Does Implant Design Influence Failure Rate of Lateral Unicompartmental Knee Arthroplasty? A Meta-Analysis

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Title: **“Does implant design influence failure rate of lateral unicompartmental knee arthroplasty? A meta-analysis.”**

Authors: Fratini Stefano[1], Meena Amit[2], Alesi Domenico[1], Cammisa Eugenio[1], Zaffagnini Stefano[1,3], Marcheggiani Muccioli Giulio Maria[1,3]

[1] 2nd Orthopaedic and Traumatologic Clinic, IRCCS Istituto Ortopedico Rizzoli, Via G.B. Pupilli 1, 40136, Bologna, Italy

[2] Central Institute of Orthopaedics, Vardhman Mahavir Medical College & Safdarjung Hospital, New Delhi, 110029, India

[3] University of Bologna, Via Zamboni, 33, 40126, Bologna, Italy

Corresponding author: Dr. Stefano Fratini, MD, dr.stefano.fratini@gmail.com

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Does implant design influence failure rate of lateral unicompartmental knee arthroplasty? A meta-analysis.

Abstract

Background

Lateral unicompartmental knee arthroplasty (UKA) is a viable solution for isolated lateral compartment arthritis. Several prosthetic designs are available such as Fixed Bearing Metal-Backed (FB M-B), Fixed Bearing All Polyethylene (FB A-P), and Mobile Bearing Metal Backed (MB M-B) implants. The purpose of this meta-analysis is to compare failure rates of different prosthetic designs.

Methods

Preferred Reporting Items for Systematic Reviews and Meta-Analyses systematic review was conducted using 4 databases (MEDLINE, EMBASE, Cochrane, and PubMed) to identify all studies that investigate outcomes of lateral UKA. 21 studies met the inclusion criteria, and failure rates were compared by implant type and follow-up time separately in order to assess potential confounding factors. Two separate analyses have been performed among different implant designs (FB M-B *vs* FB A-P *vs* MB M-B) and different follow-ups (less than 5 years, between 5 and 10 years, more than 10 years).

Results

The failure rate of FB M-B lateral UKA was significantly lower compared to other lateral unicompartmental knee arthroplasty designs present on the market (0,8% *vs* 8,6% and 7,1% for FB M-B, FB A-P and MB M-B, respectively). No significative difference among groups has been detected when comparing all implants with regard to follow-up time.

Conclusion

Considering actual evidence, for a surgeon approaching lateral UKA, the Fixed Bearing Metal Backed design is preferable, given the lower failure rates and subsequently a longer implant survivorship.

Keywords

Lateral, Unicompartmental, Knee, Arthroplasty, Survivorship, Meta-analysis

Background

Lateral unicompartmental knee arthroplasty (UKA) is an appealing alternative to total knee arthroplasty (TKA) for patients with isolated lateral compartment arthritis. Whilst degenerative joint disease may affect any compartment of the knee, the isolated lateral compartment arthritis of the knee is less common and much more challenging to treat. It is estimated that only less than 1% of the total number of knee arthroplasty and only 5–10% of all unicompartmental knee replacements are performed for lateral compartment disease[1,2]. This number might be artificially low because the majority of surgeons prefer total rather than lateral unicondylar knee arthroplasty for the treatment of lateral compartment osteoarthritis[3]. Compared to TKA, UKA has several potential advantages, which include a less invasive procedure, improved postoperative range of motion, preservation of the cruciate ligaments, fat pad and bone stock, improved proprioception, increased patient satisfaction, earlier return to activities, shorter hospital stay, and fewer complications [4–9]. Moreover, it leaves the healthy contralateral tibiofemoral compartment intact.

Despite these benefits, lateral compartment knee arthroplasty is more difficult to perform than medial compartment UKA due to its anatomic and biomechanical characteristics. The lateral collateral ligament is looser than the medial ligament, and the lateral femoral condyle anteroposterior translation is deeper than the medial side.[10] Moreover, the lateral tibial plateau is rounder compared to the medial plateau, the lateral femoral condyle is smaller than the medial condyle, and the screw-home mechanism is far more significant on the lateral side [11,12]. All these anatomic and biomechanical characteristics lead to a technically challenging procedure, a more difficult surgical approach, a significantly longer learning curve, therefore the need to perform a large number of procedures to achieve the lowest reoperation rates, which have traditionally been higher in UKA compared with TKA surgery[13,14].

Because of the infrequency of this procedure, few studies describe the survivorship and the causes of failure in lateral UKA[15]. These studies mainly include case series that involve a small cohort of patients, further comprised by mixed data including medial UKA[16]. Nevertheless, the scarce evidence in literature has shown acceptable results for short and mid-term survivorship of lateral UKA with remaining concerns on the long-term survivorship together with difficulties about identifying the main reasons for failure. Hence it is fundamental to systematically examine failure rates, evaluate the etiology and the mechanism of lateral UKA failure to improve the understanding and the revision strategy of a failed lateral UKA.

Several prosthetic designs are commercially available, which differ concerning the bearing and the materials. They can be divided into three groups: Fixed Bearing All-Polyethylene (FB A-P), Fixed Bearing Metal-Backed (FB M-B), and Mobile Bearing Metal-Backed (MB M-B) implants.

To our knowledge, limited evidence is available in literature on survivorship in lateral UKA in relation to implant design. Therefore, we performed a systematic review and metanalysis, pooling failure rates of studies that reported lateral UKA survivorship. The aim of this study was to assess the different rates of lateral UKA failures with regard to implant design.

