzeys G, Cottenie D, Van Isacker T, Pouliart N, Handelberg F, Casteleyn P-P, Gheysen F, Verdonk R (2006) The Oxford unicompartmental knee prosthesis: an independent 10-year survival analysis. Knee Surg Sports Traumatol Arthrosc 14(1):40–45
14. Walton NP, Jahromi I, Lewis PL, Dobson PJ, Angel KR, Campbell DG (2006) Patient-perceived outcomes and return to sport and work: TKA versus mini-incision unicompartmental knee arthroplasty. J Knee Surg 19(2):112–116
15. Witjes S, Gouttebarge V, Kuijer PPFM., van Geenen RCI, Poolman RW, Kerkhoffs GMMJ. (2016) Return to sports and physical activity after total and unicondylar knee arthroplasty: a systematic review and meta-analysis. Sports Med 46(2):269–292
16. Australian Orthopaedic Association National Joint Registry (2015) Hip and Knee Arthroplasty Annual Report 2015
17. National Joint Registry for England, Wales and Northern Ireland (2015) 12th Annual Report 2015
18. New Zealand Joint Registry (2014) The New Zealand Registry Annual Report
19. Wright JG, Swiontkowski MF, Heckman JD (2003) Introducing levels of evidence to the journal. J Bone Joint Surg Am 85–A(1):1–3
20. Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J (2003) Methodological index for non-randomized studies (minors): development and validation of a new instrument. ANZ J Surg 73(9):712–716
21. Chawla H, van der List JP, Christ AB, Sobrero MR, Zuiderbaan HA, Pearle AD (2017) Annual revision rates of partial versus total knee arthroplasty: a comparative meta-analysis. Knee 24(2):179–190
22. van der List JP, Chawla H, Zuiderbaan HA, Pearle AD (2017) Survivorship and functional outcomes of patellofemoral arthroplasty: a systematic review. Knee Surg Sports Traumatol Arthrosc 25(8):2622–2631
23. Pabinger C, Benjamin Lumenta D, Cupak D, Berghold A, Boehler N, Labek G (2015) Quality of outcome data in knee arthroplasty comparison of registry data and worldwide non-registry studies from 4 decades. Acta Orthop 86(1):58–62
24. Pabinger C, Berghold A, Boehler N, Labek G (2013) Revision rates after knee replacement. Cumulative results from worldwide clinical studies versus joint registers. Osteoarthr Cartil 21(2):263–268
25. Belmont PJJ, Heida K, Keeney JA, Hamilton W, Burks R, Waterman BR (2015) Return to work and functional outcomes following primary total knee arthroplasty in U.S. Military servicemembers. J Arthroplasty 30(6):968–972
26. Biswas D, Van Thiel GS, Wetters NG, Pack BJ, Berger RA, Della Valle CJ (2014) Medial unicompartmental knee arthroplasty in patients less than 55 years old: minimum of two years of follow-up. J Arthroplasty 29(1):101–105
27. Bruni D, Akkawi I, Iacono F, Raspugli GF, Gagliardi M, Nitri M, Grassi A, Zaffagnini S, Bignozzi S, Marcacci M (2013) Minimum thickness of all-poly tibial component unicompartmental knee arthroplasty in patients younger than 60 years does not increase revision rate for aseptic loosening. Knee Surg Sports Traumatol Arthrosc 21(11):2462–2467
28. Callaghan JJ, Martin CT, Gao Y, Pugely AJ, Liu SS, Goetz DD, Kelley SS, Johnston RC (2015) What can be learned from minimum 20-year followup studies of knee arthroplasty? Clin Orthop Relat Res 473(1):94–100
29. Collier MB, Eickmann TH, Sukezaki F, McAuley JP, Engh GA (2006) Patient, implant, and alignment factors associated with revision of medial compartment unicondylar arthroplasty. J Arthroplasty 21(6 Suppl 2):108–115
