**ORIGINAL PAPER**

# The patient results and satisfaction of knee arthroplasty in a validated grading system

Christiaan Rudolf Oosthuizen[1,2] · Catherine Van Der Straeten[3] · Innocent Maposa[4] · Christian Hugo Snyckers[5] · Duwayne Peter Vermaak[5] · Sebastian Magobotha[2]

## Abstract

**Introduction** The validated Knee Osteoarthritis Grading System (KOGS) was implemented and clinical results were compared with patient satisfaction data and implant survivorship in a multi-centre study with surgeons familiar with unicompartmental knee arthroplasty (UKA), patellofemoral arthroplasty (PFA) and total knee arthroplasty (TKA).

This is also the first study to evaluate the prevalence of UKA and TKA in consecutive osteoarthritis (OA) knee arthroplasties assessed by this system..

**Method** A consecutive cohort of knees was gathered at three different institutions as categorized by KOGS and surgically treated with the recommended implant unless clinical reasons or patient preference precluded such an option.

One thousand one hundred seventy-seven consecutive knees were evaluated including 311 TKA (26%), 695 medial UKA (59%), 154 lateral UKA (13%) and 17 PFA (2%) and the results of the categories evaluated with the Oxford Knee Score (OKS) and the complications reflected in the different categories.

**Results** The failure rate of the UKA (3.5%) or TKA (1.6%) is not higher than accepted results in the literature and the difference in complications is negligible between the UKA (72%) and TKA (26%) cohorts.

Revision of a UKA to a TKA as an endpoint was 0.58% with ipsilateral progression at 0.8% over a period of five to 84 months (mean follow-up of 36 months) despite the 'excessive' proportion of UKA in this cohort.

The Oxford Score improvement is significant in TKA and UKA and contributes to the acceptable outcomes (The OKS for TKA improved from 20 pre-operatively to 36 post-operatively and the UKA improved from 22 pre-operatively to 39 post-operatively).

**Conclusion** KOGS achieves acceptable early survival and functional results when implemented and is a suitable tool for identifying the preferred implant as was validated.

**Keywords** X-ray · Osteoarthritis · Grading · Knee · Arthroplasty · Replacement

✉ Christiaan Rudolf Oosthuizen
drcroosthuizen@gmail.com

Catherine Van Der Straeten
cathvds@telenet.be

Innocent Maposa
innocent.maposa@wits.ac.za

Christian Hugo Snyckers
thejointunit@gmail.com

Duwayne Peter Vermaak
duwaynesbones@gmail.com

Sebastian Magobotha
mago@mweb.co.za

1   Private Orthopaedic Practice, Johannesburg, South Africa

2   Division of Orthopaedic Surgery, University of the Witwatersrand, Johannesburg, South Africa

3   Head of the Health Innovation and Research Institute, Ghent University Hospital, Ghent, Belgium

4   Faculty of Health Sciences, Wits School of Public Health, University of the Witwatersrand, Johannesburg, South Africa

5   Private Orthopaedic Practice, Pretoria, South Africa

## Introduction

The osteoarthritic (OA) knee presents to the clinician due to pain, function loss or deformity and in the process of degeneration requiring the appropriate clinical evaluation, activity level, range of motion (ROM), special investigations and discussion of the patient's expectations.

The patient morphotype is unique, with the wear pattern the key to the kinematic pathological process, culminating in a particular solution that is currently predominantly a total knee arthroplasty (TKA) irrespective of the wear pattern and without native kinematic restoration.

The institutionalized neglect advocated by surgeons until eventual TKA leads to poor patient and social acceptance as demonstrated in the publication by Kazarian et al. [1] and a 'staged approach' for the deteriorating knee can be beneficial. On balance, the unicompartmental knee arthroplasty (UKA) identification and surgical experience has been a barrier to the orthopaedic surgeon performing the procedure, as there are distinct problems associated with the selection, the technique and the different implants.

The ability to identify and implant an appropriate arthroplasty is essential in the surgeon's practice, with the Kellgren and Lawrence (K&L) in 1957 [2] and the modification by Ahlbäck in 1968. The K&L is inaccurate when applied to the tricompartmental knee, as the varying degrees of deteriorating pathology of the three different compartments are not assimilated in one comprehensive system.