Material and Methods

Article Identification and Selection

This study was conducted in accordance with the 2009 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement[17] (Fig.1). A systematic review of the literature regarding the existing evidence for survivorship and clinical outcomes of Lateral Unicompartmental Knee Arthroplasty (UKA) was performed using the Cochrane Central Register of Controlled Trials, PubMed, MEDLINE (2011-2021), and EMBASE. The queries were performed in April 2021. The literature search strategy included the following: (lateral[All Fields] AND ("arthroplasty, replacement, knee"[MeSH Terms] OR ("arthroplasty"[All Fields] AND "replacement"[All Fields] AND "knee"[All Fields]) OR "knee replacement arthroplasty"[All Fields] OR ("unicompartmental"[All Fields] AND "knee"[All Fields] AND "arthroplasty"[All Fields]) OR "unicompartmental knee arthroplasty"[All Fields])) AND ("2011/01/01"[PDat] : "2021/04/28"[PDat]).

Inclusion criteria were as follows: survivorship and/or failure rates stated for lateral unicompartmental knee arthroplasty, English language, minimum follow-up of 2 years for all patients in the cohort, minimum of 20 patients in each study cohort, study published within the last 10 years, same implant used for all patients in each cohort, and human studies. We excluded cadaveric studies, animal studies, biomechanical reports, basic science articles, editorial articles, case reports, literature reviews, surgical technique descriptions, instructional courses, and tumors.

Two independent reviewers (S.F., A.M.) performed a review of the abstracts from all identified articles. Full-text articles were obtained for review, if necessary, to allow for a further assessment of inclusion and exclusion criteria. Additionally, all references from the included studies were reviewed and reconciled to verify that no relevant articles were missing from the systematic review.

Data Collection and Processing

The level of evidence of the studies was assigned according to the classification system specified by Wright et al.[18] Data were abstracted from the full text of all eligible articles using standardized data collection forms. Abstracted and recorded data included patient demographics, the follow-up period, the type of implant used, failure rates and/or survivorship rates. For continuous variables (e.g. age, follow-up), the means, SDs, interquartile ranges, and ranges were collected (if reported). Data were recorded into a custom spreadsheet using a modified information extraction table.

Literature Quality Evaluation

Two reviewers (S.F., A.M.) used a modified version of the Coleman methodology score (mCMS) to assess the methodological quality of each study. The 2-part mCMS grades cartilage-related studies based on 10 criteria. Part A includes the study size, mean follow-up, number of different surgical procedures, type of study, description of the surgical procedure, postoperative rehabilitation, participants’ magnetic resonance imaging outcome, and participants’ histological outcome. Part B includes the outcome criteria, procedure for assessing clinical outcomes, and description of the participant selection process. The maximum mCMS is 100, which indicates a study that largely avoids chance, biases, and confounding factors.

Statistical Analysis

The primary outcome of the meta-analysis was the difference in failure rate among the three groups of implants evaluated (FB A-P, FB M-B, and MB M-B). The statistical analysis and the forest plot was carried out according to Neyeloff et al. using Microsoft Excel (release 2103 16.0.13901.20400 / April 13, 2021).[19] The Mantel-Haenszel method was used to evaluate the expected value[20]; Wilson’s confidence intervals were preferred because of data sparsity, either in terms of event rates being low or study size being small; therefore the standard error estimates using inverse variance methods were considered inadequate.[21] With no heterogeneity, the estimation of the expected value and its 95% confidence interval (CI) was based on fixed-effect analysis of variance; the random effect model was used otherwise. Statistical heterogeneity was evaluated by the I-square statistic and Cochrane’s Q.[22] The comparisons among groups were based on the z-score transformation of the difference. The rationale is that, under a normal-distribution assumption, a 95% CI is 2*1.96 standard error's (SE) wide; therefore it is possible to estimate the SE for each group from the CI around each expected value. Then, the SE for the difference between the two groups can be calculated as $SE(B-A)=\sqrt{SE(B)^2+SE(A)^2}$ and $Z=\frac{(B-A)}{SE(B-A)}$. The *p*-value of the difference can be carried out from the normal standard distribution and then corrected with the Bonferroni method for multiple comparisons. Two investigators independently assessed the risks of bias (low, high or unclear). Publication bias was also assessed using a funnel plot (Fig. 2). Subgroup analyses based on differences in the follow-up period were also performed to explore a potential source of heterogeneity. Three subgroups were accordingly created in each group: short-term (<5 years), midterm (5–10 years), and long-term (>10 years) follow-up.

Results

A total of 2215 studies were selected for the analysis. After a review of the titles, abstracts, full titles, and excluding the unrelated studies, 21 articles were selected as eligible for the final meta-analysis.[23–43] Four of the 21 studies were prospective trials, while the others were retrospective analyses. The mean follow-up period ranged from 3 to 14.2 years. Additional details about study characteristics and patient demographics can be found in Table 1.

Within the selected studies, the FB A-P implants were from two manufacturers: HLS Uni Evolution (Tournier) and AMC Uniglide (Corin); the FB M-B implants were from five manufacturers: Restoris MCK (Stryker), Sled UKA (Waldemar Link), Unicompartmental High Flex Knee (Zimmer), Miller-Galante Unicompartmental Knee (Zimmer), iUni G1 (Conformis), Respicci II UKA (Biomet), Vanguard M UKA (Biomet); the MB M-B implants were from two manufacturers: Oxford Doomed Lateral UKR (Zimmer Biomet), Preservation UKA (DePuy).

<u>Failure rates analysis by implant design</u>

A total of 3378 knees were examined, and 219 experienced failure and subsequent revision. The total failure rate was 5,0% (95% C.I. 3,1%-6,9%). I^2 was 85% showing substantial heterogeneity;

therefore random effect was applied.[22] The FB A-P group showed a failure rate of 8,6% (95% C.I. 3,2%-14,1%) with an I^2=54%; therefore random effect was applied. The FB M-B group showed a failure rate of 0,8% (95% C.I. 0,0%-1,6%) with no heterogeneity; therefore fixed effect was applied. The MB M-B group showed a failure rate of 7,1% (95% C.I. 5,3%-8,9%) with an I^2=52%, therefore random effect was applied. Data are summarized in Table 2 and Figure 3.

