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Research Article

Kneeling of the Normal Knee. A Prospective Study of Non-Arthritic Individuals Compared to Retrospective Cohorts of Unicompartmental and total Knee Arthroplasty Patients

MA Hassaballa*, AJ Porteous and JPH Tam

Bristol Knee Group, Winford Knee Research Unit, Avon Orthopaedic Centre, Southmead Hospital, Bristol, UK

***Corresponding Author:** MA Hassaballa, Winford Unit, Avon Orthopaedic Centre, Southmead Hospital, Bristol, UK.

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Abstract

Introduction: Although kneeling is an important function of the knee, there is no information available on kneeling ability in the normal elderly population. Our hypothesis is that kneeling ability achieved with current knee prostheses is worse than the average age-matched patient without clinical symptoms of knee arthritis.

Methods: The kneeling ability in a group of individuals aged over 60 years (n = 96) without any clinical evidence of arthritis was investigated. The range of motion of the knee joint was recorded. We assessed the ability to kneel on a chair at 90° (padded point kneeling), on the floor at 90° (hard point kneeling) and floor at 120° (deep flexion kneeling). Comparisons were made with data obtained from groups of patients who had undergone unicompartmental knee arthroplasty (UKA; n = 45) and total knee arthroplasty (TKA; n = 36). Linear Regression Analysis was used to assess if knee flexion was a predictor of subjective outcome (Oxford Knee Score). Subjective outcome was compared between the two arthroplasty groups.

Results: The mean knee flexion of the native knee with a mean age of 72 ± 7 was 131° ± 9°, significantly greater than patients with TKA = 105° ± 16° (p = 0.001). Patients with UKA flexed to a mean of 122° ± 13° which showed no statistical difference to native joints (p = 0.415), but this was greater than flexion in TKA (mean difference 15° p = 0.001). Deep flexion kneeling was possible in 83% of normal individuals, compared to <50% of patients in the surgical groups. Free flexion was a predictor for subjective outcome for both UKA (r = 0.409, p = 0.012) and TKA (r = 0.378, p = 0.002). OKS score was significantly greater in the UKA () vs TKA () group.

Conclusion: The data demonstrate a disparity between the kneeling ability of normal individuals over 60 years of age and knee arthroplasty patients. The flexion and kneeling ability of UKA patients was closer to normal, whereas TKA showed worse flexion and kneeling function. Furthermore, reduced flexion at the knee is a predictor of poor subjective outcome in surgical patients. These factors will need to be addressed in the future, as patients increasingly demand "normal" function from their knee arthroplasty.

Keywords: Kneeling; Non-Arthritic Native Knees; Total Knee Arthroplasty (TKA); Unicompartmental Knee Arthroplasty (UKA); Range of Motion

Introduction

The ability to kneel is important for many activities of daily living and certain occupations. Kneeling has also been shown to be an important intermediate position used by older individuals to enable them to rise from the floor [1]. The necessity of being able to adequately perform this task is not culture or gender specific; followers of many worldwide religions assume deep knee flexion as they kneel during prayer, people living in Far Eastern cultures use deep knee flexion during daily living activities like eating and socialising [2-5]. However, even if such specific activities are not required, the ability to kneel is beneficial worldwide during gardening, domestic activities and many manual occupations (e.g. plumbers, electricians/data cablers/floor and carpet fitters) [6].

Total knee arthroplasty (TKA) is the treatment of choice for patients with end-stage knee arthritis [7]. Whilst the main indication for TKA is pain relief, there is an ever-increasing expectation of good functional outcome, particularly amongst the younger, more active population [8]. Strikingly, in a USA population awaiting TKA, kneeling has been published as one of the most important activities required by those patients [9].

Kneeling is also a demanding function of the knee joint. Nagura., *et al.* [10] showed that compared with walking and stair climbing, there are greater net forces through the knee during the ascending and descending phases of kneeling. Conventional TKA is associated with a restricted range of movement (ROM) of the knee compared to a normal knee [11,12] and we have shown that there are greater forces through the patella when kneeling at 90° compared with 120° [13]. It is likely that current conventional TKA options that limit flexion at the knee are prohibitive to kneeling performance [14]. As well as the impedance to daily function, kneeling at a lower than optimal degree of flexion, or attempting flexion beyond the safe limit of a given prosthesis may lead to accelerated wear of the implant [15].