30. Elmallah RDK, Jauregui JJ, Cherian JJ, Pierce TP, Harwin SF, Mont MA (2016) Effect of age on postoperative outcomes following total knee arthroplasty. J Knee Surg 29(8):673–678
31. Faour MO, Valverde GJ, Martín FMÁ, Vega CA, Zuil AP, Suárez DPC (2015) The young patient and the medial unicompartmental knee replacement. Acta Orthop Belg 81(2):283–288
32. Felts E, Parratte S, Pauly V, Aubaniac J, Argenson J (2010) Function and quality of life following medial unicompartmental knee arthroplasty in patients 60 years of age or younger. Orthop Traumatol Surg Res 96(8):861–867
33. Forsythe ME, Englund RE, Leighton RK (2000) Unicondylar knee arthroplasty: a cementless perspective. Can J Surg 43(6):417–424
34. Gao F, Henricson A, Nilsson KG (2009) Cemented versus uncemented fixation of the femoral component of the NexGen CR total knee replacement in patients younger than 60 years. A prospective randomised controlled RSA study. Knee 16(3):200–206
35. Hamilton TW, Pandit HG, Jenkins C, Mellon SJ, Dodd CAF, Murray DW (2017) Evidence-based indications for mobile-bearing unicompartmental knee arthroplasty in a consecutive cohort of thousand knees. J Arthroplasty 32(6):1779–1785
36. Henricson a, Linder L, Nilsson KG (2008) A trabecular metal tibial component in total knee replacement in patients younger than 60 years: a two-year radiostereophotogrammetric analysis. J Bone Joint Surg Br 90(12):1585–1593
37. Heyse TJ, Khefacha A, Peersman G, Cartier P (2012) Survivorship of UKA in the middle-aged. Knee 19(5):585–591
38. Illgen R, Tueting J, Enright T, Schreibman K, McBeath A, Heiner J (2004) Hybrid total knee arthroplasty: a retrospective analysis of clinical and radiographic outcomes at average 10 years follow-up. J Arthroplasty 19(7 Suppl 2):95–100

39. Ingale PA, Hadden WA (2013) A review of mobile bearing unicompartmental knee in patients aged 80 years or older and comparison with younger groups. J Arthroplasty 28(2):262–267
40. Kamath AF, Lee G-C, Sheth NP, Nelson CL, Garino JP, Israelite CL (2011) Prospective results of uncemented tantalum monoblock tibia in total knee arthroplasty: minimum 5-year follow-up in patients younger than 55 years. J Arthroplasty 26(8):1390–1395
41. Keenan ACM, Wood AM, Arthur CA, Jenkins PJ, Brenkel IJ, Walmsley PJ (2012) Ten-year survival of cemented total knee replacement in patients aged less than 55 years. J Bone Joint Surg Br 94(7):928–931
42. Keeney JA, Nunley RM, Wright RW, Barrack RL, Clohisy JC (2014) Are younger patients undergoing TKAs appropriately characterized as active? Clin Orthop Relat Res 472(4):1210–1216
43. Von Keudell A, Sodha S, Collins J, Minas T, Fitz W, Gomoll AH (2014) Patient satisfaction after primary total and unicompartmental knee arthroplasty: an age-dependent analysis. Knee 21(1):180–184
44. Kievit AJ, Schafroth MU, Blankevoort L, Sierevelt IN, van Dijk CN, van Geenen RCI (2014) Early experience with the Vanguard complete total knee system: 2–7 years of follow-up and risk factors for revision. J Arthroplasty 29(2):348–354
45. Kim Y-H, Choi Y, Kim J-S (2010) Osteolysis in well-functioning fixed- and mobile-bearing TKAs in younger patients. Clin Orthop Relat Res 468(11):3084–3093
46. Kim Y-H, Park J-W, Kim J-S (2016) A comparison of 5 models of total knee arthroplasty in young patients. J Arthroplasty 31(5):994–999
47. Kim Y-H, Park J-W, Kim J-S, Lee J-H (2015) Highly crosslinked-remelted versus less-crosslinked polyethylene in posterior cruciate-retaining TKAs in the same patients. Clin Orthop Relat Res 473(11):3588–3594