Meta-analysis evaluation showed a statistically significant difference among groups FB M-B and FB A-P (p=0,024) and among groups FB M-B and MB M-B (p<0,01). No significative difference has been noted among FB A-P and MB M-B groups (p>0,99). Bonferroni correction has been applied due to the comparison among the three groups. Data are summarized in Table 3.

Failure rates analysis by mean follow-up

Twelve of the 21 studies had a mean follow-up between 3 and 5 years [24–26,29–32,35,36,38,41,43], six had a mean follow-up between 5 and 10 years[23,27,33,34,40,42] and three had a follow-up longer than 10 years [28,37,39]. The shortest follow-up group showed a failure rate of 3,9% (95% C.I. 1,6%-6,3%) with an I^2=87%; therefore random effect was applied. The 5-to-10 years follow-up group showed a failure rate of 7,0% (95% C.I. 2,6%-11,4%) with an I^2=82%; therefore random effect was applied. Lastly, the longest follow-up group showed a failure rate of 8,9% (95% C.I. 0%-18,7%) with an I^2=83%, and again random effect was applied. Data are summarized in Table 4 and Figure 4.

Meta-analysis evaluation did now show any statistically significant difference among groups. Data are shown in Table 5.

Reoperation and Failure

Reoperation and failure results were reported in all the studies included in the present analysis. Data is summarized in Appendix.

Discussion

The most important finding of the present meta-analysis was that the failure rate of Metal-Backed Fixed Bearing lateral unicompartmental arthroplasty was significantly lower compared to other lateral unicompartmental knee arthroplasty designs present on the market (0,8% *vs* 8,6% and 7,1% for FB M-B, FB A-P and MB M-B respectively).

A recent systematic review and meta-analysis evaluating mobile *vs* fixed bearing UKAs found better survival rates for fixed bearing implants. The mobile bearing implants showed an approximately four times higher risk of revision than fixed bearing designs when used for lateral UKA.[44]

Burger et al. found similar observations in their work and stated that revision risk is lower with FB implants than MB ones in lateral UKAs. According to them the annual revision rate was 2.16 (95% CI 1,54-3,04), 1.81 (95% CI 0,98-3,34) and 0.94 (95% CI 0,66-1,33) for MB, domed MB and FB designs respectively.[45] A study from Dutch arthroplasty registry data also reported similar results where the use of Mobile Bearing lateral UKA was associated with increased revision rate.[46]

The lateral knee compartment shows a different behavior with regard to the medial side. During knee flexion, while the medial condyle remains relatively static on the anteroposterior (AP) plane with approximatively 1,5mm of translation, the lateral side presents an inherent instability and has a greater degree of freedom with an AP translation from 9 to 15mm.[47,48]

The less constrain on the lateral knee condyle increases the underlying risk of bearing dislocation for MB implants. A fixed bearing construct reduces the system complexity and the bearing instability, providing a simpler and stronger construct.

To decrease bearing dislocation incidences, domed mobile bearing tibial implants were introduced in order to require more distractive force before the polyethylene insert dislocates. Those implants have a convex tibial component augmented with biconcave bearings, compared to previous designs, which featured a flat tibial component. Although by using domed implants the dislocation rate was significantly decreased with respect to non-domed implants, it does not eliminate the chance of bearing dislocation. Therefore, various modifications have been introduced to address this issue, such as placing a screw in the intercondylar notch, even if further increasing the system complexity.[25,30,49]

When analyzing failures based on the type of implant used, it can be found that bearing dislocation is the main responsible for failure when mobile bearing implants are used, whereas osteoarthritis progression is responsible for most failures in fixed bearing implants. Polyethylene wear is not the main determinant for survivorship, presumably thanks to improvement in polyethylene manufacturing, processing, design, sterilization, and storage which significantly improved over the last few years. [16,50]

When evaluating Metal-Backed and All-Polyethylene designs, a very scarce bibliography can be found on lateral UKAs. Studies based on medial UKAs show superiority of Metal-Backed tibial implants over All-Polyethylene designs.[51,52] It has to be noted, however, that the biomechanics of the medial side, as previously discussed, is different with regard to the lateral side, and those benefits may or may be not noted in lateral UKAs.

Based on the few studies on Metal-Backed *vs* All-Polyethylene lateral UKAs, no significant differences has been noted [23,53,54], while an increased risk of bearing dislocation has been described. Another study by Gunther et al. using Mobile Bearing lateral UKAs showed a 10% rate of inlay dislocations.[55] This effect is most likely due to greater AP translation of the lateral side during knee flection.[56] While this behavior can be cause for concerns, it has not been noted in more recent studies included in this analysis. [35]

The present study has some limitations. Studies available in literature are often of poor quality, with few patients and incomplete data. However, a complete literature search has been performed with the aim of providing a complete analysis.

Lateral UKAs are less implanted than medial UKAs and have strict indications, despite comparable survivorships being shown at short, medium and long follow-up. [57] The surgeon experience and the number of lateral UKA performed play an essential role in outcomes and failures. For this reason, the same studies have been evaluated with regard to follow-up time as well, mixing all the designs together for assessing a potential confounding factor. No significative differences have been noted when evaluating failure rates by follow-up, confirming that the simpler implant design provides the lowest failure rates.

As things stand today, for a surgeon approaching lateral UKA, Fixed Bearing Metal-Backed design is preferable, given the lower failure rates and subsequently longer implant survivorship.

