

1 **Changes in patella tendon length over five years after different types of knee Arthroplasties**

Abstract

Purpose:

Post-operative shortening of the patellar tendon resulting in an abnormally low-lying patella has been described previously but the degree of change in patella tendon length over time and extent of its progression after different types of knee arthroplasties remains unknown. This study assesses the incidence of patella tendon length change following lateral unicompartmental knee arthroplasty (UKA), medial UKA and total knee arthroplasty (TKA), and its impact on patient-reported outcome at 5-years post-surgery.

Methods:

Immediate post-operative, one-year and five-year radiographs were reviewed for 50 patients undergoing each operation (n=150), with the Insall-Salvati ratio used as a measure of patella tendon length. Clinical outcome was assessed using the Oxford Knee Score (OKS).

Results:

At 5 year follow up no significant change in patella tendon length was found following medial UKA (1.07 to 1.05), whilst a significant shortening was found after TKA (1.02 to 0.96), and a significant lengthening found after lateral UKA (1.02 to 1.05). For the UKA groups no further change in tendon length was observed after the first year post-surgery whereas the TKA group continued to shorten between years one and five. OKS was significantly better in the UKA groups as compared to TKA group. Change in patella tendon length within individual groups did not correlate with OKS at 5 years.

Conclusion:

Patella tendon length shortening is more prevalent in TKAs whilst lengthening is more prevalent in lateral UKAs. Despite the vertical incision through the patella tendon, lateral UKAs do not cause increased tendon shortening at five years post-surgery. However, in the medium-term changes in patella tendon length do not affect patient-reported outcome.

Level of evidence:

Retrospective, comparative study, Level III.

Keywords:

Lateral unicompartmental knee arthroplasty

Patella tendon length

32	Domed lateral UKA
33	PTL
34	Insall-Salvati ratio
35	Total knee replacement
36	Total knee arthroplasty
37	Patella baja
38	Patella infera
39	Patella alta

Introduction

Patellar tendon shortening has previously been shown to be associated with TKA [7, 11, 13, 21], fractures about the knee [14], high tibial osteotomy[10], and anterior cruciate ligament (ACL) reconstruction [4]. An abnormally low-lying patella (patella infera), a direct result of significant patellar tendon shortening has been linked with patello-femoral pain[6], initial postoperative weakness of the extensor apparatus [21], and reduced functional scores following TKA[13].

Although patellar tendon shortening is widely recognised, its aetiology is not completely understood and its causation is likely to be multivariate [17, 21]. Noyes et al. described the development of patella infera as the result of ischaemic or traumatic injury sustained during surgery leading to a transient tendon shortening following peri-patellar and fat pad contractures and quadriceps weakness [17]. This is followed by joint stiffness due to associated arthrofibrosis, permanent shortening of the tendon, and eventual onset of patello-femoral arthrosis. Lemon et al support the idea that ischaemic injury contributes demonstrating that preserving the infra-patellar fat pad, and hence the blood supply, reduced patellar tendon shortening [12]. Other theories suggest that formation of new bone [18] or tethering of the tendon by intra-articular fibrous bands may be responsible [19]. Clinical studies have previously linked patella infera with patella-femoral pain [6], initial postoperative weakness of the extensor apparatus [21], and reduced functional scores following TKA [13].

It has been shown that TKA results in a significant shortening of the patellar tendon [9, 13, 21] and this shortening has also been shown to be greater than that observed following medial UKA [21]. It was postulated that this was due to the more extensive surgical exposure required to perform TKA compared with UKA and the longer rehabilitation associated with TKA. Previous studies comparing the patellar tendon length following medial UKA have caused some debate in the literature. Weale et al found no significant change in tendon length following medial UKA [21], while others have shown a significant change [16], or mixed results depending on the method of measurement [1, 15].

