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ORIGINAL PAPER

Patellar tendon shortening following patellofemoral joint replacement

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Abstract

Purpose Patellar tendon shortening may occur following patellofemoral joint replacement (PFJR). We hypothesized that patellar tendon shortening results in unfavourable patient-reported outcomes (PROs). The aim of this study was to determine the effect of patellar tendon shortening following PFJR on PROs.

Methods In this substudy of a prospective cohort study, a total of 108 patients with isolated patellofemoral osteoarthritis underwent 124 patellofemoral joint replacements. We measured both patellar tendon length and length of the patella on pre-operative radiographs, and on radiographs acquired at eight weeks and at one year post-operative. More than 10% decrease in patellar tendon length relative to the pre-operative patellar tendon length was defined as patellar tendon shortening. Clinical outcomes were assessed using the knee-specific KOOS questionnaire (Knee Injury and Osteoarthritis Outcome Score). Repeated measures ANOVA was used to analyze for differences in change from baseline KOOS subscales between patients with and patients without patellar tendon shortening.

Results A complete series of standardized pre-operative, eight weeks and one year post-operative radiographs was available for 87 knees in 82 patients. At eight weeks, 16 of 87 knees (18%) showed patellar tendon length shortening, and 27 of 87 knees (31%) at one year. We found no statistically significant relation between patellar tendon length shortening and change from baseline KOOS subscales at one year follow-up (pain $p = 0.29$, symptoms $p = 0.56$, ADL $p = 0.23$, sport or recreation $p = 0.22$, knee-related quality of life (QOL) $p = 0.15$).

Conclusions Patellar tendon length shortening following PFJR occurs in 31% of knees at one year, and does not result in inferior PROs.

Keywords Patellar tendon shortening · Patellofemoral joint replacement · Patient-reported outcomes · KOOS

Introduction

Patellar tendon shortening (PTS) is a recognized complication following knee replacement, high tibial osteotomy, fractures around the knee, and ACL surgery [1–3]. In total knee replacement, PTS occurs in a significant proportion of patients, ranging from 12 to 38% [3–6]. Some potential risk factors have been suggested, such as removal of Hoffa's fat pad [7, 8], formation of scar tissue secondary to peripatellar fat pad inflammation [9], post-operative weakness of the quadriceps muscle [1, 3], post-operative rehabilitation [10], and surgical technique including patellar eversion and lateral release [3, 4, 7].

PTS is less prevalent in medial unicompartmental knee replacement [3, 6]. One previous study reported on patellar tendon length in patients with patellofemoral joint replacement, and found that shortening occurs infrequently and less severely compared with total knee replacement [11].

In patients undergoing total knee replacement, PTS may result in adverse outcomes [3, 4], with diminished stair climbing ability and function scores [12]. It is however unclear whether PTS in patellofemoral joint replacement likewise results in unfavourable clinical outcomes.

The aim of this study was to determine the effect of PTS following patellofemoral joint replacement on patient-reported outcomes. We hypothesized that patellar tendon shortening does occur in patellofemoral joint replacement, and that it results in unfavourable patient-reported outcomes.

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Methods

Study design and study population

In this substudy of a prospective cohort study, a total of 108 consecutive patients with isolated patellofemoral osteoarthritis (PFOA) underwent 124 patellofemoral joint replacements at a single institution. All patients had Iwano stages III and IV isolated PFOA [13]. Patients with previous surgery or trauma involving the patella, patellar tendon, or proximal tibia, and patients with inadequate or incomplete sets of standardized pre-operative, eight weeks, and one year weight-bearing anteroposterior and lateral radiographs in 30° of flexion were excluded.

Surgical treatment

All surgeries were performed by one experienced orthopaedic surgeon between April 2010 and September 2015. We used the Zimmer Gender-Solutions® prosthesis (Zimmer, Warsaw, IN, USA) in 110 knees and the Journey® patellofemoral prosthesis (Smith and Nephew, Memphis, TN, USA) in 14. A pneumatic tourniquet was inflated to 300 mmHg while holding the knee in 90 to 110° of flexion. After a midline incision with a medial arthrotomy, the patella was everted. Hoffa's fat pad was not excised. However, some tissue directly adjacent to the patella was removed in order to accurately resect the patella. Femoral component rotation was assessed using a technique described previously [14]. Anatomical landmarks were used to optimally position the patellar component [15]. No lateral releases were performed. All patients received the same post-operative treatment with immediate post-operative weight-bearing with crutches. Weight-bearing anteroposterior and lateral radiographs in 30° of flexion were obtained at eight weeks and one year in accordance with a nationwide protocol.