The utilization rates of a specific knee arthroplasty vary greatly and there is no clear consensus regarding the implementation of a specific arthroplasty in the evolution of degenerative knee disease whether focal or tricompartmental [3] with the commensurate unavailability of a comparable accounting of the variable severity and distribution of OA in the use of arthroplasty.

The research publication from Adelani confirms that magnetic resonance imaging (MRI) is not the most suitable examination as a therapeutic indicator when the joint space is less than 50% of normal (in the category that progressively becomes suitable for arthroplasty) [4]. Furthermore, treating surgeons often have limited funds to incorporate MRI in the treatment algorithm of knee OA and generally also rely on the varied interpretation of a radiologist with little or no clinical experience. MRI cost and sensitivity remains a problem although the MRI is required with pain and function loss without the necessary X-ray confirmation of bone-on-bone degeneration.

## Current TKA status

The TKA has been accepted for the past 40 years as the panacea solution for single compartment degeneration as well as tricompartmental degeneration and is used in 90% of all knee arthroplasty. It has been established as a successful treatment of end-stage knee OA achieving pain relief, improvement of function and quality of life with very good to excellent implant longevity up to 91–96.8% at 20–25 years [5]. This leads to better survival results of TKA but includes a substantial percentage of dissatisfied patients with functional impairment in whom a TKA may not have been appropriate in the beginning [6, 7].

The rate of major complications of patients undergoing a TKA is higher than UKA as researched by Liddle [8], and even computer-assisted surgery has not improved the results compared with conventional instrumentation as studied by D'Amato [9].

Chronic pain (persisting in excess of 3 to 6 months) after TKA is prevalent in about 20% of all TKA procedures associated with functional limitations (25%), pain-related distress, depression and social isolation according to a review study by Wylde [10].

The recently improved function-based outcome assessments highlighted the relative inadequacy of the TKA with the UKA becoming a more functional alternative as evaluated in the meta-analysis from Migliorini [11] and a further study by Lons (INOR), Dec. 2017 indicated the large metal surface of TKA generates a significant detrimental elevation of chrome, cobalt and titanium one year after implantation which can lead to allergy, hypersensitivity etc. [12].

## Current UKA status

A prospective study with different evaluation methods such as "Forgotten Joint Score (FJS), the short form of the Knee Injury and Osteoarthritis Outcome Score (KOOS PS), EuroQOL Five Dimensions Questionnaire (EQ-5D), and the Knee Society Score (KSS)" has shown that in arthroplasty surgery, the UKA patients are less aware of their prosthesis than TKA from as early as two weeks post-operatively to 12 months [13].

The progression of OA to the ipsilateral compartments (the most common mode of failure beyond 10 years) is generally no more than 2.5% over 15 years in the study of Pandit of over 1000 mobile UKA [14].

Willis-Owen, in his study of more than 41,000 knee arthroplasties, indicated that at least 47.6% of knee OA is suitable for UKA [15]. The 2018 National Joint Registry report (United Kingdom) indicates the utilization of TKA at 89.5% and the UKA at 9.4% [16].

The drive to identify the suitable knee for a UKA is increasing and a recent watershed publication in the Journal of Bone and Joint Surgery 2018 by Kazarian et al. [1] indicates the cost-effectiveness of the UKA as

a treatment modality and "found that unicompartmental knee arthroplasty was universally the best treatment option for focal knee arthritis from 40 until the age of 87." This study included the results of reliable registries that indicated UKA's have more excellent and fewer poor results than TKA's, but are revised more often, as identified by Goodfellow [17].

The Open Review Article by Rodríguez-Merchán and Gómez-Cardero in 2018, details an overview of the current indications, technical issues and results of the UKA [18].

This is not a comparative study of any specific procedure for OA although the results are literature conforming. The UKA is a favourable procedure as studied by Won-Joon Cho et al. [19] and Kim in 2019 [20] confirming a better short-term functional outcome and return to recreational and sporting activities than high tibial osteotomy in medial OA.

The UKA results will be enhanced by further developments where the same system can be used for medial and lateral OA together with the option of a mobile and fixed-bearing as studied by Saragaglia, confirming excellent results [21].