The aim of this study was to report the kneeling ability in elderly non-arthritic individuals and compare this to an age-matched group of knee arthroplasty patients; the primary hypothesis being that there was a difference in kneeling function between normal individuals and arthroplasty patients. Our secondary question was to investigate the relationship between knee kneeling function and patient-centred outcome.

Material and Methods

Ethics approval was granted for the study by the local trust's ethics committee. Normal healthy volunteers consented for the test.

A group of healthy volunteers who did not have osteoarthritis of the knee and two groups of patients (TKA or UKA) who had undergone arthroplasty for knee arthritis were included in this study.

Group 1: Non- osteoarthritic knees

The control group consisted of healthy volunteers with asymptomatic knees and no known osteoarthritic changes - referred to as the "normal" group.

One hundred elderly individuals (59 males and 41 females) were recruited for this study at random from the North Bristol area. The inclusion criteria were that they were aged over 60 years, lived within a 10 mile radius and had no clinical evidence of arthritis of the knee. The mean age was 72.4 ± 6.8 years.

Group 2: Total knee arthroplasty (TKA)

Thirty-six patients (23 males and 13 females) were included in this group. All TKA patients received the same prosthesis design (cruciate retaining Kinemax plus, fixed-bearing, Stryker, Limerick, Ireland). All patellae were resurfaced. The mean age was 76.12 ± 8.88 years.

Group 3: Unicompartmental knee arthroplasty (UKA)

Forty-five patients (44 males and 21 females) were included in this group. All UKA patients had medial unicompartmental replacement with the same fixed bearing all-polyethylene tibial implant (St. Georg Sled, Waldemar Link, Germany). The mean age was 70.9 ± 8.4 years.

Kneeling protocol

The kneeling protocol used has been previously reported by the authors [16]. Each subject and patient was asked "can you kneel" and the answers recorded as "yes" or "no". Each patient was examined and the range of movement (ROM) was recorded, as measured by two separate observers using a standardized 30cm goniometer. Hip range of movement was screened by clinical examination, assessing full ROM at the hip. Individuals with apparent limitations in any plane were recorded. The presence or absence of subjective pain in the knee or hip was also recorded. The subjects were asked about knee paraesthesia and their answers were recorded. Each patient was then asked to try to kneel, first at 90° on a standard chair with a seat height of 45 cm, then at 90° on a non-padded carpet mat on the floor, and finally at 120° on the same mat on the floor.

The role of the chair was to enable assessment of kneeling ability without the influence of confounding co-morbidities, which would have prevented some patients from getting down to the floor or getting up again. Those who found it difficult or uncomfortable to kneel on the chair were not asked to try to kneel on the floor and were considered unable to kneel.

Subjective outcome

Subjective outcome was assessed using the Oxford Knee Score (OKS) [17] in the UKA and TKA groups.

Statistical methods

The results of the normal kneeling group were compared with two groups of knee arthroplasty patients from our database whose kneeling ability has been reported previously [18] Chi-square or Fisher's exact test were used to determine uncorrected P-values for the qualitative data and corrections were made for multiple comparisons where appropriate. The knee range of movement data was examined by one-way ANOVA following transformation by squaring the values to meet the assumptions of the test. Differences between arthoplasty groups for Oxford Knee Score were determined using an independent t-test. Statistical significance was considered when a P-value was obtained of < 0.05. A linear regression analysis including flexion at the knee and OKS score in TKA and UKA patients was performed.

Results

Paraesthesia, joint pain and hip range of movement

Knee paraesthesia was found to be significantly lower (p = 0.002) in normal individuals compared to both the arthroplasty groups (Table 1). No differences were observed for knee or hip pain. There were no differences between the three groups in the proportions of individuals showing a decreased range of hip movement, which was only demonstrated in four normal individuals, three UKR patients and no TKR patients.