There has been much less data collected regarding the effect of lateral UKA on patellar tendon length. This may be of clinical importance, especially given the fact that the Oxford domed lateral UKA requires a vertical incision through the patellar tendon. This could potentially induce increased shortening as a result of increased scarring and damage to the tendon. Van Duren et al. concluded that there was no increased risk of patella infera at one year

with the Oxford domed lateral UKA [5]. Previous studies have shown that there is no further shortening beyond the first year with either TKA or medial UKA [11, 21]. No data is available at five years post-operatively for the lateral UKA so this study intends to analyse this.

The aims of this study are primarily to assess the incidence of change in the patellar tendon length following lateral UKA up to five years postoperatively, and to compare this with both medial UKA and TKA to conclude whether there is a significant difference in the length change between each operation. A further aim is to establish whether there is a correlation between the post-operative length of the patellar tendon and the functional outcome of patients.

Materials and Methods

This retrospective cohort study was performed using patients from the Nuffield Orthopaedic Centre, Oxford and the Royal Berkshire Hospital, Reading. Patients meeting the following inclusion criteria were selected sequentially from the operation databases at each hospital. There were no restrictions on age, gender or surgical experience. All patients were diagnosed with primary osteoarthritis and had significant symptoms necessitating surgical intervention. Patients received either a TKA, a medial UKA, or a lateral UKA. The decision regarding the type of knee arthroplasty was based on the severity and localization of osteoarthritis. Patients who required further surgery or Manipulation Under Anaesthetic within the 5 year follow up period were excluded from the study.

Fifty patients were included for each operation type, with complete radiographic and clinical assessment follow up available for each as seen in table 1.

All surgeries were performed using standard surgical technique under tourniquet using cemented components and all patients were offered uniform post-operative regime for pain control and physiotherapy. TKAs were performed using a midline incision, medial parapatellar approach and patella eversion while UKAs were carried out using minimally invasive parapatellar surgical incision without patella eversion. Patients undergoing medial UKA demonstrated bone-on-bone appearance in the affected medial compartment with a functionally intact ACL and lateral compartment. Patients undergoing lateral UKA demonstrated bone-on-bone appearance in the affected lateral compartment with a functionally intact ACL and medial compartment. Patients undergoing TKA usually had osteoarthritis affecting more than one compartment of the knee with or without intact ACL.

Patellar Tendon Length measurements

A set of lateral radiographic images were obtained for each patient containing both immediate post-operative and one and five year follow up post-operative images. The images were obtained digitally in DICOM format and subsequently converted to a tagged image file format (.TIFF) file. These were all templated using a custom designed user interface developed using Matlab in order to define the necessary anatomical landmarks. To overcome the obstacle presented by varying magnifications in the images, which may alter the length of the patellar tendon, it was decided to use the Insall-Salvati (IS) ratio [8] as a measure of change in the tendon length. This is the ratio between the length of the patella tendon (defined as the distance between distal point of the patella and the patella tendon insertion at the tibial tubercle) and the length of the patella (defined as the distance between the most proximal and most distal points of the patella). This ratio was used as it is simple to measure and well established. As the intention was to study the incidence and effect of specifically patellar tendon shortening the available measurement ratios were limited. Other widely used ratios such as Blackburne-Peel [2] and Caton-Deschamps [3] use the joint line as a reference point and as a result it is not possible to differentiate between true patella infera resulting from patellar tendon shortening and pseudo patella infera resulting from a raised joint line.

As reliably identifying the origin and insertion of the tendon can sometimes prove difficult, and because the shape of the patella may change due to surgical resurfacing and removal of osteophytes, the radiographs for each patient were measured consecutively such that the same anatomical landmarks on both the immediately post-operative and the follow up radiographs could be identified. All measurements were performed by a single observer with a random sample of 20 patients being measured by a separate observer such that inter-observer variability could be calculated. In addition to this, a separate sample of 20 radiographs was again measured by the initial observer at least 3 weeks after the initial measurements in order to calculate intra-observer variability. The observer was blinded to the clinical outcome although this was not possible with regards to operation procedure as the implant type is visible in the radiographs.

Previous publications have defined patella infera as a decrease of 10% in the length of the tendon and patella alta as an increase of 10% in the length of the tendon [1, 21]. A change in patellar tendon length of more than 10% was therefore considered significant in this study.