The research aim is to evaluate the results of KOGS determined arthroplasty procedures in a cohort of 1177 knees.

## Materials and methods

### The KOGS

The *Knee Osteoarthritis Grading System (KOGS)* is a dynamic radiological tool for progressing degenerative tricompartmental OA of the knee, validated and published in The Journal of Arthroplasty (JOA) in March 2019 by Oosthuizen et al. [22].

The system is *initiated* with bony contact in one compartment, a K&L grade 4 classification, and identifies the isolated wear lesion whether in the tibiofemoral (TF) or patellofemoral (PF) joints. With the specified X-ray views, the specific type of implant can be considered according to the grading achieved. A recent study in INOR confirmed that the complete obliteration (K&L grade IV) of the joint renders better results in TKA than a joint space of more than 2 mm (K&L grade III) [23]. This has also been proven in the UKA studies and is a pillar of the KOGS.

"KOGS was able to identify true Partial Knee Arthroplasty (PKAs) (sensitivity) based on X-ray method in the range of 92.2% to 98.5% across all the different evaluators. This method was able to identify a PKA or a TKA with an accuracy ranging from 89.6% to 98.8% across all different evaluators. Percentage agreement between the two cohorts for the same assessor ranged from 88.5% to 99.5%, suggesting an almost perfect agreement" [22].

This grading developed from the "X-ray Knee Instability and Degenerative Score" (X-KIDS) [24] and the decision aid (DA) for medial wear [25]. However, these methods did not evaluate the knee as a tricompartmental joint but focused on the weight bearing TF joints as several authors proclaimed the PF joint having little influence on the outcome of the medial UKA [26].

Full thickness PF joint degeneration is seldom a contraindication for UKA [27] but grooving of the lateral facet in the isolated medial and lateral TF OA was considered to be a contraindication or an indication for patellofemoral arthroplasty (PFA) or TKA. The existence of PF degeneration in TKA had no detrimental effect on TKA surgery when the PF joint was not resurfaced even in Outerbridge grade IV according to Guo-Chun Zha [28], a similar approach is therefore taken in the UKA in this study.

Isolated PF joint OA with intact TF joints can be treated with a PFA. This is a less invasive procedure with similar or better results, as recently published, than a TKA [29].

The clinical indications for surgery were based on the publication and experience of the Oxford Group as KOGS is not a standalone decision maker and complements the clinical evaluation, minimizes the possibility of ipsilateral progression and improves the evaluation of the knees that are suitable for a UKA and TKA.

Three surgeons in different locations assessed the outcomes of KOGS evaluated procedures in their practices. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee (University of the Witwatersrand [WITS] with Clearance Certificate Nos. M1704111 and M1704112) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

The specific KOGS X-ray sequence was implemented as a routine requirement for every patient at the radiological facility of the various hospitals with no involvement by the clinicians (Fig. 1).

The X-ray sequence method is based on standard preoperative X-rays and includes the following:

1. Anteroposterior (AP) and lateral knee views and a 30° skyline patella view
2. 15° (medial OA) and 45° (lateral OA) Rosenberg/Lyon views
3. Stress views in 20° of flexion

The inclusion proviso in this assessment for arthroplasty is that all the X-rays are available. At least one of the tricompartmental joints should be a K&L grade 4 and has bone-on-bone contact [30]. The results were evaluated based on the incidence of major complications and the functional Oxford Scores [23] (Tables 1 and 2).

A synopsis of the KOGS is included as an Appendix to this publication and in the JOA March 2019 publication [22].

## Results

There are no significant differences (log-rank $P$ value = 0.160) in the survivorship probabilities between patients that receive partial knee arthroplasty and those that receive total knee arthroplasty based on the KOGS grading criteria (as a supportive diagnosis measure) (Table 2)