48. Kim Y-J, Kim B, Yoo S, Kang S, Kwack C, Song M-H (2017) Mid-term results of Oxford medial unicompartmental knee arthroplasty in young Asian patients less than 60 years of age: a minimum 5-year follow-up. Knee Surg Relat Res 29(2):122–128
49. Kiran A, Bottomley N, Biant LC, Javaid MK, Carr AJ, Cooper C, Field RE, Murray DW, Price A, Beard DJ, Arden NK (2015) Variations in good patient reported outcomes after total knee arthroplasty. J Arthroplasty 30(8):1364–1371
50. Kort NP, Van Raay JJAM., Van Horn JJ (2007) The Oxford phase III unicompartmental knee replacement in patients less than 60 years of age. Knee Surg Sport Traumatol Arthrosc 15(4):356–360
51. Kristensen PW, Holm HA, Varnum C (2013) Up to 10-year follow-up of the Oxford medial partial knee arthroplasty—695 cases from a single institution. J Arthroplasty 28(9 Suppl):195–198
52. Krych AJ, Reardon P, Sousa P, Pareek A, Stuart M, Pagnano M (2017) Unicompartmental knee arthroplasty provides higher activity and durability than valgus-producing proximal tibial osteotomy at 5 to 7 years. J Bone Joint Surg Am 99(2):113–122
53. Lee JH, Barnett SL, Patel JJ, Nassif NA, Cummings DJ, Gorab RS (2016) Ten year follow-up of gap balanced, rotating platform total knee arthroplasty in patients under 60 years of age. J Arthroplasty 31(1):132–136
54. Lizaur-Utrilla A, Miralles-Muñoz FA, Lopez-Prats FA (2014) Similar survival between screw cementless and cemented tibial components in young patients with osteoarthritis. Knee Surg Sport Traumatol Arthrosc 22(7):1585–1590
55. Long WJ, Bryce CD, Hollenbeak CS, Benner RW, Scott WN (2014) Total knee replacement in young, active patients: long-term follow-up and functional outcome: a concise follow-up of a previous report. J Bone Joint Surg Am 96(18):e159
56. McCalden RW, Robert CE, Howard JL, Naudie DD, McAuley JP, MacDonald SJ (2013) Comparison of outcomes and survivorship between patients of different age groups following TKA. J Arthroplasty 28(8 Suppl):83–86
57. Meding JB, Wing JT, Keating EM, Ritter MA (2007) Total knee arthroplasty for isolated patellofemoral arthritis in younger patients. Clin Orthop Relat Res 464:78–82
58. Meftah M, White PB, Ranawat AS, Ranawat CS (2016) Long-term results of total knee arthroplasty in young and active patients with posterior stabilized design. Knee 23(2):318–321
59. Miettinen SSA, Torssonen SK, Miettinen HJA, Soininvaara T (2016) Mid-term results of Oxford phase 3 unicompartmental knee arthroplasties at a small-volume center. Scand J Surg 105(1):56–63
60. Mont MA, Sayeed SA, Osuji O, Johnson AJ, Naziri Q, Delanois RE, Bonutti PM (2012) Total knee arthroplasty in patients 40 years and younger. J Knee Surg 25(1):65–69
61. Nilsson KG, Henricson A, Norgren B, Dalén T (2006) Uncemented HA-coated implant is the optimum fixation for TKA in the young patient. Clin Orthop Relat Res 448:129–139
62. Nunley RM, Nam D, Berend KR, Lombardi AV, Dennis DA, Della Valle CJ, Barrack RL (2015) New total knee arthroplasty designs: do young patients notice? Clin Orthop Relat Res 473(1):101–108
63. Odland AN, Callaghan JJ, Liu SS, Wells CW (2011) Wear and lysis is the problem in modular TKA in the young OA patient at 10 years. Clin Orthop Relat Res 469(1):41–47
64. Parratte S, Pauly V, Aubaniac JM, Argenson JNA (2012) No long-term difference between fixed and mobile medial unicompartmental arthroplasty. Clin Orthop Relat Res 470(1):61–68