Variable	Normal		UKR		TKR		p-value
	Present	Absent	Present	Absent	Present	Absent	
Knee pain	4	96	3	42	3	33	0.744
Paraesthesia	1	99	8	37	6	30	0.002
Hip pain	4	96	3	42	0	36	0.229

Table 1: Comparison of the presence or absence of knee pain (Presumably during the study during kneeling - if not why are there 4 patients with knee pain in the 'normal' group - I don't know the answer to this!)- paraesthesia and hip pain in the 4 different groups of individuals.

Range of movement at the knee

Normal individuals had significantly greater knee flexion than both knee arthroplasty groups (p = 0.001 for both). The mean range of movement in the normal group was 131° ± 9°, compared with 122° ± 13° for the UKA and 105° ± 16° for the TKA groups. Flexion in the UKR group was significantly greater than that of the TKA group (p = 0.001). There were 7 patients in the UKA group who could not reach 0° extension (mean = 5° ± 3°) and 1 patient in the TKA group (20° of fixed flexion). All normal individuals were able to fully extend the knee. See table 1.

Kneeling ability

The proportion of normal individuals able to kneel at 120° was significantly greater than both surgical groups (82% versus UKA 53% p = 0.001 and TKA 33% p < 0.0001) (Table 2). There were no significant differences between groups for kneeling at 90 on the chair or on the floor.

Subjective outcome and linear regression

The OKS score for UKA patients (mean = 39 ± 10) was significantly higher than TKA (mean = 34 ± 8, p = 0.005). Linear regres-

Variable	Normal n = 100		UKR n = 45			TKR n = 36		
	Yes	No	Yes	No	p-value	Yes	No	p-value
	% (n)		% (n)			% (n)		
Chair kneeling	90 (90)	10 (10)	87 (39)	13 (6)	0.56	88 (32)	12 (4)	0.75
Floor kneeling 90°	82 (82)	18 (18)	84 (38)	16 (7)	1.00	75 (27)	25 (9)	0.32
Floor kneeling 120°	82 (82)	18 (18)	54 (24)	46 (21)	0.001	33 (12)	67 (24)	<0.0001

Table 2: Comparison of kneeling abilities between the different groups. P-values refer to comparison of each respective arthroplasty group with the normal group. Significant, p-values were corrected for multiple comparisons.

sion revealed a predictive relationship between flexion at the knee and subjective outcome score in both UKA (r = 0.409) and TKA (r = 0.369) groups.

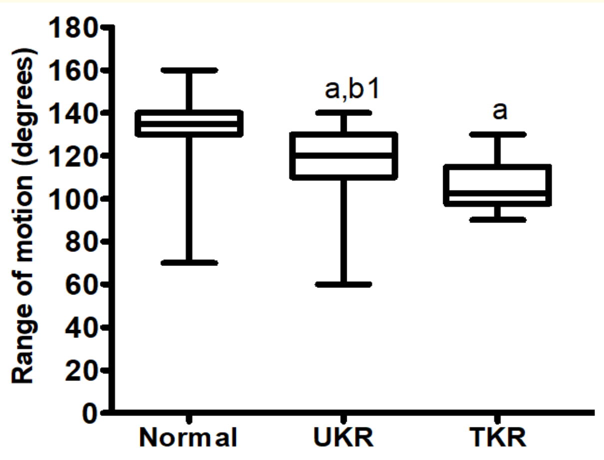

Figure 1: Box and whisper plot showing the range of KNEE movement in all four groups. a, p < 0.001 Normal vs UKR, Normal vs TKR, Normal vs PFR; b1, p<0.01 TKR vs UKR; b2, p<0.05 TKR vs PFR.

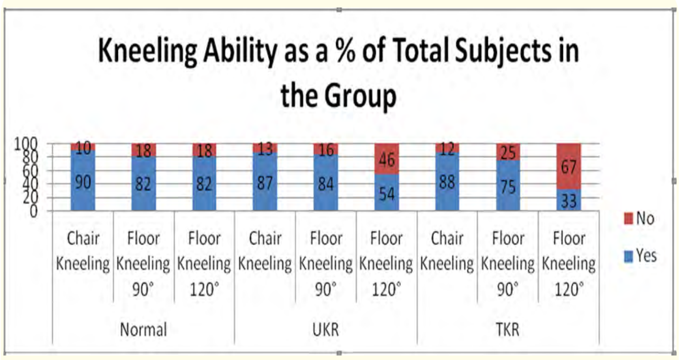

Figure 2: Bar chart showing the kneeling ability across all 3 groups.