Conclusion

Considering actual evidence, for a surgeon approaching lateral UKA, the Fixed Bearing Metal-Backed design is preferable, given the lower failure rates and subsequently longer implant survivorship.

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Figures / Tables

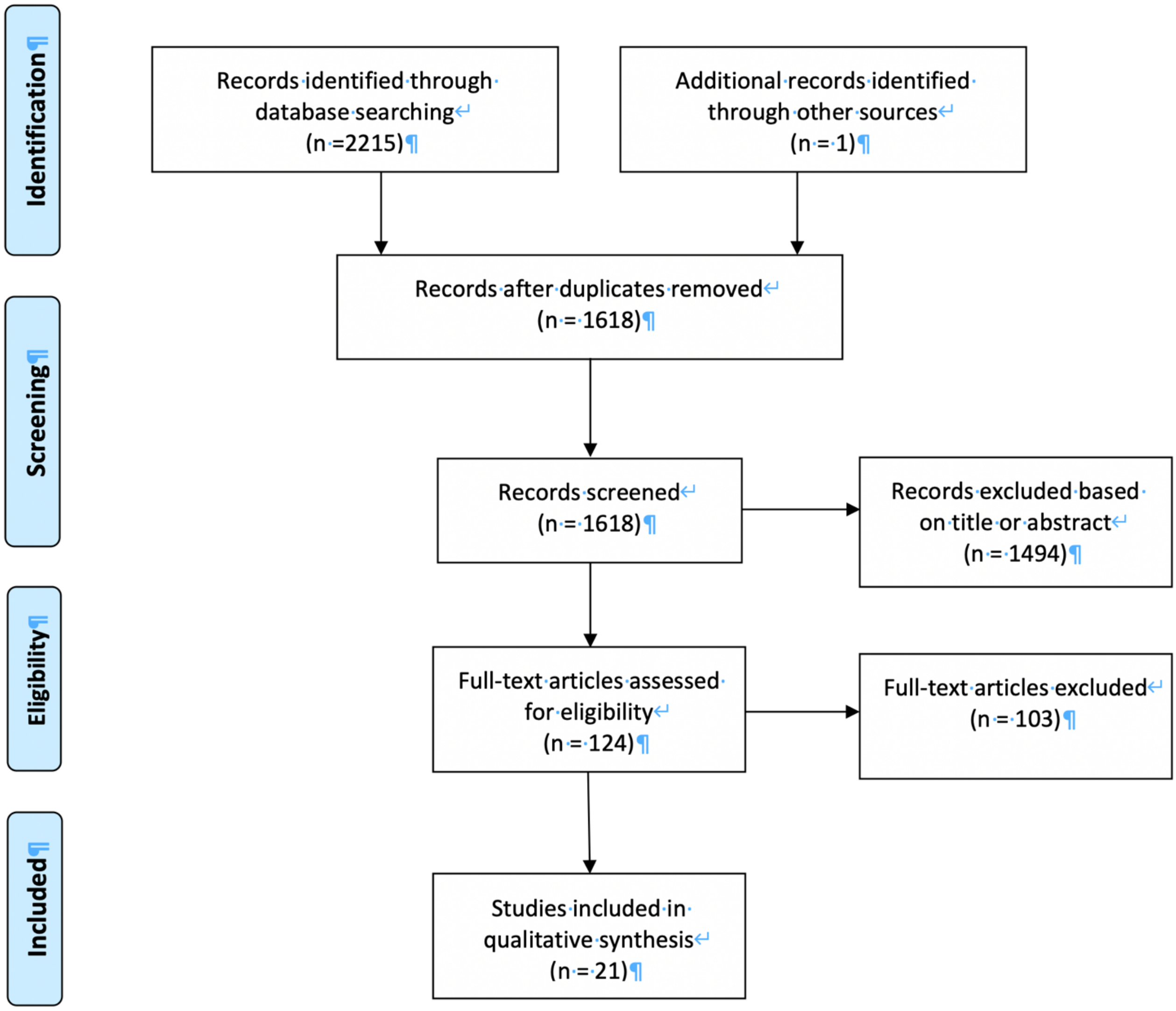

Fig.1 Overview of screening and selection process for the systematic review.