Outcome assessment

All patients completed the Knee Injury and Osteoarthritis Outcome Score (KOOS) questionnaire both pre-operatively and at the one year post-operative visit [16]. The KOOS is a validated knee-specific score containing 42 questions that assesses five different outcomes: pain, symptoms, ADL, sport or recreation, and knee-related quality of life (QOL). The KOOS scale ranges from 0 to 100, with the latter being the highest possible result. The minimally important difference of the KOOS is 10 points [17].

Assessment of patellar tendon shortening

Commonly used patellar-height indices are not reliable indicators of patellar tendon length after partial or total knee replacement as the patella shape may have been altered by resurfacing the patella or the removal of osteophytes. We therefore used the technique described by others [6, 10, 11]. Two observers (LE and HJ) assessed PTS. We measured both patellar tendon length and length of the patella on the pre-operative radiographs, and on the radiographs acquired at eight weeks and at one year post-operative (Fig. 1). Simultaneous examination of sequential radiographs of each knee made it possible to identify the same bony landmarks on a series of radiographs. PTS at both eight weeks and one year was then calculated relative to the pre-operative patellar tendon length, thereby eliminating possible differences in magnification. One observer (LE) measured all radiographs two weeks later to assess intraobserver reliability. We stratified the amount of PTS into two groups: less than or equal to 10% shortening at one year and more than 10% shortening of the patellar tendon at one year post-operative. Although Insall and Salvati described patella infera as shortening of the patellar tendon by at least 20% relative to the length of the patella [18], more recent studies used 10% shortening in their definition of patella infera [6, 11].

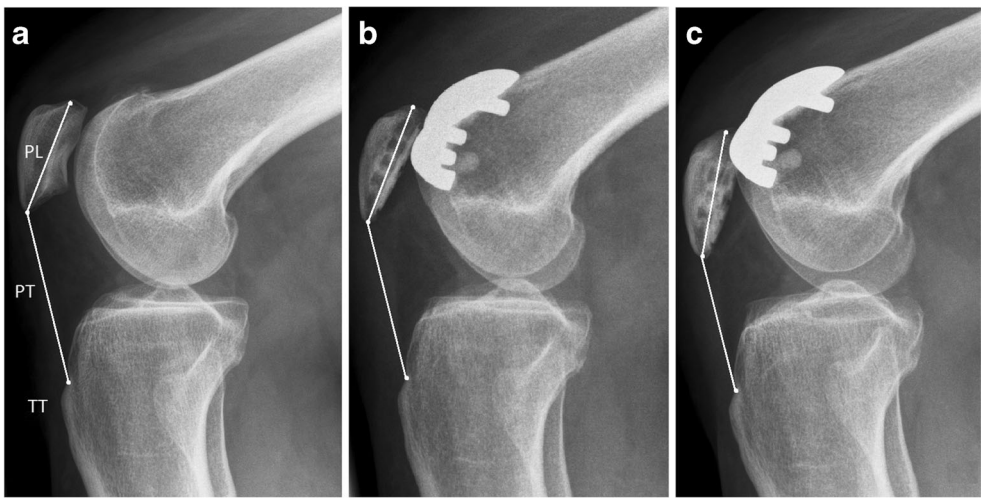

Fig. 1 Lateral radiographs of the knee demonstrating measurement of patellar length (PL) and patellar tendon length (PT) pre-operative (**a**), post-operative at 8 weeks (**b**), and at 1 year (**c**). Simultaneous examination made it possible to identify the same bony landmarks on sequential radiographs. Tibial tuberosity is shown at TT

Table 1 Patient characteristics. Continuous values are given as the mean with range in parentheses

Characteristic	
Number of knees	87
Side (right: left)	47: 40
Mean (range) age at surgery	50 (29–84) years
Sex (female: male)	66: 21
Mean (range) height	172 (148–200) cm
Mean (range) weight	83 (54–125) kg
Mean (range) body mass index	28 (20–41) kg/m^2

Statistical analysis

Baseline characteristics were analyzed by descriptive statistics using the mean and range for continuous variables and frequencies for categorical variables. The two-tailed paired *t* test was used to analyze for differences in pre-operative and post-operative KOOS subscales. We analyzed for differences in change from baseline KOOS subscales between patients with and patients without PTS at one year follow-up using repeated measures ANOVA. Intra- and interobserver reliability for the measurements at one year was assessed by calculating the intraclass correlation coefficient (ICC). The values were interpreted as described by Cicchetti [19]. A p value ≤ 0.05 was considered to indicate statistical significance.