Clinical outcome

All patients were assessed prior to undergoing surgery as well as at one year and five years post-surgery during routine check-ups at the time of the follow up radiograph. The Oxford Knee Score (OKS) was used to quantify the clinical outcome during these assessments.

Statistical analysis

Shapiro Wilks tests showed that the data was not normally distributed and hence non-parametric tests were used. The Wilcoxon Rank sum test was used to analyse changes in the IS within groups at both follow up periods. The Wilcoxon Rank sum test was also used to compare OKS at these periods. A Mann-Whitney U test was used to compare the means of the OKS score between patients whose tendons had shortened by more than 10% and those that hadn't. Spearman's rank correlation coefficient was used to perform a correlation analysis between the IS and OKS of the complete dataset as well as within each operation group. Intra-class correlation coefficient was used in order to establish the reliability and repeatability of the IS results. The power of the study was retrospectively assessed using an Altman nomogram to calculate the required sample size based on our results. It was calculated that a sample size of 38 would be required to demonstrate a significant difference based on a power of 0.8 and a p value <0.05. Statistical significance was set at a value of $p < 0.05$. Statistical analysis was performed using PASW Statistics 18 (SPSS Inc., IBM 2010).

Results

Patellar tendon length change

As evident in table 2, there was no difference in mean IS ratio between the post-surgery and either one year or five year values for the medial UKA (1.07, 1.06, 1.05). In contrast both the lateral UKA and TKA had a significant change at five years post-operatively. The IS ratio of the lateral UKAs increased from 1.02 to 1.06 ($p < 0.05$) at one year, with no further change between one year and five years post-operatively. The IS ratio of the TKAs did not change in the first year post-operatively but decreased from 1.01 to 0.96 ($p < 0.05$) between one and five years post-operatively. The percentage of patients undergoing each operation type whose IS ratios changed by more than 10% can be seen in table 3. Intra-class correlation coefficient showed an inter-observer reliability of 0.925 and an intra-observer reliability of 0.965 (table 4).

Clinical outcomes

There was a significant improvement in OKS scores at one year and five years post-operatively as compared to the pre-operative scores for all operation types (table 5). Separating the knees into those that had shortened by more than 10% and those that had not (table 6) showed that when the dataset was analysed as a whole there was no difference between the groups either in the OKS at 5 years or the change in OKS between pre-operatively and five year follow up. When analysing the individual operation types, there was no difference with either the medial UKA or lateral UKA. With regards to TKA the knees that had shortened by more than 10% had a higher 5 year OKS than those that had not ($p=0.013$), although there was no difference in the change between pre-operative and five year follow up.

The correlation analysis did not find any significant correlation between percentage IS ratio change and OKS at final follow up when analysing the data as a whole. When analysed separately there was no significant correlation following either TKA or lateral UKA whilst the medial UKA showed a significant Spearman's correlation coefficient of 0.534. The Spearman's rank correlation coefficients are summarised in table 7.

Discussion

The most important finding of this study is that IUKA does not increase the likelihood of patellar tendon shortening up to five years post-operatively. The aim of the study was to assess the incidence and severity of patellar tendon shortening following TKA, medial UKA, and lateral UKA. Given the paucity of evidence in the literature we were particularly interested in whether the trans-patellar tendon incision used in the Oxford domed lateral UKA did increase the likelihood of patella infera.

In accordance with other reports in the literature, this study demonstrates a significant shortening of the patellar tendon at five years follow up following TKA, with 38% of knees shortened by more than 10% at this point. A randomised controlled study performed by Weale et al. found similar results, with 34.1% of their sample demonstrating a shortening of more than 10% following the same operation [21]. Koshino et al. also reported findings of this nature with 64.9% of their series demonstrating shortening of more than this amount [11]. Our results following medial UKA also correspond with previously published data. No significant change after medial UKA was noted, a finding which is again consistent with that of Weale et al. [21]. Further published data also reported that the IS ratio is not reduced following medial UKA [15] in agreement with our findings.