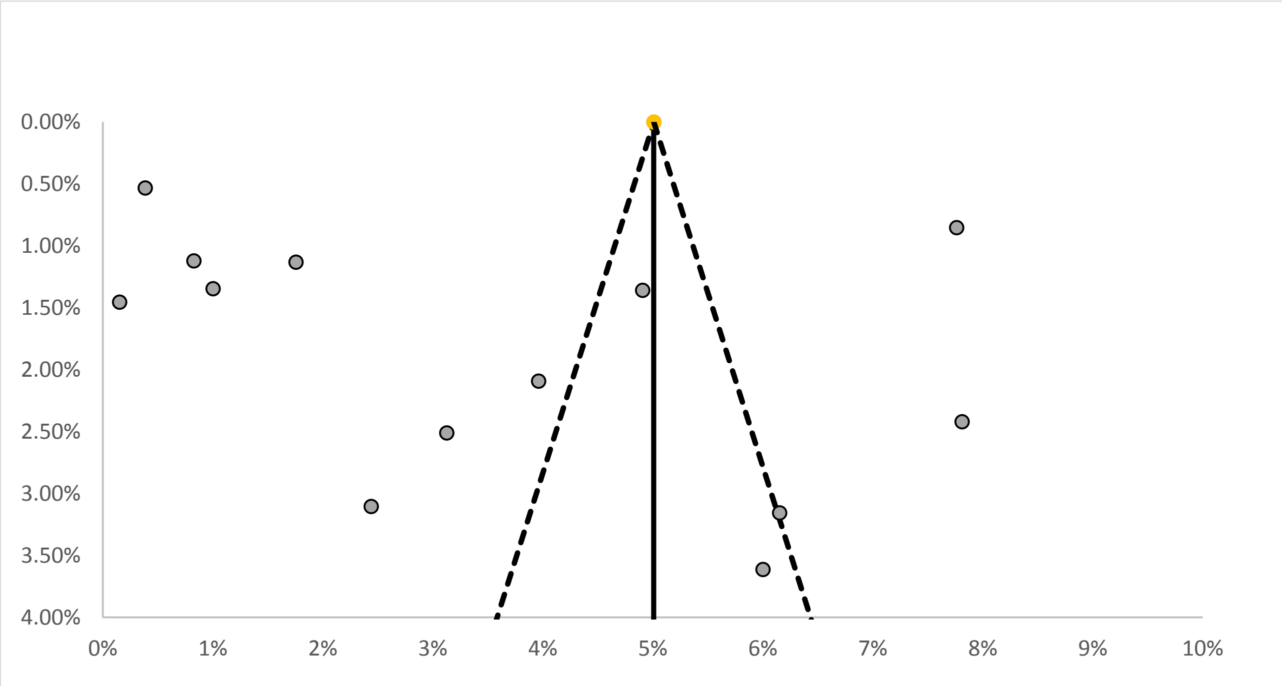

Fig. 2 Funnel plot assessing potential publication bias from failure rates. Thirteen studies were analyzed, the abscissa axis showed the failure rates, and the vertical axis showed the standard error.

Author	Year	LOE	Type of Study	No. Of Patients (Knees)	Age, Mean ± SD (Range), y	Male Sex, n (%)	Type of Implant	Implant	Follow-up, Mean ± SD (Range), y	Quality score (mCS)
Burger et al.	2020	IV	Retrospective	NA (171)	64.4 ± 11 (NA)	69 (40.4)	FB M-B	Stryker Restoris MCK	4.3 ± 1.7 (NA)	65
Kennedy et al.	2020	II	Prospective	300 (325)	64.9 ± 11 (39-90)	96 (37)	MB M-B	Zimmer Biomet Oxford Doomed Lateral UKR	7 ± 2,7 (3-14)	70
Mohammad et al.	2020	II	Retrospective	NA (992)	64.5 ± 12,5 (NA)	351 (35.4)	MB M-B	Zimmer Biomet Oxford Doomed Lateral UKR	5 ± 3.0 (NA)	41
Tu et al.	2020	II	Prospective	121 (121)	70.2 ± 8.8 (NA)	38 (31.4)	FB M-B	Waldemar Link Sled UKA	5.3 ± 2.5 (2-12.4)	84
Xue et al.	2020	IV	Retrospective	248 (260)	70.6 ± 8.5 (NA)	56 (28.3)	FB M-B	Waldemar Link Sled UKA	4.7 ± 1.1 (NA)	61
Deroche et al.	2019	IV	Retrospective	52 (54)	65.4 ± 11 (25-79)	6 (15.4)	FB A-P	NA, two different implants	17.9 ± 2 (15-23)	66
Zambianchi et al.	2019	IV	Retrospective	66 (67)	62.1 ± 9.5 (NA)	16 (24.2%)	FB M-B	Stryker Restoris MCK	3.0 ± NA (NA)	51
Fornell et al.	2018	IV	Retrospective	41 (41)	63 ± 10.8 (38-81)	10 (24.4)	MB M-B	Zimmer Biomet Oxford Doomed Lateral UKR	4.1 ± 1.2 (2.1-7)	62
Walker et al.	2018	IV	Retrospective	327 (344)	65 ± 13 (36-88)	90 (27.5)	MB M-B	Zimmer Biomet Oxford Doomed Lateral UKR	3.1 ± 1.7 (1-7.8)	64
Edmiston et al.	2017	IV	Retrospective	65 (65)	61.3 ± 11.2 (NA)	22 (34)	FB M-B	Zimmer Unicompartimental High Flex Knee, Zimmer Miller-Galante Unicompartmental Knee	6.6 ± 3.1 (NA)	48
Newman et al.	2017	IV	Retrospective	58 (64)	71 ± 12 (44-92)	17 (29.3)	MB M-B	Zimmer Biomet Oxford Doomed Lateral UKR	6.7 ± 2.0 (2-9.9)	72
Kim et al.	2016	IV	Retrospective	27 (30)	63.3 ± 8 (48-80)	15 (50)	FB M-B	Zimmer Unicompartmental High Flex Knee	3.2 ± 0.5 (2-4)	61
Demange et al.	2015	IV	Retrospective	32 (33)	57.5 ± 8.9 (36-88)	20 (39.2)	FB M-B	ConforMIS iUni G1 (1st gen) Zimmer Miller-Galante Unicompartmental Knee	4.7 ± 1.2 (2-9.1)	66
Lustig et al.	2014	IV	Retrospective	52 (54)	72.2 ± 15.2 (25-85)	7 (15.9)	FB A-P	Tornier HLS Uni Evolution	14.2 ± 1.95 (10.2-18)	66
Smith et al.	2014	IV	Retrospective	100 (101)	64.8 ± 13.8 (36-91)	32 (32)	FB A-P	Corin AMC Uniglide	5.0 ± 0.0 (5-5)	82
Weston-Simons et al.	2014	II	Prospective	258 (265)	64 ± 14.5 (32-90)	91 (35.3)	MB M-B	Zimmer Biomet Oxford Doomed Lateral UKR	4.0 ± 2.2 (0.5-8.3)	72
Altuntas et al.	2013	IV	Retrospective	58 (64)	71 ± 12 (44-92)	17 (29.3)	MB M-B	Zimmer Biomet Oxford Doomed Lateral UKR	3.2 ± 0.8 (2-5.1)	59
Liebs et al.	2013	IV	Retrospective	128 (128)	73.6 ± 11.8 (44-91)	NA (33)	MB M-B	DePuy Preservation UKA	6.0 ± 1.9 (2.1-9.8)	75
Berend et al.	2012	IV	Retrospective	97 (100)	68.8 ± 14 (NA)	38 (30)	FB M-B	Biomet Respicci II UKA Biomet Vanguard M UKA	3.3 ± 1.2 (2-6.8)	59
Streit et al.	2012	II	Prospective	50 (50)	60 ± 11.3 (36-81)	20 (40)	MB M-B	Zimmer Biomet Oxford Doomed Lateral UKR	3 ± 0.6 (2-4.3)	71
Lustig et al.	2011	IV	Retrospective	47 (49)	72.2 ± 3 (25-88)	8 (17)	FB A-P	Tornier HLS Uni Evolution	8.4 ± 2.6 (5.3-15.8)	60