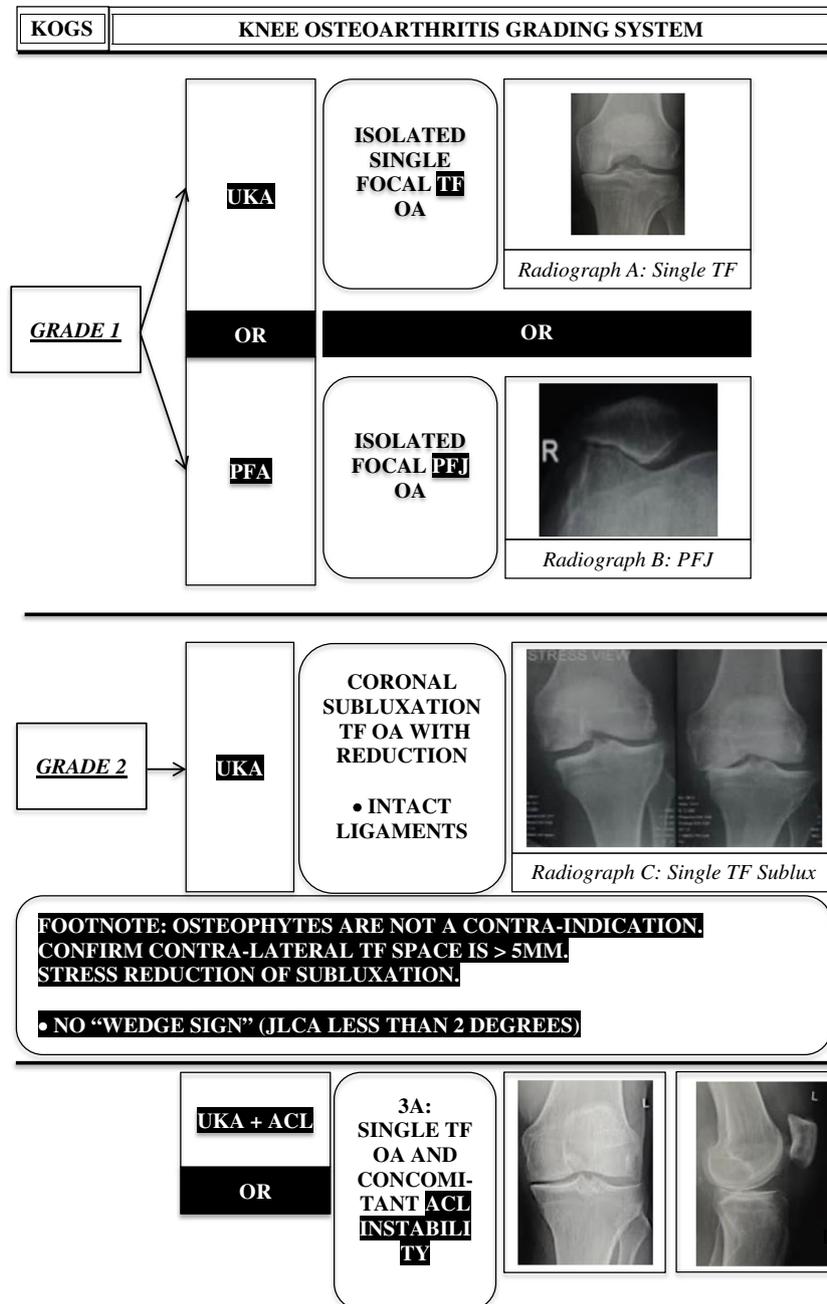*There is no statistical difference between the complication rates of the PKA vs. TKA.*


