Why Do Lateral Unicompartmental Knee Arthroplasties Fail Today?

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Abstract

In large studies, the failure modes of lateral unicompartmental knee arthroplasty (UKA) are usually presented in combination with medial UKA, which is mainly due to low surgical frequency of lateral UKA. Because lateral UKA differs from medial UKA in anatomic and kinematic characteristics, failure modes of lateral UKA should not be presented in combination with medial UKA. Therefore, we performed a systematic review to assess failure modes in lateral UKA and compared failure modes in cohort studies with those found in registry-based studies. A search performed in PubMed, Embase, and Cochrane identified 25 studies (23 cohort studies and 2 registry-based studies) that were eligible in presenting failure modes in lateral UKA. Most common failure modes in lateral UKA were progression of osteoarthritis (OA; 29%), aseptic loosening (23%), and bearing dislocation (10%). In cohort studies, progression of OA was more common (36%) than bearing dislocation (17%) and aseptic loosening (16%), while in the registry-based studies, aseptic loosening (28%) was more common than progression of OA (24%) and bearing dislocation (5%). In conclusion, progression of OA is the most common failure mode in lateral UKA. In the future, both cohort studies and registry-based studies should report the failure modes of medial and lateral UKA separately.

In 1975, Skolnick and colleagues[1] introduced unicompartmental knee arthroplasty (UKA) for patients with isolated unicompartmental osteoarthritis (OA). They reported a study of 14 UKA procedures, of which 12 were at the medial and 2 at the lateral side. Forty years since this procedure was introduced, UKA is used in 8% to 12% of all knee arthroplasties.[2-6] A minority of these procedures are performed at the lateral side (5%-10%).[6-8]

The considerable anatomical and kinematical differences between compartments[9-14] make it impossible to directly compare outcomes of medial and lateral UKA. For example, a greater degree of femoral roll and more posterior translation at the lateral side in flexion[9,10,13] can contribute to different pattern and volume differences of cartilage wear.[15] Because of these differences, and because of implant design factors and lower surgical volume, lateral UKA is considered a technically more challenging surgery compared to medial UKA.[12,16,17]

Since isolated lateral compartment OA is relatively scarce, current literature on lateral UKA is limited, and most studies combine medial and lateral outcomes to report UKA outcomes and failure modes.[3,4,18-20] However, as the UKA has grown in popularity over the last decade,[2,21-25] the number of reports about the lateral UKA also has increased. Recent studies reported excellent short-term survivorship results of the lateral UKA (96%-99%)[26,27] and smaller lateral UKA studies reported the 10-year survivorship with varying outcomes from good (84%)[14,28-30] to excellent (94%-100%).[8,31,32] Indeed, a recent systematic review showed survivorship of lateral UKA at 5, 10, and 15 years of 93%, 91%, and 89%, respectively.[33]

Because of the differences between the medial and lateral compartment, it is important to know the failure modes of lateral UKA in order to improve clinical outcomes and revision rates. We performed

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a systematic review of cohort studies and registry-based studies that reported lateral UKA failure to assess the causes of lateral UKA failure. In addition, we compared the failure modes in cohort studies with those found in registry-based studies.

Patients and Methods

Search Strategy and Criteria

Databases of PubMed, Embase, and Cochrane (Cochrane Central Register of Clinical Trials) were searched with the terms "knee, arthroplasty, replacement," "unicompartmental," "unicondylar," "partial," "UKA," "UKR," "UCA," "UCR," "PKA," "PKR," "PCA," "prosthesis failure," "reoperation," "survivorship," and "treatment failure." After removal of duplicates, 2 authors (JPvdL and HAZ) scanned the articles for their title and abstract to assess eligibility for the study. The full text of these eligible articles was further viewed and useful studies were selected using the inclusion and exclusion criteria. The references of these articles were scanned for additional studies and national registries (**Figure 1**).

Inclusion criteria were: (I) English language articles describing studies in humans published in the last 25 years, (II) retrospective and prospective studies, (III) featured lateral UKA, (IV) OA was indication for surgery, and (V) included failure modes data. The exclusion criteria were studies that featured: (I) only a specific group of failure (eg, bearing dislocations only), (II) previous surgery in ipsilateral knee (high tibial osteotomy, medial UKA), (III) acute concurrent knee diagnoses (acute anterior cruciate ligament rupture, acute meniscal tear), (IV) combined reporting of medial and lateral UKA, or (V) multiple studies with the same patient database.