Tab. 1 Study characteristics and patients demographics. FB, Fixed Bearing; MB, Mobile Bearing; A-P, All Polyetilene; M-B, Metal Backed; NA, Non Available

	Failure Rate	95% CI Lower Limit	95%CI Upper Limit
FB A-P	8,6%	3,2%	14,1%
FB M-B	0,8%	0,0%	1,6%
MB M-B	7,1%	5,3%	8,9%
All	5,0%	3,1%	6,9%

Tab. 2 Failure rates by implant design

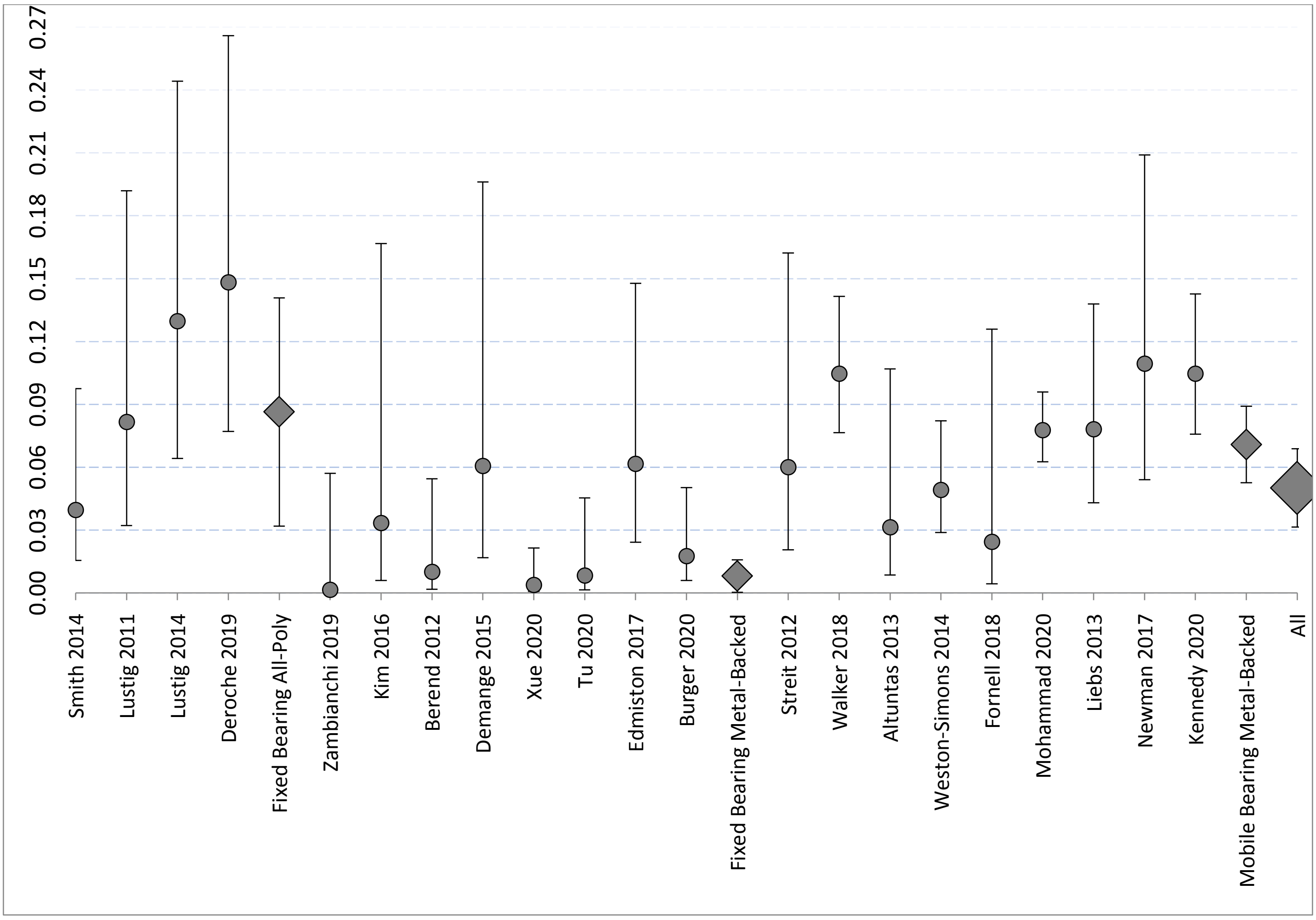

Fig. 3 Results of aggregate analysis for comparison of failure rates between patients with FB A-P, FB M-B and MB M-B implants. Y-axis shows failure rate, X-axis shows examined studies.