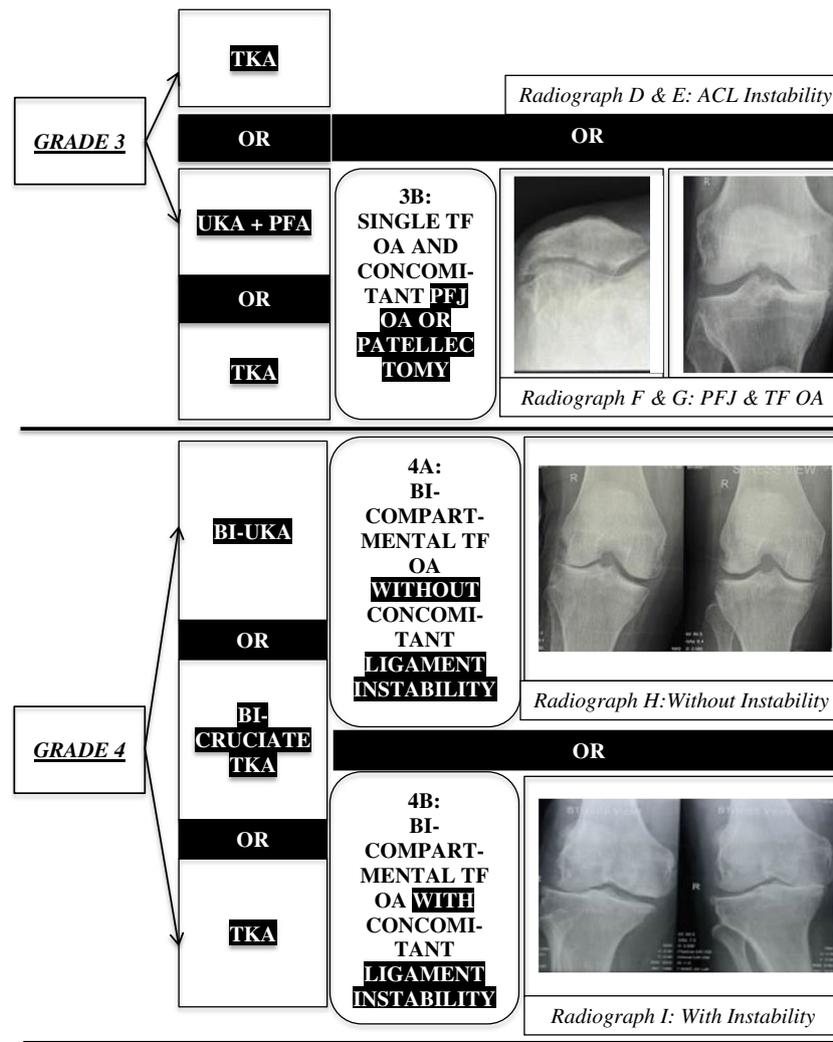
Fig. 1 KOGS flowchart with radiographs

**Fig. 1** continued.

- There are no significant differences in the survival probabilities between patients that receive their surgical option based on a KOGS grading assessment of 1, 2, 3 or 4 (log-rank $P$ value = 0.156) and those who experience major complications (Fig. 2).

Patients who smoke are at a significantly higher risk of experiencing major complications compared with those who do not smoke (log-rank $P$ value < 0.001).

The KOGS could identify the arthroplasty required and when implemented, there are no statistical differences in the failure rate of the different categories.

The higher failure rate of 6.2% is seen in grade 2 (comprising 12.3% [145 cases] of the total cohort), compared with the 2.6% in grade 1 and the 3% in grade 4 [Table 2].

The functional data (OKS and ROM) of the PKA performs better than the TKA and also indicates that the more severely affected KOGS grade 3 and grade 4 (usually TKA's) do not achieve the same improvement as the grade 1 and grade 2's (usually PKA's) (Table 1).

When the PKA revision endpoint is determined by a revision to a TKA, the incidence is 0.58% (major complications are 3% of the full cohort) with smokers having an increased complication rate in the complete cohort (Smokers' major complication rate is at 11% with non-smokers at 2.2%) (Tables 2 and 3).

## Discussion

The implementation of the UKA is between 8 and 10% worldwide, with a major stumbling block being the reliable identification of the focal lesion and the variety of degenerative stages of the tricompartmental knee. Although the statistical survival assessment of the UKA compared with the TKA can

**Table 1** KOGS selection, demographics, and Oxford Knee Scores

| | PKA | TKA | PFA |
| --- | --- | --- | --- |
| | $n = 849$ (72%) | $n = 311$ (26%) | $n = 17$ (2%) |
| KOGS grading | | | |
|   KOGS grade 1 | 671 (79.0) | 32 (10.3) | 17 (100) |
|   KOGS grade 2 | 134 (15.8) | 11 (3.5) | 0 |
|   KOGS grade 3 | 37 (4.4) | 106 (34.1) | 0 |
|   KOGS grade 4 | 7 (0.8) | 162 (52.1) | 0 |
| Gender | | | |
|   Female | 419 (49.4) | 213 (68.5) | 13 (76.5) |
|   Male | 430 (50.6) | 98 (31.5) | 4 (23.5) |
| Mean age (SD) | 64.4 (9.20) | 65.4 (10.58) | 64.9 (10.81) |
| Median time to major complication [IQR] | 28.6 [15.64–46.35] | 29.19 [16.79–42.21] | 36.68 [19.88–57.85] |
| Oxford Knee Score (OKS) averages | | | |
|   Pre-operative | 22 | 20 | 19 |
|   6-week post-operative | 34 | 33 | 32 |
|   3-month post-operative | 37 | 36 | 36 |
|   Most recent | 39 | 36 | – |