Data Collection

All studies that reported modes of failure were used in this study and these failure modes were noted in a datasheet in Microsoft Excel 2011 (Microsoft). The data of failures of lateral UKA are presented in **Table 1** and are divided in cohort studies and registry-based studies. The final failure mode rates were presented in percentages (**Table 2**).

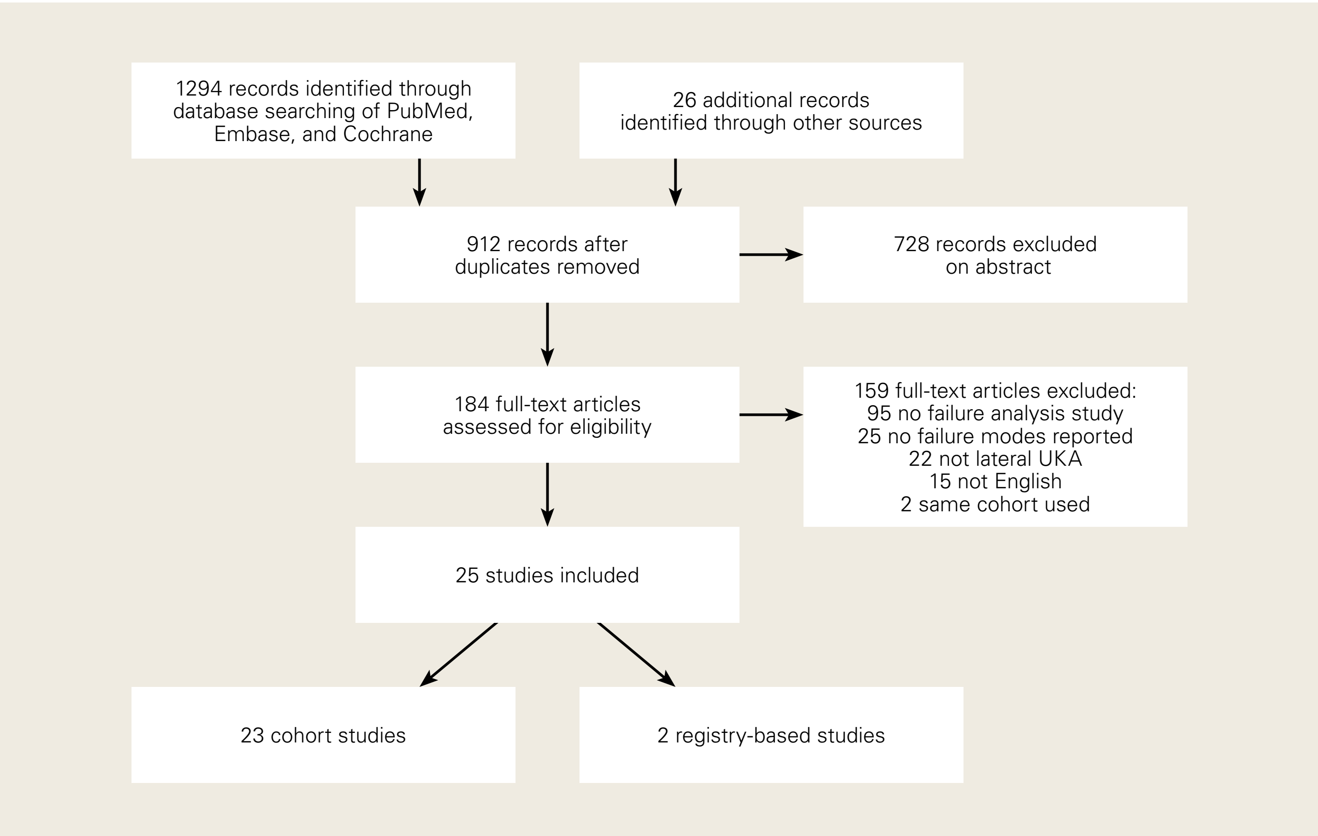

Figure 1. A flow diagram of lateral UKA failure modes with the included and excluded studies.
Abbreviation: UKA, unicompartmental knee arthroplasty.