Implant design (comparison)	Mean Failure Rate	95% CI Lower Limit	95% CI Upper Limit	*p*-value
FB A-P	**9%**	**3%**	**14%**	**0,024**
FB F-B	**1%**	**0%**	**2%**	
FB A-P	**9%**	**3%**	**14%**	**>0,999**
MB M-B	**7%**	**5%**	**9%**	
FB M-B	**1%**	**0%**	**2%**	**0,000**
MB M-B	**7%**	**5%**	**9%**	

Tab. 3 Comparison of failure rates among groups by implant designs.

	Failure Rate	95% CI Lower Limit	95%CI Upper Limit
FU < 5y	3,9%	1,6%	6,3%
5y <FU < 10y	7,0%	2,6%	11,4%
FU > 10y	8,9%	0,0%	18,7%
All	5,0%	3,1%	6,9%

Tab. 4 Failure rates by follow-up time

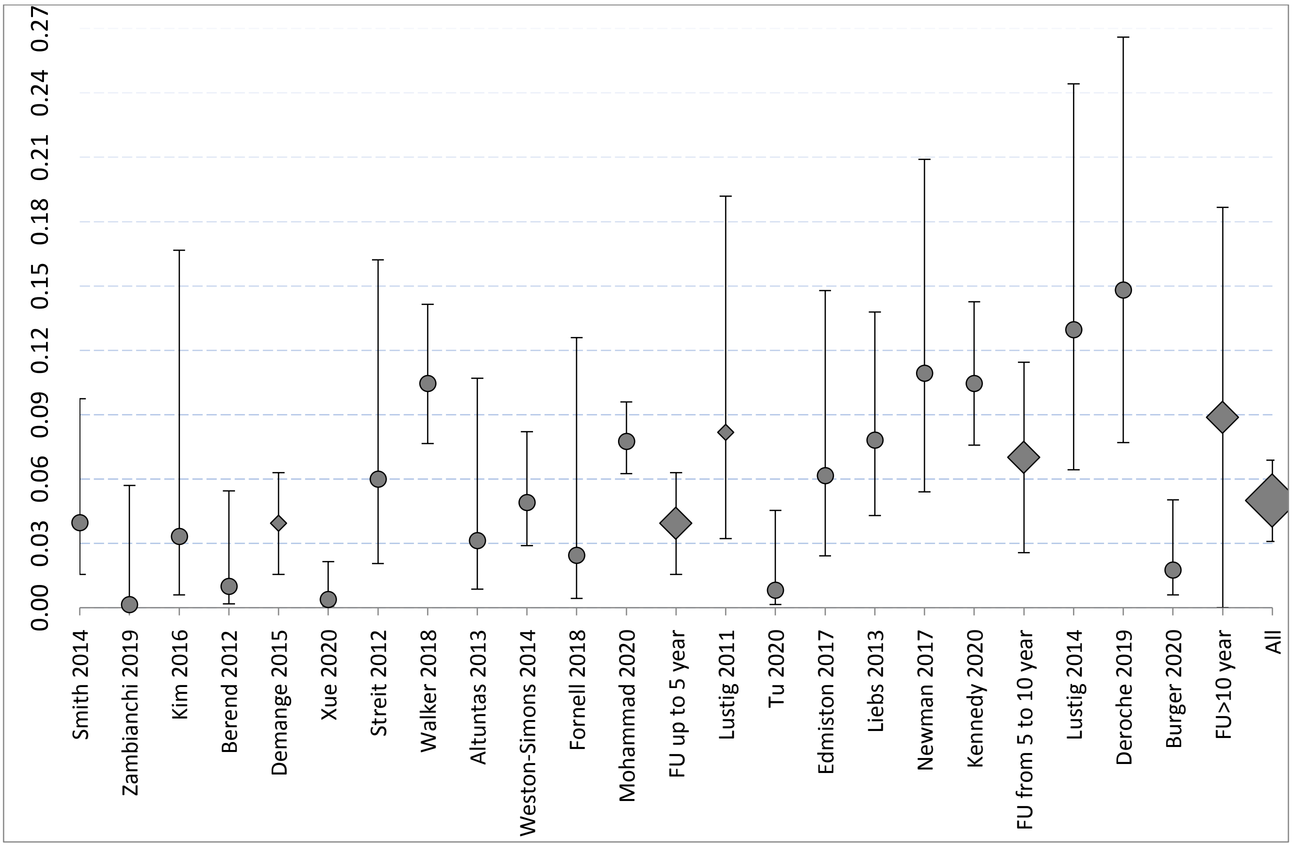

Fig. 4 Results of aggregate analysis for comparison of failure rates between patients with a follow-up less than 5 years, between 5 and 10 years, and more than 10 years. Y-axis shows failure rate, X-axis shows examined studies.

Follow-up (comparison)	Mean Failure Rate	95% CI Lower Limit	95% CI Upper Limit	*p*-value
FU < 5y	4%	2%	6%	0,582
5y <FU < 10y	7%	3%	11%	
FU < 5y	4%	2%	6%	0,754
FU > 10y	9%	0%	19%	
5y <FU < 10y	7%	3%	11%	>0,999
FU > 10y	9%	0%	19%	

Tab. 5 Comparison of failure rates among groups by follow-up time.