65. Parvizi J, Nunley RM, Berend KR, Lombardi AVJ, Ruh EL, Clohisy JC, Hamilton WG, Della Valle CJ, Barrack RL (2014) High level of residual symptoms in young patients after total knee arthroplasty. Clin Orthop Relat Res 472(1):133–137
66. Pennington DW, Swienckowski JJ, Lutes WB, Drake GN (2003) Unicompartmental knee arthroplasty in patients sixty years of age or younger. J Bone Jt Surg Ser A 85(10):1968–1973
67. Price AJ, Dodd CAF, Svard UGC, Murray DW (2005) Oxford medial unicompartmental knee arthroplasty in patients younger and older than 60 years of age. J Bone Joint Surg Br 87(11):1488–1492
68. Ranawat AS, Mohanty SS, Goldsmith SE, Rasquinha VJ, Rodriguez JA, Ranawat CS (2005) Experience with an all-polyethylene total knee arthroplasty in younger, active patients with follow-up from 2 to 11 years. J Arthroplasty 20(7 Suppl 3):7–11
69. Rand JA, Trousdale RT, Ilstrup DM, Harmsen WS (2003) Factors affecting the durability of primary total knee prostheses. J Bone Jt Surg Am 85–A(2):259–265
70. Roberts TD, Clatworthy MG, Frampton CM, Young SW (2015) Does computer assisted navigation improve functional outcomes and implant survivability after total knee arthroplasty? J Arthroplasty 30(9 Suppl):59–63
71. Sébilo A, Casin C, Lebel B, Rouvillain J-L, Chapuis S, Bonnevialle P (2013) members of the Société d'Orthopédie et de Traumatologie de l'Ouest (SOO) (2013) Clinical and technical factors influencing outcomes of unicompartmental knee arthroplasty: retrospective multicentre study of 944 knees. Orthop Traumatol Surg Res 99(4 SUPPL):S227–S234
72. Streit MR, Streit J, Walker T, Bruckner T, Philippe Kretzer J, Ewerbeck V, Merle C, Aldinger PR, Gotterbarm T (2015) Minimally invasive Oxford medial unicompartmental knee arthroplasty in young patients. Knee Surg Sport Traumatol Arthrosc 25(3):660–668
73. Tabor OB Jr, Tabor OB, Bernard M, Wan JY (2005) Unicompartmental knee arthroplasty: long-term success in middle-age and obese patients. J Surg Orthop Adv 14(2):59–63

74. Tai CC, Cross MJ (2006) Five- to 12-year follow-up of a hydroxyapatite-coated, cementless total knee replacement in young, active patients. J Bone Joint Surg Br 88(9):1158–1163
75. Vazquez-Vela Johnson G, Worland RL, Keenan J, Norambuena N (2003) Patient demographics as a predictor of the ten-year survival rate in primary total knee replacement. J Bone Jt Surg 85(1):52–56
76. Venkatesh HK, Maheswaran SS (2015) Mid-term results of Miller-Galante unicompartmental knee replacement for medial compartment knee osteoarthritis. J Orthop Traumatol 17(3):199–206
77. Vessely MB, Whaley AL, Harmsen WS, Schleck CD, Berry DJ (2006) The Chitranjan Ranawat award: long-term survivorship and failure modes of 1000 cemented condylar total knee arthroplasties. Clin Orthop Relat Res 452:28–34
78. Walker T, Streit J, Gotterbarm T, Bruckner T, Merle C, Streit MR (2015) Sports, physical activity and patient-reported outcomes after medial unicompartmental knee arthroplasty in young patients. J Arthroplasty 30(11):1911–1916
79. Whiteside LA, Vigano R (2007) Young and heavy patients with a cementless TKA do as well as older and lightweight patients. Clin Orthop Relat Res 464:93–98
80. Wing CK, Kwok-Hing C (2012) Sixteen years' result of posterior-stabilized TKA. J Knee Surg 25(3):245–248