Table 1. **Modes of Failure in Lateral Unicompartmental Knee Arthroplasty**

	N of UKA	N of failures[a]	OA prog	Asep loos	Bearing disloc	Infect-ion	Insta-bility	Pain	Fract-ure	Wear	Mal-align	Tibial subsid	Other[b]	Time to Revision (years)			Type UKA
														Mean	Min	Max	
Pandit et al 2010[50]	219	21	3	1	10	4			1				2		1[c]	9[c]	Mob
Citak et al 2015[57]		16	9	3			1			2			1	9.4	0.1	21.1	
Ashraf et al 2002[11]	88	15	9	6										8	1	16	Fixed
Liebs et al 2013[58]	128	14	3	6					2				3	6[c]	2.1[c]	9.8[c]	Mob
Weston-Simons et al 2014[59]	265	12	3		4	2		3						2.6	0.1	6.5	Mob
Gunther et al 1996[51]	53	11		1	6	3			1					2.4	0.2	8	Mob
Thompson et al 2013[60]	30	11	2			3		2	2		1	1		1.2	0	3.4	Mult
Walton et al 2006[54]	32	7	6	1											5	13	Fixed
Lustig et al 2014[55]	54	7	6	1										14.2[c]	10.2[c]	18[c]	Fixed
Bertani et al 2008[29]	35	5	4									1		9[c]	2[c]	22[c]	Mult
Argenson et al 2008[14]	160	5	4	1										5.9	0.9	13.7	Fixed
Saxler et al 2004[61]	46	5	1		3								1	5.5[c]	2.3[c]	12.5[c]	Mob
Smith et al 2014[26]	101	4	1	1		1							1	3.6	1.4	6.9	Fixed
Forster et al 2007[62]	30	4		3					1					3	2	4	Mult
Berend et al 2012[27]	132	3						1	1				1	3.3	2	6.8	Fixed
Streit et al 2012[63]	50	3			2	1								0.9	0.1	1.4	Mob
Altuntas et al 2013[64]	64	2	1				1							1.6	1	2	Mob
Ashraf et al 2004[65]		2	1			1								5.1	1.3	9	Fixed
Ohdera et al 2001[47]	38	2	1	1										7.3	3.5	11	Mult
O'Rourke et al 2005[56]	14	2	2											12.9	4.2	21.6	Fixed
Schelfaut et al 2013[66]	25	2			1			1						0.6	0.3	0.9	Mob
Marson et al 2014[67]	27	1			1									2.9	1.3	5	Fixed
Walker et al 2014[68]	22	1				1								1.8			Fixed
Cohort studies	**1613**	**155**	**56**	**25**	**27**	**16**	**2**	**7**	**8**	**2**	**1**	**2**	**9**				
Lewold et al 1998[7]	1336	140	48	43	5		10		3	8	5	3	15				Mult
Baker et al 2012[6]	2052	71	3	17	5	7	11	15	2		1		10				Mult
Registry studies	**3388**	**211**	**51**	**60**	**10**	**7**	**21**	**15**	**5**	**8**	**6**	**3**	**25**				
Total lateral UKA	5001	366	107	85	37	23	23	22	13	10	7	5	34				
Total (%)		**100**	**29.2**	**23.2**	**10.1**	**6.3**	**6.3**	**6.0**	**3.6**	**2.7**	**1.9**	**1.4**	**9.3**				

[a]N indicates number of failed medial unicompartmental knee arthroplasty.
[b]Other causes include patellar problems, arthrofibrosis, stiffness, other and unknown cause.
[c]These studies only reported time of follow-up.

Abbreviations: Asep loos, aseptic loosening; Bearing disloc, bearing dislocation; Malalign, malalignment; Max, maximum; Min, minimum; Mult, multiple types of UKA; Mob, mobile bearing; OA prog, progression of osteoarthritis, Tibial subsid, tibial subsidence; UKA, unicompartmental knee arthroplasty.

Statistical Analysis

For this systematic review, statistical analysis was performed with IBM SPSS Statistics 22 (SPSS Inc.). We performed chi square tests and Fisher's exact tests to assess a difference between cohort studies and registry-based studies with the null hypothesis of no difference between both groups. A difference was considered significant when $P < .05$.

Results

Through the search of the databases, 1294 studies were identified and 26 handpicked studies were added. Initially, based on the title and abstract, 184 of these studies were found eligible. After reviewing the full text of these articles, 25 studies (23 cohort studies and 2 registry-based studies) met the inclusion criteria and were included for the analysis of lateral UKA failure (Figure 1).

A total of 366 lateral UKA failures were included. The most common failure modes were progression of OA (29%), aseptic loosening (23%), and bearing dislocation (10%). Infection (6%), instability (6%), unexplained pain (6%), and fractures (4%) were less common causes of failure of lateral UKA (Table 2).

One hundred fifty-five of these failures were reported in the cohort studies. The most common modes of failure were OA progression (36%), bearing dislocation (17%) and aseptic loosening (16%). Less common were infection (10%), fractures (5%), pain (5%), and other causes (6%). In registry-based studies, with 211 lateral UKA failures, the most common modes of failure were aseptic loosening (28%), OA progression (24%), other causes (12%), instability (10%), pain (7%), bearing dislocation (5%), and polyethylene wear (4%) (Table 2).