Appendix

Author	Reoperations	Failure, n (%)	Survivorship
Lustig 2011	4 cases were revised 1 TKA 3 revisions for UKA in the medial compartment	NA	98.08% at 10 years; end-point removal of the prosthesis
Berend 2012	3 patients had reoperations 1 ORIF for fracture 1 arthroscopy for a medial meniscal tear 1TKA revision for pain	NA	NA
Streit 2012	3 patients had revision 2 TKA due to dislocation 1 TKA due to MRSA infection	3 cases (6.2%) Dislocation at 3 years.	94% at 3 years, end-point revision for any reason
Altuntas 2013	4 patients had reoperation 2 had re-operations unrelated to the implant 2 required revision of prosthesis [Instability (1); Medial OA (1)]	3.1% failure rate of prosthesis no case of bearing dislocation	97% at 38 months; end point revision of implant
Liebs 2013	14 patient had revision 6 Aseptic loosening 2 Medial OA 2 Fracture 1 Patellofemoral pain 1 Internal fixation with screws, no change of implant components 1 Impingement 1 Arthroscopy, without change of components	NA	83% at 9 years; end-point prosthesis survival
Lustig 2014	7 patient had undergone a second operation 3 were revised to TKA 3 had medial UKAs for medial OA 1 TKA for tibial tray malpositioning	NA	91.4% at 15 years ,end-point removal of the prosthesis
Smith 2014	4 knees had revision 1 Medial OA 1 Tibial loosening 1 Infection 1 Unknown	NA	95.5% at 5 year; end-point removal of the prosthesis
Weston-Simons 2014	13 knees (4.9%) had re-operations 4 dislocation 3 Medial OA 3 Infection 3 Ongoing pain	NA	92.1% at 8 years; end point any revision
Demange 2015	In custom implant group 2 revision 1 infection so two-stage re-implantation with custom implant 1 prosthesis failure so TKA In the standard implant group, 3 implants failed 1 Infection 2 progression of disease	NA	97% at average 37 months, in custom implant group 85% at an average of 33 months in the standard implant group
Kim 2016	Rivision to TKA in 1 case due to ongoing pain	3.3 % failure rate of prosthesis	96.7% at 38 months, end point removal of prosthesis
Edmiston 2017	4 patient had revision surgery 1 ongoing pain 1 posttraumatic wound dehiscence 1 medial OA 1 patellofemoral arthritis	5% failure in in lateral approach 7% failure in medial approach	94% at a mean of 82 months; end point revision surgery
Newman 2017	2 patient revised into TKA (1 Medial OA, 1 ongoing pain) 6 patient had further surgery without prosthesis removal 1 exchange of bearing due to instability 1 arthroscopic lavage for haematoma 1 ACL reconstruction with bearing exchange 2 medial UKRs for medial OA 1 exchange of bearing due to instability	7% knee revised 13% was reoperation rate	87% at 80.6 months; end point re-operation
Fornell 2018	1 patient revesied to TKA due to ongoing pain 1 arthroscopic reduction of dislocation	2.4% revision 2.4% dislocation	97.5% at 5 years; endpoint revision for any reason
Walker 2018	36 knees had revision surgery (in 6 patient more than 1 procedure) 3 infection 20 dislocation (19 revised while 1 had spontaneous repostioning) 18 patients revised into TKA (5 dislocation, 6 medial OA, 3 instability, 3 ongoing pain, 1 femoral component loosening)	10.5 % revision 8.5 % dislocation	85.0% at 5 years; end point revision surgery
Deroche 2019	8 knees had revision 3 medial uka for medial OA 4 TKA for medial and symptomatic patellofemoral OA 1TKA for aseptic loosening of the tibial component	20.5 % revision	82.1% at 15 years and 79.4% at 20 years end point prosthesis removal and/or a second UKA for OA
Burger 2020	3 revision to TKA 1 infection 1 Aseptic loosening 1 ongoing pain	NA	97.7% at 5 Year; end point revision surgery
Zambianchi 2019	Arthroscopy performed in 2 cases 1 for medial meniscus tear 1 for synovitis in medial cpmartment Radiological outcome was not reported	No revisions	100% at 3 years; revision as the endpoint 96.9% (CI 88.0–99.2%) at 3 years; reoperation as the endpoint
Kennedy 2020	7 bearing exchange alone 7 bearing exchange with screw augmentation	34 (10%) revisions 14 knees bearing dislocation	92.1% at 5 year; end-point revision for any reason 84.6% at 10 years, end-point revision for any reason

	1 bearing exchange with debridment 1 bearing exchange with exploration for pain 1 bearing exchange with femoral component revision 11single-stage TKA 5 addition of medial uKa 1 conversion to a fixed bearing tibial component 1 two-stage TKA Radilogical outcome was not reported	12 knees progression of osteoarthritis 1 aseptic femoral loosening 1 deep infection 2 recurrent haemarthrosis 1 unrelated patellar fracture 3 bearing exchanged	
Mohammad 2020	NA Radiological outcome was not reported	77 knees (7.8%) revision surgery	92.4% (CI: 90.3-94.1) at 5 year; endpoint any revision surgery 88.6% (CI: 85.3-91.2) at 10 year; endpoint any revision surgery
		23 Dislocation subluxation revision	96.0% (CI: 91.4-98.2) at 5 year for normal weight
		15 Pain	92.3% (CI: 88.3-95.0) at 5 year for overweight
		14 Aseptic loosening	89.7% (CI: 84.8-93.1) at 5 year for obse obese
		12 OA progression	
		6 Component dissociation	86.0% (CI: 80.2-90.3) at 5 year for <55 year
		6 Infection	92.9% (CI: 88.4-95.7) at 5 year for 55-64 years
		3 Instability	94.9% (CI: 91.3-97.1) at 5 year for 65-74 year
		1 Periprosthetic fracture	95.6% (CI: 91.1-97.8) at 5 year for 75 and more
		1 Lysis	
		1 Wear	
		1 Stiffness	
		14 others	
Tu 2020	1 medial UKA for medial OA	NA	99.2%, at 5 years; revision for any reason as the end point
Xue 2020	1 medial UKA for medial OA	NA	99.5% at 5 years; endpoint revision of prosthesis

Reoperations and failures overview