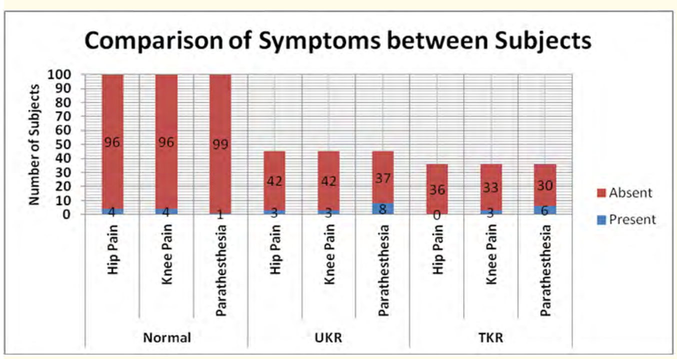

Figure 3: Bar chart showing the symptoms experienced across all 3 groups.

Discussion

We have demonstrated the kneeling ability of a group of normal individuals. Comparisons in kneeling ability were made between this group and patients who had undergone knee arthroplasty: only 18% of the individuals in the normal group could not kneel on the floor at 120° compared with 47% of the UKA and 67% of the TKA groups. The free active flexion of the knee in normal individuals was 131°, which was significantly greater than the mean 122° achieved by the UKA group, which in turn was significantly greater than the TKA group whose mean was 105°. Patient-centred outcome was significantly lower in the TKA group (34 ± 8) than the UKA group (39 ± 10, p = 0.005). Linear regression analyses revealed a weak predictive relationship between flexion of the knee and patient satisfaction for both the UKA groups (r = 0.409) and TKA (r = 0.205). We propose that the restricted knee function related to the reduced flexion of this cohort of cruciate-retained knee replacement may contribute to the lower subjective score.

Limitations of the study

Our study only has the scope for reporting empirical data on kneeling ability and knee flexion in normal versus arthoplasty groups. Therefore, any conclusions about knee function and its contribution to patient satisfaction is only speculative at this stage.

ROM and Kneeling ability

Flexion at the knee was greater, but not statistically different in normal knees (mean 131°) compared with UKA (mean 122°, p = 0.415) whereas cruciate-retained TKA showed a statistically lower flexion range (mean 105°, p = 0.001). These average flexion angles followed the trend for kneeling ability at 120°: normal>UKA>TKA. There was no difference in kneeling ability at 90° on the floor or on the chair between the groups (p = 0.75 and p = 0.32 respectively), as would be expected by the absence of any hip pathology in any group. Previous authors who have assessed the ROM at early follow up have found comparable results to our cohort. The published ROM for standard TKA at 1 - 2 years follows up in the literature ranges from 105° - 110° for mean values [19]. Previous data on UKA has reported ROM around 125° [20].

In terms of kneeling performance, our results support the findings of Noble., et al. in their comprehensive study comparing a wide range of self-reported functions in normal knees versus TKA, where they found that 63% of normal knees could kneel compared with 42% of TKA knees. They showed that as activity demand increased, the divide between the groups also increased; although the groups were comparable for activities such as walking and swimming, they became significantly different in their abilities to perform squatting or kneeling. Other authors have reported that compared with preoperative levels (i.e an osteoarthritic knee), kneeling ability was improved following TKA [21], although this was not assessed in our study.