When pooling cohort and registry-based studies, progression of OA was significantly more common than aseptic loosening (29% vs 23%, respectively; $P < .01$). It was also significantly more common in the cohort studies (36% vs 16%, respectively; $P < .01$) but no significant difference was found between progression of OA and aseptic loosening in registry-based studies (24% and 28%, respectively; $P = .16$) (Table 2).

When comparing cohort with registry-based studies, progression of OA was higher in cohort studies (36% vs. 24%; $P < .01$). Other failures modes that were more common in cohort studies compared with registry-based studies were bearing dislocation (17% vs 5%, respectively; $P < .01$) and infections (10% vs 3%, $P < .01$). Failure modes that were more common in registry-based studies than cohort studies were aseptic loosening (28% vs 16%, respectively; $P < .01$), other causes

Table 2. **Failure Modes of Lateral UKA in Different Study Designs (%)**

	Overall	Cohort Studies	Registry-Based Studies	Cohort vs Registries
Progression of OA	29.2	36.1	24.2	$P < .01$
Aseptic loosening	23.2	16.1	28.4	$P < .01$
Bearing dislocation	10.1	17.4	4.7	$P < .01$
Infection	6.3	10.3	3.3	$P < .01$
Instability	6.3	1.3	10.0	$P < .01$
Pain	6.0	4.5	7.1	$P = .15$
Fracture	3.6	5.2	2.4	$P = .08$
Polyethylene wear	2.7	1.3	3.8	$P = .07$
Malalignment	1.9	0.6	2.8	$P = .13$
Tibial subsidence	1.4	1.3	1.4	$P = .64$
Other[a]	9.3	5.8	11.8	$P = .02$

[a]Other causes include patellar problems, arthrofibrosis, stiffness, other, and unknown cause.
Abbreviations: OA, osteoarthritis; UKA, unicompartmental knee arthroplasty.

(12% vs 6%, respectively, $P = .02$), and instability (10% vs 1%, respectively, $P < .01$) (Table 2).

Discussion

In this systematic review, the most common failure modes in lateral UKA review were OA progression (29%), aseptic loosening (23%), and bearing dislocation (10%). Progression of OA and bearing dislocation were the most common modes of failure in cohort studies (36% and 17%, respectively), while aseptic loosening and OA progression were the most common failure modes in registry-based studies (28% and 24%, respectively).

Progression of OA is the most common failure mode in lateral UKA, followed by aseptic loosening. Anatomic and kinematic factors such as alignment, mechanical forces during dynamic phase, and correction of valgus seem to play important roles in failure modes of lateral UKA.

As mentioned above, there are differences in anatomy and kinematics between the medial and lateral compartment. When the lateral UKA failure modes are compared with studies reporting medial UKA failure modes, differences in failure modes are seen.[34] Siddiqui and Ahmad[35] performed a systematic review of outcomes after UKA revision and presented a table with the failure modes of included studies. Unfortunately they did not report the ratio of medial and lateral UKA. However, when assuming an average percentage of 90% to 95% of medial UKA,[6,7,36] the main failure mode in their review in 17 out of 21 studies was aseptic loosening. Indeed, a recent systematic review on medial UKA failure modes showed that aseptic loosening is the most common cause of failure following this procedure.[34] Similarly, a search through registry-based studies[6,7] and large cohort studies[37-40] that only reported medial UKA failures showed that the majority of these studies[7,37-39] also reported aseptic loosening as the main cause of failure in medial UKA. When comparing the results of our systematic review of lateral UKA failures with the results of these studies of medial UKA failures, it seems that OA progression seems to play a more dominant role in failures of lateral UKA, while aseptic loosening seems to be more common in medial UKA.

Differences in anatomy and kinematics of the medial and lateral compartment can explain this. Malalignment of the joint is an important factor in the etiology of OA[41,42] and biomechanical studies showed that this malalignment can cause decreased viability and further degenerative changes of cartilage of the knee.[43] Hernigou and Deschamps[44] showed that the alignment of the knee after medial UKA is an important factor in postoperative joint changes. They found that overcorrection of varus deformity during medial UKA surgery, measured by the hip-knee-ankle (HKA) angle, was associated with increased OA at the lateral condyle and less tibial wear of the medial UKA. Undercorrection of the varus caused an increase in tibial wear of polyethylene. Chatellard and colleagues[45] found the same results in the correction of varus, measured by HKA. In addition, they found that when the prosthetic (medial) joint space was smaller than healthy (lateral) joint space, this was correlated with lower prosthesis survival. A smaller joint space at the healthy side was correlated with OA progression at the lateral compartment and tibial component wear.