improve significantly if progression of degeneration is not penalized (primary implant did not fail or was revised from its bony attachment), the improvement in ipsilateral compartment assessment (stress and Rosenberg views) will prevent some implant failure due to progression. Although this study has a relatively short mean post-operative period, it has been shown that if the UKA is functioning well in the short term, the long-term outcome is likely to be satisfactory.

The system categorizes the deficient anterior cruciate ligament and focal TF lesion in grade 3A and allows comparative results with the isolated focal lesion in grades 1 and 2. The use of a fixed or mobile-bearing in this category seems to be irrelevant in the short term as studied by Tecame et al. [31].

The cost-effectiveness study of Kazarian [1] and Wilson in BMJ 2019 [32] are watershed publications for the suitability

**Table 2** Complications in the various categories (demographic, KOGS grading, surgery type, etc. for UKA and TKA)

| Characteristic | Type of complication | | P value |
| --- | --- | --- | --- |
| | Major $n = 35$ (2.9%) | None and minor $n = 1142$ (97.1%) | |
| Age at operation | 62.3 (1.510) | 64.8 (0.287) | 0.247 |
| Time since operation (median) | 4.8 (1.47–14.17) | 29.19 (16.43–45.49) | 0.467 |
| KOGS grading | | | |
|   KOGS grading 1 | 19 (2.6%) | 701 (97.4%) | |
|   KOGS grading 2 | 9 (6.2%) | 136 (93.8%) | |
|   KOGS grading 3 | 2 (1.4%) | 141 (98.6%) | |
|   KOGS grading 4 | 5 (3%) | 164 (97%) | 0.246 |
| Surgery type | | | |
|   PKA + PFA ($n = 866$) | 30 (3.5%) | 836 (96.5%) | |
|   TKA ($n = 311$) | 5 (1.6%) | 306 (98.4%) | 0.063 |
| Smoking | | | |
|   Yes | 11 (11%) | 100 (8.5%) | |
|   No | 24 (2.2%) | 1077 (91.5%) | |

**Fig. 2** KOGS grading and effect on time to major complication
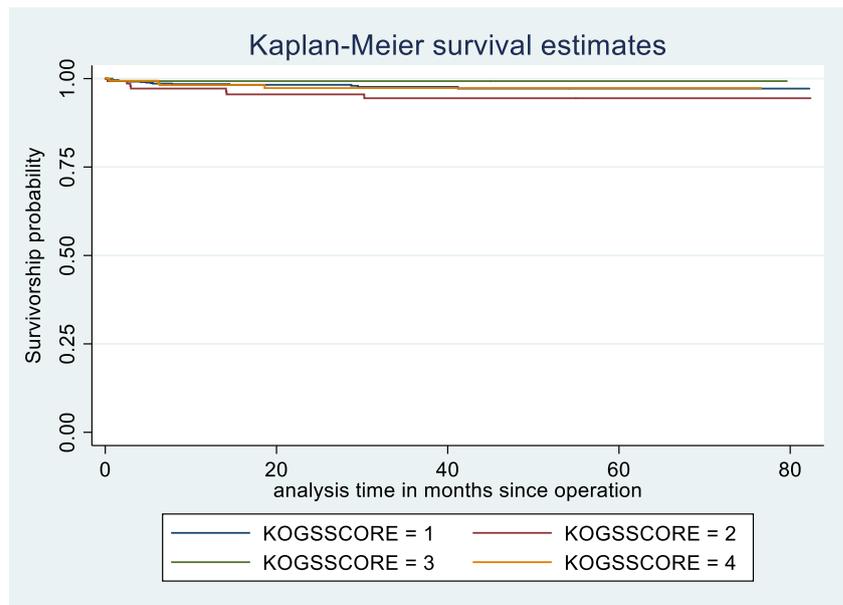


of the partial knee surgical treatment for focal knee OA and coupled with better identification techniques e.g. KOGS [22], X-KIDS [24] and DA [25] will improve the implementation of the correct treatment modalities for focal OA.