Kneeling at >120° is a demanding and complex function which involves significant leg strength, as well as flexibility. Whilst we do not discount the contribution that ROM at the knee will have to kneeling, simply increasing knee flexion may carry its own set of problems; high-flexion knee arthroplasty is yet to be accepted as a superior alternative to the standard knee [22]. We have previously shown that when kneeling at 90°, almost 94% of the individual's body weight is transferred through the knees, as opposed to approximately 50% at full flexion. Nagura., *et al.* [10] were able to demonstrate that double-legged deep flexion was significantly more strenuous in terms of forces at the knee than walking and stair climbing, and showed that there is a high demand on the quadriceps and hamstrings during deep bending. Silva., *et al.* [23] assessed the muscle function following TKA when compared normal subjects at 2 years post-op. They found an approximately 30% decrease in both flexion and extension peak torque values in the TKA groups when compared to normal. Barker., *et al.* [24] also demonstrated a loss in lower limb power following UKR in comparison with predicted norms. They suggested that current rehabilitation protocols are not sufficient to overcome the effects of surgery on muscle strength. Jenkins., *et al.* [25] were able to demonstrate that rehabilitation protocols had a significant effect on kneeling ability, showing that TKA patients can acquire the skill required to kneel if adequately taught, highlighting the fact that technique as well as strength is required to kneel successfully. We speculate that relative muscle weakness and poor technique may be additional factors that affect kneeling ability in our cohort, which may be due to the effects of surgery itself or because of shortfalls in rehabilitation, although this was not assessed.

A number of participants in the normal group had limited kneeling ability. Hip ROM did not appear to be a contributing factor, with only four individuals from the normal group having an abnormal hip examination, and no marked change in kneeling ability at 90° on a chair or on the floor. Anecdotally, those who experienced difficulty (4 patients from the normal group) attributed this to discomfort over the front of their knees or difficulty in returning to standing. However, there was no significant difference in the prevalence of reported pain in the normal versus arthroplasty groups ($p = 0.744$). In further support of the hypothesis that quadriceps strength is an important factor in kneeling, weakness of the knee extensor mechanism is also associated with anterior knee pain. It is feasible that once again muscle strength may be the important contributing factor, rather than the pain itself.

To explain the differences between the arthroplasty groups and the normal group, we propose that in the normal knee, strength is greater, and flexion is increased compared to a prosthetic knee, hence kneeling performance is better in these individuals. There may of course be selection bias here, as the TKA group are likely to have more severe changes of joint failure preoperatively, including reduced flexion range, proprioception and muscle strength. It is well established that the strongest predictor for post-operative flexion is pre-operative flexion [26]. The UKA group compared better with the normal group, suggesting that strength as well as flexion may be better preserved following this procedure than with TKA.

Factors relating to patient-centred outcome

Patient-centred outcome was better in the UKA group than the TKA group (34 ± 8 vs 39 ± 10 in Oxford Knee Score, $p = 0.005$). In addition, we found that flexion at the knee was a predictor for patient-centred outcome for the UKA and TKA groups. The relationship was stronger in the UKA group.

Previously published mean satisfaction scores as determined by OKS for TKA range from 25 - 40 [27] and 22 - 39 [28] for UKA. Other authors have attempted to identify predictive factors for a good outcome following knee replacement. Baker., *et al.* [29] found that both pain and, to a lesser extent, function significantly influenced patient satisfaction scores. In our cohort there was no significant difference in reported pain between groups. Jenkins., *et al.* [30] found the single factor that predicted patient reported kneeling ability at 1 year postoperatively was the physical therapy received at 6 weeks after surgery. The patients had received kneeling advice and education as part of their postoperative rehabilitation programme. Komnik., *et al.* [31] found that function was the strongest predictor of a good outcome score in their cohort, and those with greater than 95° flexion had better scores than those with less than 95°. In addition, Brander., *et al.* [32] found that preoperative pain level and depression predicted poor scores on patient-reported outcome, particularly when looking at function subscales. The association between psychological status and patient-reported function is well documented [33,34].

Conclusion

The data presented here show that a disparity exists between the kneeling ability of normal individuals and patients who have undergone arthroplasty of the knee, specifically those undergoing cruciate-retained TKA. Surgeons offering CR-TKA should counsel their patients regarding the expected outcome in terms of functional limitation based on current literature, in order to provide realistic patient expectation.

We believe that whilst kneeling ability is multifactorial, flexion at the knee is clearly an important contributing factor. As long as a difference between arthroplasty patients and normal individuals exists, there will be a demand for refinements in surgical technique, arthroplasty design and rehabilitation protocols to maximise possible patient outcome, including kneeling ability.

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