These studies explain the mechanism of progression of OA and aseptic loosening. Harrington[46] assessed the load in patients with valgus and varus deformity. Patients with a valgus deformity have high mechanical load on the lateral condyle during the static phase, but during the dynamic phase, a major part of this load shifts to the medial condyle. In the patients with varus deformity, the mechanical load was noted on the medial condyle during both the static and dynamic phase. Ohdera and colleagues[47] advised, based on this biomechanical study and their own experiences, to correct the knee during lateral UKA to a slight valgus angle (5°-7°) to prevent OA progression at the medial side. van der List and colleagues[48] similarly showed that undercorrection of 3° to 7° was correlated with better functional outcomes when compared to more neutral alignment. Moreover, Khamaisy and colleagues[49] recently showed that overcorrection during UKA surgery is more common in lateral than medial UKA.

These studies are important to understanding why OA progression is more common as a failure mode in lateral UKA. The shift of mechanical load from the lateral to medial epicondyle during the dynamic phase also could explain why aseptic loosening is less common in lateral UKA. As Hernigou and Deschamps[44] and Chatellard and colleagues[45] stated, undercorrection of varus deformity in medial UKA is associated with higher mechanical load on the medial prosthesis side and smaller joint space width. These factors are correlated with mechanical failure of medial UKA. We think this process can be applied to lateral UKA, with the addition that the mechanical load is higher on the healthy medial compartment during the dynamic phase. This causes more forces on the healthy (medial) side in lateral UKA, and in medial UKA more forces on the prosthesis (medial) side, which results in more OA progression in lateral UKA and more aseptic loosening in medial UKA. This finding is consistent with the results of our review of more OA progression and less aseptic loosening in lateral UKA. This study also suggests that medial and lateral UKA should not be reported together in studies that present survivorship, failure modes, or clinical outcomes.

A large discrepancy was seen in bearing dislocation between cohort studies (17%) and registry-based studies (5%). When we take a closer look to the bearing dislocation failures in the cohort studies, most of the failures were reported in only 2 cohort studies.[50,51] In a study by Pandit and colleagues,[50] 3 different prosthesis designs were used in 3 different time periods. In the first series of lateral UKA (1983-1991), 6 out of 51 (12%) bearings dislocated. In the second series (1998-2004), a modified technique was used and 3 out of 65 (5%) bearings dislocated. In the third series (2004-2008), a modified technique and a domed tibial component was used and only 1 out of 68 bearings dislocated (1%). In a study published in 1996, Gunther and colleagues[51] also used surgical techniques and implants that were modified over the course of the study period. Because of these modified techniques, different implant designs, and year of publication, bearing dislocation most likely plays a smaller role than the 17% reported in the cohort studies. This discrepancy is a good example of the important role for the registries and registry-based studies in reporting failure modes and survivorship, especially in lateral UKA due to the low surgical frequency. Pabinger and colleagues[52] recently performed a systematic review of cohort studies and registry-based studies in which they stated that the reliability in non-registry-based studies should be questioned and they considered registry-based studies superior in reporting UKA outcomes and revision rates. Furthermore, given the differences in anatomic and kinematic differences between the medial and lateral compartment and different failure modes between medial and lateral UKA, it would be better if future studies presented the medial and lateral failures separately. As stated above, most large cohort studies and especially annual registries currently do not report modes of failure of medial and lateral UKA separately.[3,4,18-20]

There are limitations in this study. First, this systematic review is not a full meta-analysis but a pooled analysis of collected study series and retrospective studies. Therefore, we cannot exclude sampling bias, confounders, and selection bias from the literature. We included all studies reporting failure modes of lateral UKA and excluded all case reports. We made a conscious choice about including all lateral UKA failures because this is the first systematic review of lateral UKA failure modes. Another limitation is that the follow-up period of the studies differed (Table 1) and we did not correct for the follow-up period. As stated in the example of bearing dislocations, some of these studies reported old or different techniques, while other, more recently published studies used more modified techniques[11,29,53-56] Unfortunately, most studies did not report the time of arthroplasty survival and therefore we could not correct for the follow-up period.

In conclusion, progression of OA is the most common failure mode in lateral UKA, followed by aseptic loosening. Anatomic and kinematic factors such as alignment, mechanical forces during dynamic phase, and correction of valgus seem to play important roles in failure modes of lateral UKA. In the future, failure modes of medial and lateral UKA should be reported separately.

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