The studies by Liddle, on how to optimize the UKA outcomes, confirm the percentage usage as the key factor where the surgeon should preferably increase the percentage of UKA in his knee practice to approximately 50% to achieve a lesser revision rate than with his TKA [33].

KOGS identifies the increased percentage of knees required for UKA and selects the suitable knee with a validated system that is cost effective with minimal ipsilateral progression, 0.47%, at a mean of three years, is possible. According to the review study on lateral UKA

failures by Ernstbrunner [34], the progression of OA is the most common problem in mid-term and late-term failures in mobile or fixed UKA and this can be minimized by improved selection.

The conclusions are as follows:

1. The KOGS can delineate focal pathology with minimal ipsilateral progression and implant options can be successfully implemented. Although the mean follow-up is only 36 months, it is known that failure in the UKA is predominantly early.
2. The KOGS can be used to scientifically compare the results of different stages of degeneration with the different modalities of treatment implemented.

**Table 3** Major complications listed

| Type of complication (35 major complications) | | |
| --- | --- | --- |
| | PKA (866), $n = 30$ (3.5%) | TKA (311), $n = 5$ (1.6%) |
| Ipsilateral pathology (OA, avascular necrosis, spontaneous chondrolysis) | 7 (0.8%) | 0 |
| Avulsion of infra-patellar tendon | 0 | 1 (0.3%) |
| Dislocation of bearing (lateral higher) | 10 (1.2%) | 2 (0.7%) |
| Fracture | 6 (0.7%) | 0 |
| Haematoma | 0 | 1 (0.3%) |
| Incarceration of patella | 1 (0.1%) | 0 |
| Infection | 1 (0.1%) | 0 |
| Patella fracture | 0 | 1 (0.3%) |
| Subsidence | 5 (0.6%) | 0 |

3. The functional results, despite the irregular high proportion of UKA, are acceptable as seen by the OKS improvement.

**Author declarations** We, the authors declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. All authors have participated in the research. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We understand that the Corresponding Author, CR Oosthuizen, is the sole contact for the Editorial process.

## Compliance with ethical standards

**Conflict of interest** All authors declare that they received no research grants from funding agencies for this research.

Author 1 is an ad hoc paid consultant for Zimmer Biomet and Amplitude. Author 2 has received a speaker honorarium for a presentation on general aspects of Research and Innovation from Smith & Nephew.

No other interests required declaration as no benefits in any form have been received from a commercial party related directly or indirectly to the subject of this article.

**Ethical approval** Ethical approval was obtained from the Human Research Ethics Committee at the University of the Witwatersrand (WITS) to study the data and X-rays of the individual orthopaedic practices with Clearance Certificate Nos. M1704111 and M1704112. All procedures performed in studies involving human participants were in accordance with the ethical standards of the above named institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

## Appendix. Synopsis of KOGS [22]

The grading system consists of four grades with treatment options to be implemented. Despite the specific grading achieved, there are clinical reasons which can influence the final decision for a particular prosthesis e.g. rheumatoid arthritis, clinically assessed disruption of ligaments, excessive deformities or patient-specific considerations or preferences. KOGS cannot be the only deciding factor.

Grade 1

Single TF or PF joint OA

Degeneration affects any one of the three compartments, with K&L grade 4 degeneration.

Grade 2

Single TF OA and 'pseudolaxity'

AP view subluxation, isolated K&L grade 4 wear defects cause AP translation without ligament instability (stress X-ray restoration of JLCA < 2°).

On average, above this line would be UKA and below TKA

Grade 3

A: Single TF OA with K&L grade 4 and concomitant ACL instability with sagittal translation.

B: Single TF OA with K&L grade 4 and severe PF joint pathology or patellectomy.

Grade 4

4 A: Both TF joints are K&L grade 3 or 4 (< 5 mm space) with ligament stability.

4 B: Both TF joints

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