81. Yim J-H, Song E-K, Seo H-Y, Kim M-S, Seon J-K (2013) Comparison of high tibial osteotomy and unicompartmental knee arthroplasty at a minimum follow-up of 3 years. J Arthroplasty 28(2):243–247
82. El-Tawil S, Arendt E, Parker D (2016) Position statement: the epidemiology, pathogenesis and risk factors of osteoarthritis of the knee. J ISAKOS Jt Disord Orthop Sport Med 1(4):219–228
83. Hooper G, Lee AJ, Rothwell A, Frampton C (2014) Current trends and projections in the utilisation rates of hip and knee replacement in New Zealand from 2001 to 2026. N Z Med J 127(1401):82–93
84. Kurtz S, Ong K, Lau E, Mowat F, Halpern M (2007) Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Jt Surg Am 89(4):780–785
85. Furnes O, Espehaug B, Lie S, Vollset SE, Engesaeter LB, Havelin LI (2007) Failure mechanisms after unicompartmental and tricompartmental primary knee replacement with cement. J Bone Joint Surg Am 89(3):519–525
86. Liddle AD, Judge A, Pandit H, Murray DW (2014) Adverse outcomes after total and unicompartmental knee replacement in 101,330 matched patients: a study of data from the National Joint Registry for England and Wales. Lancet 384(9952):1437–1445
87. Chatellard R, Sauleau V, Colmar M, Robert H, Raynaud G, Brilhault J (2013) Medial unicompartmental knee arthroplasty: does tibial component position influence clinical outcomes and arthroplasty survival? Orthop Traumatol Surg Res 99(4 Suppl):S219–S225
88. Hernigou P, Deschamps G (2004) Alignment influences wear in the knee after medial unicompartmental arthroplasty. Clin Orthop Relat Res 423:161–165
89. Vasso M, Del Regno C, D'Amelio A, Viggiano D, Corona K, Schiavone Panni A (2015) Minor varus alignment provides better results than neutral alignment in medial UKA. Knee 22(2):117–121
90. Li Y, Wang S, Wang Y, Yang M (2017) Does kinematic alignment improve short-term functional outcomes after total knee arthroplasty compared with mechanical alignment? A systematic review and meta-analysis. J Knee Surg. https://doi.org/10.1055/s-0037-1602136
91. van der List JP, Chawla H, Pearle AD (2016) Robotic-Assisted Knee Arthroplasty: An Overview. Am J Orthop (Belle Mead NJ) 45(4):202–211
92. Barbadoro P, Ensini A, Leardini A, D'Amato M, Feliciangeli A, Timoncini A, Amadei F, Belvedere C, Giannini S (2014) Tibial component alignment and risk of loosening in unicompartmental knee arthroplasty: a radiographic and radiostereometric study. Knee Surg Sports Traumatol Arthrosc 22(12):3157–3162
93. Zuiderbaan HA, van der List JP, Chawla H, Khamaisy S, Thein R, Pearle AD (2016) Predictors of subjective outcome after medial unicompartmental knee arthroplasty. J Arthroplasty 31(7):1453–1458
94. Goodfellow JW, O'Connor JJ, Murray DW (2010) A critique of revision rate as an outcome measure: re-interpretation of knee joint registry data. J Bone Joint Surg Br 92(12):1628–1631
95. Baker P, Jameson S, Critchley R, Reed M, Gregg P, Deehan D (2013) Center and surgeon volume influence the revision rate following unicondylar knee replacement: an analysis of 23,400 medial cemented unicondylar knee replacements. J Bone Joint Surg Am 95(8):702–709
96. Baker PN, Petheram T, Avery PJ, Gregg PJ, Deehan DJ (2012) Revision for unexplained pain following unicompartmental and total knee replacement. J Bone Joint Surg Am 94(17):e126
97. Koskinen E, Eskelinen A, Paavolainen P, Pulkkinen P, Remes V (2008) Comparison of survival and cost-effectiveness between unicondylar arthroplasty and total knee arthroplasty in patients with primary osteoarthritis: a follow-up study of 50,493 knee replacements from the Finnish Arthroplasty Register. Acta Orthop 79(4):499–507