Results

Review of the available radiographs showed that standardized pre-operative, eight weeks, and one year weight-bearing anteroposterior and lateral radiographs in 30° of flexion were available for 90 knees (85 patients). Three knees (3 patients) have had previous surgery involving the patellar tendon (transfer of the tibial tuberosity, ACL reconstruction) and were excluded, resulting in complete data for 87 knees in 82 patients. Mean time to follow-up was 1.1 years (range, 1 to 1.2 years).

The patient's demographic data are presented in Table 1. Clinical outcomes as assessed with the KOOS questionnaire showed a statistically significant ($p < 0.0001$) improvement at one year follow-up for each of the five subscales (Table 2). No complications were noted from the surgical procedure within the first year. The one year clinical and radiographic follow-up showed no signs of patellar instability, knee stiffness, or radiographic signs of patellar or femoral component loosening. No problems were reported with the KOOS questionnaire.

In 16 of 87 knees (18%) a patellar tendon length shortening of more than 10% was detected at eight weeks, and 27 of 87 knees (31%) showed more than 10% shortening at one year follow-up (Fig. 2).

We found no statistically significant correlation between patellar tendon length shortening and change from baseline KOOS subscales at one year follow-up (Table 3). Additionally, we found no statistically significant correlation between stair-climbing abilities in the KOOS questionnaire (P6, A1, and A2), and patellar tendon shortening.

The intra- and interobserver reliability for the patellar length measurements at one year was excellent with an ICC of respectively 0.85 (95% CI 0.78 to 0.90) and 0.80 (95% CI 0.71–0.87).

Discussion

The most important finding is that significant (more than 10%) PTS occurs in 31% of knees in the first year following PFJR. No relation was found between the amount of PTS and patient-reported outcomes as assessed with the KOOS questionnaire.

PTS is a well-documented phenomenon in total knee replacement [3–6, 8]. Some researchers reported patella infera, defined as 10% or more of shortening, in 34% of patients [3]. Using this same definition, others observed shortening in 38% of knees at five years follow-up following total knee replacement [6]. Similar results were reported in another paper with more than 10% decrease of the Insall-Salvati index in 28% of knees at one year post-operative [5]. Our study found a similar incidence (31%) of shortening at one year follow-up. One previous study evaluated patella tendon length after PFJR [11], and found that more than 10% shortening occurred in only 2.5% of knees at one year. This is in marked contrast to our findings, for which we have no satisfactory explanation.

One investigator postulated that the higher incidence of PTS in total knee replacement compared with medial

Table 2 Clinical outcome after patellofemoral joint replacement with pre-operative and 1-year post-operative clinical scores (standard deviation in parentheses)

	Preoperative	Postoperative	*p* value
KOOS pain	37.1 (15.5)	72.9 (20.2)	< 0.0001
KOOS symptoms	45.5 (15.1)	71.1 (15.4)	< 0.0001
KOOS function in daily living	38.1 (15.9)	72.8 (19.8)	< 0.0001
KOOS function in sport and recreation	10.2 (13.4)	39.8 (27.6)	< 0.0001
KOOS knee-related quality of life	21.0 (12.4)	54.6 (20.3)	< 0.0001