An interesting finding of this study is that significant lengthening of the patellar tendon in fact occurs following lateral UKA. Patellar tendon lengthening, which occurred in 24% of lateral UKA at 1 year post-operatively and 22% at five years post-operatively, has been previously shown to occur in 14% of knees undergoing medial UKA by Weale et al[21] and also by Tria et al. in 7% of knees undergoing ACL reconstruction[20]. More recently, work by van Duren et al. studied the change in patellar tendon length following domed lateral UKA at 1 year post-operatively. Their data demonstrated a higher proportion of patients showing greater than 10% lengthening as opposed to shortening, and also that the average absolute length of the patellar tendon was significantly increased[5]. The work of van Duren does not provide any data regarding the long-term effect of the operative procedure on the tendon length, and here it is demonstrated that at 5 years there is still significant lengthening of the tendon.

As yet, a complete explanation for the lengthening witnessed has not been found. One suggestion is that pre-operative pain and degeneration resulting from the degenerative processes lead to shortening of the tendon, and following surgery this is corrected as the function improves. This explanation may well be the case, although it does not demonstrate why lengthening would be significantly more frequent following lateral UKA as compared to medial UKA or TKA, which suggests the mechanisms are in fact more complex. Another possible explanation is the use of a vertical incision through the patellar tendon during the domed lateral UKA surgery which can induce scarring and weaken the tendon, thereby causing its lengthening. Again, this appears to be an incomplete explanation as it fails to explain reports of patella tendon shortening following trauma to the tendon during ACL reconstruction and none of our subjects complained of weakness in the knee post-surgery and no extension lag was demonstrated in any of the cases.

As previously stated, no difference was found between the clinical outcome of patients whose knees had shortened by more than 10% and those that had not. There was also no strong correlation found between changes in IS ratio and the OKS.

This present study does have certain limitations. Radiographs and patients were reviewed retrospectively providing a potential bias in the distribution of patients to each procedure type. Furthermore, similarly to the majority of studies previously published on the topic, distortion of the radiographs was uncorrected leading to the assumption that this has only a minimal effect. Another limitation to our study includes the lack of formal identification of an

appropriate degree of knee flexion, and thus load across the patella tendon, at the time of radiograph acquisition. This leads to a possible lack of consistency in the radiographs measured as we cannot guarantee that the tension in the tendon was always sufficient to ensure it was measured at its true length. A future adequately powered study with radiographs taken with patella tendon under tension will help answer these uncertainties. It may also have been beneficial to assess clinical outcome with a separate patellofemoral joint-specific score, which may have enabled more subtle clinical differences to be extracted.

Conclusion

In conclusion, medial or lateral UKA did not lead to significant shortening of the patellar tendon despite being evident after TKA. The vertical incision through the tendon required to perform the lateral UKA therefore does not induce significant shortening and in fact lengthening of the tendon was seen following this operation type. For the UKA groups no further change in tendon length was observed after the first year post-surgery whereas the TKA group continued to shorten between years one and five. Tendon shortening was not associated with reduction in the clinical scores within individual groups, however in general clinical outcome was inferior after TKA as compared to either medial or lateral UKA.

233 List of abbreviations

234 TKA – Total Knee Arthroplasty

235 UKA – Unicompartamental Knee Arthroplasty

236 ACL – Anterior Cruciate Ligament

237 IS – Insall Salvati

238 OKS – Oxford Knee Score

239

240 Competing interests

241 The author(s) declare that they have no competing interests

242

243 Author's contributions

244 GD performed the radiographic assessment, collated the data, drafter the manuscript. BvD developed the

245 software for radiographic assessment and provided mentoring and teaching regarding use of the software. MS

246 also performed the radiographic assessment. PGR and JM collected suitable patients and provided their

247 radiographs and clinical information. PM participated in the study design and coordination along with DM and

248 HP.

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294 **Figure legends:**

295 Figure 1: Illustration showing the points templated on the radiograph images. Distal pole of patella (DPP),
296 inferior pole of the patella (IPP), tibial tubercle (TT).

297 Figure 2: Mean percentage IS change for each operation type with time after operation.