98. Niinimäki T, Eskelinen A, Mäkelä K, Ohtonen P, Puhto A-P, Remes V (2014) Unicompartmental knee arthroplasty survivorship is lower than TKA survivorship: a 27-year Finnish registry study. Clin Orthop Relat Res 472(5):1496–1501
99. Rodriguez-Merchan EC (2014) Medial unicompartmental osteoarthritis (MUO) of the knee: unicompartmental knee replacement (UKR) or total knee replacement (TKR). Arch bone Jt Surg 2(3):137–140
100. Isaac SM, Barker KL, Danial IN, Beard DJ, Dodd CA, Murray DW (2007) Does arthroplasty type influence knee joint proprioception? A longitudinal prospective study comparing total and unicompartmental arthroplasty. Knee 14(3):212–217
101. Thompson SAJ, Liabaud B, Nellans KW, Geller JA (2013) Factors associated with poor outcomes following unicompartmental knee arthroplasty: redefining the "classic" indications for surgery. J Arthroplasty 28(9):1561–1564
102. Behrend H, Giesinger K, Giesinger JM, Kuster MS (2012) The "Forgotten Joint" as the ultimate goal in joint arthroplasty. Validation of a new patient-reported outcome measure. J Arthroplasty 27(3):430–436
103. Zuiderbaan HA, van der List JP, Khamaisy S, Nawabi DH, Thein R, Ishmael C, Paul S, Pearle AD (2017) Unicompartmental knee arthroplasty versus total knee arthroplasty: which type of artificial joint do patients forget? Knee Surg Sports Traumatol Arthrosc 25(3):681–686
104. Insall JN, Dorr LD, Scott RD, Scott WN (1989) Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res 248:13–14
105. Na SE, Ha CW, Lee CH (2012) A new high-flexion knee scoring system to eliminate the ceiling effect. Clin Orthop Relat Res 470(2):584–593
106. Zahiri CA, Schmalzried TP, Szuszczewicz ES, Amstutz HC (1998) Assessing activity in joint replacement patients. J Arthroplasty 13(8):890–895
107. Waldstein W, Kolbitsch P, Koller U, Boettner F, Windhager R (2016) Sport and physical activity following unicompartmental knee arthroplasty: a systematic review. Knee Surgery Sport Traumatol Arthrosc 25(3):1–12
108. Bini S, Khatod M, Cafri G, Chen Y, Paxton EW (2013) Surgeon, implant, and patient variables may explain variability in early

revision rates reported for unicompartmental arthroplasty. J Bone Joint Surg Am 95(24):2195–2202
109. Dy CJ, Marx RG, Bozic KJ, Pan TJ, Padgett DE, Lyman S (2014) Risk factors for revision within 10 years of total knee arthroplasty. Clin Orthop Relat Res 472(4):1198–1207
110. Harrysson OLA, Robertsson O, Nayfeh JF (2004) Higher cumulative revision rate of knee arthroplasties in younger patients with osteoarthritis. Clin Orthop Relat Res 421:162–168
111. Jeschke E, Gehrke T, Günster C, Hassenpflug J, Malzahn J, Niethard FU, Schräder P, Zacher J, Halder A (2016) Five-year survival of 20,946 unicondylar knee replacements and patient risk factors for failure: an analysis of German insurance data. J Bone Joint Surg Am 98(20):1691–1698
112. Badawy M, Espehaug B, Indrekvam K, Havelin LI, Furnes O (2014) Higher revision risk for unicompartmental knee arthroplasty in low-volume hospitals Data from 5,791 cases in the Norwegian Arthroplasty Register. Acta Orthop 85(4):342–347
113. van der List JP, McDonald LS, Pearle AD (2015) Systematic review of medial versus lateral survivorship in unicompartmental knee arthroplasty. Knee 22(6):454–460