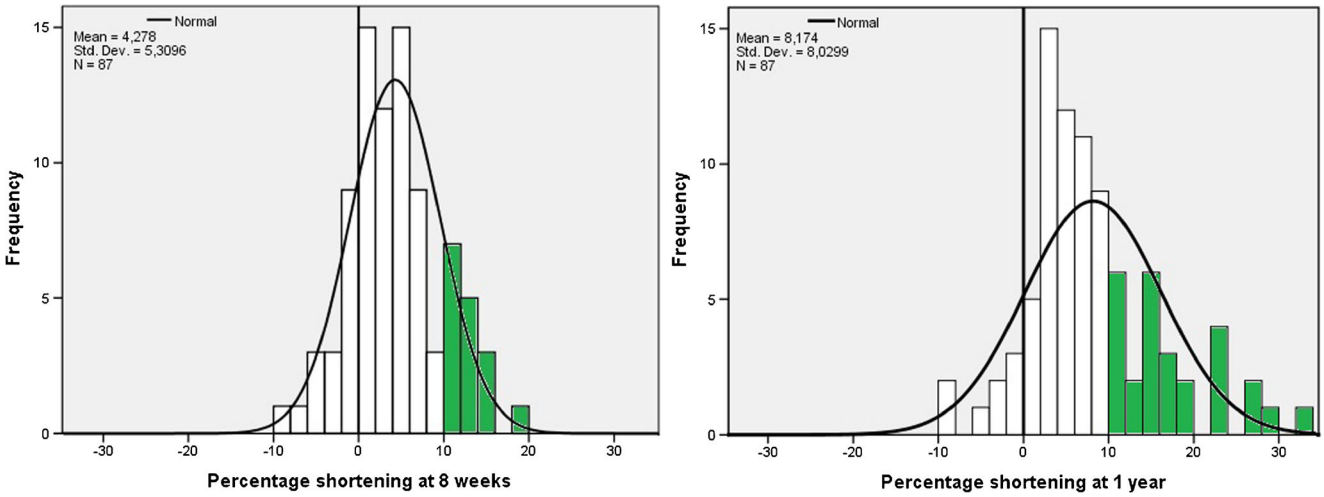

Fig. 2 Distribution of patellar tendon shortening at 8 weeks and 1-year post-operative with normal distribution from base (0). The colored bars represent the number of patients with more than 10% shortening at 8 weeks (16/87), and at 1 year post-operative (27/87)

unicompartmental knee replacement was due to the more extensive surgical procedure [3]. Since we found a similar incidence as in total knee replacement, our findings do not necessarily support this hypothesis, as PFJR is a significantly less extensive procedure. The most obvious difference between PFJR and medial unicompartmental replacement is that eversion of the patella is required to resect the patella in PFJR. A possible explanation for the observed differences is therefore the eversion of the patella. Indeed, the incidence of patella infera is lower following total knee replacement without patellar eversion [4]. Eversion of the patella possibly results in damage to the tendon with resulting inflammation and secondary scarring [4, 9, 20, 21]. Another factor that may damage the tendon is partial or total removal of Hoffa's fat pad [7, 8]. Some studies found a lower incidence of PTS in total knee replacement with partial excision of the fat pad compared with complete excision [7, 8]. In PFJR, resection of the fat pad is generally not performed. Another potentially contributing factor is the use of a tourniquet which may result in a post-tourniquet paralysis of the quadriceps muscle.

Some authors reported that PTS after total knee replacement is associated with adverse outcomes [3, 4], while others found no relation [6, 12, 22]. One previous study reported an association between PTS and diminished stair-climbing ability and function scores [12]. Following our initial analysis, we evaluated pain and difficulty with stair climbing in our study group. The KOOS questionnaire has three questions regarding the use of stairs: "What amount of knee pain have you experienced the last week during stair climbing?" (question P6), difficulty in "Descending stairs" (question A1), and "Ascending stairs" (question A2). We did not find a statistically significant correlation between the amount of PTS and these three questions.

The current study has certain limitations that should be noted. First, we examined sequential radiographs simultaneously to identify the same bony landmarks on a series of radiographs. It is possible that we measured a shorter post-operative length of the patella. This would have resulted in an underestimation of the PTS. Second, the number of patients with a complete set of standardized pre-operative,

Table 3 Mean change from baseline clinical scores in the group with > 10% patellar tendon shortening, and in the group with ≤ 10% of shortening (standard deviation in parentheses)

	> 10% patellar tendon shortening ($n = 27$)	≤ 10% patellar tendon shortening ($n = 60$)	p value
KOOS pain	32.3 (24.3)	37.6 (19.9)	0.29
KOOS symptoms	23.8 (19.9)	26.4 (18.7)	0.56
KOOS function in daily living	31.1 (23.0)	36.5 (17.6)	0.23
KOOS function in sport and recreation	30.4 (27.7)	29.2 (26.2)	0.22
KOOS knee-related quality of life	28.8 (22.4)	35.9 (19.7)	0.15
Question P6: pain stair climbing	1.4 (1.5)	1.6 (1.1)	0.59
Question A1: descending stairs	1.3 (1.2)	1.6 (1.1)	0.06
Question A2: ascending stairs	1.3 (1.4)	1.6 (1.2)	0.46

eight weeks and one year lateral radiographs was lower than anticipated. Our department is a tertiary referral centre for PFJR surgery, and we did not routinely acquire a new set of pre-operative standardized anteroposterior, lateral, and axial patellar radiographs. Furthermore, some patients preferred post-operative follow-up in a different hospital. And third, since we only used the one year follow-up data, it is possible that further changes in the patellar tendon length occur. Some authors noted further changes after the first year [6], while others found no further changes [3].

In conclusion, patellar tendon length shortening following PFJR occurs in 31% of knees at one year and does not result in inferior patient-reported outcomes.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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