Anterior knee pain following total knee replacement correlates with the OARSI score of the cartilage of the patella

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Submitted 13??-. Accepted 14-04-07

Background — Attempts to relate patellar cartilage involvement to anterior knee pain (AKP) have yielded conflicting results. We determined whether the condition of the cartilage of the patella at the time of knee replacement, as assessed by the OARSI score, correlates with postsurgical AKP.

Patients and methods — We prospectively studied 100 patients undergoing knee arthroplasty. At surgery, we photographed and biopsied the articular surface of the patella, leaving the patella unresurfaced. Following determination of the microscopic grade of the patellar cartilage lesion and the stage by analyzing the intraoperative photographs, we calculated the OARSI score. We interviewed the patients 1 year after knee arthroplasty using the HSS patella score for diagnosis of AKP.

Results — 57 of 95 patients examined had AKP. The average OARSI score of painless patients was 13 (6–20) and that of patients with AKP was 15 (6–20) (p = 0.04). Patients with OARSI scores of 13–24 had 50% higher risk of AKP (prevalence ratio = 1.5, 95% CI: 1.0–2.3) than patients with OARSI scores of 0–12.

Interpretation — The depth and extent of the cartilage lesion of the knee-cap should be considered when deciding between the various options for treatment of the patella during knee replacement.

Patellar cartilage degeneration may be one cause of anterior knee pain (AKP) following total knee replacement. However, so far, attempts to relate intraoperatively assessed patellar cartilage involvement to postsurgical AKP have yielded conflicting results (van Jonbergen et al. 2012). There have been studies both affirming (Picetti 3rd et al. 1990, Rodríguez-Merchán and Gómez-Cardero 2010) and refuting (Barrac et al. 1997, 2001, Wood et al. 2002, Burnett et al. 2004, Campbell et al. 2006, Pilling et al. 2012) a relationship between the state of the patellar cartilage at the time of arthroplasty and postoperative AKP. The original Outerbridge classification (Outerbridge 1961) and its modification by Beguin and Locker (1983) have been used in most studies for grading of cartilage degeneration.

Previous research of AKP has focused on the macroscopic cartilage changes. However, the disease process may be quite advanced at the histological level before any macroscopic changes become visible (Agha and Webb 2006, Bentley and Hill 2007).

To our knowledge, the relationship between histological changes in the cartilage of the patella at the time of arthroplasty and postsurgical AKP has not been investigated. The Osteoarthritis Research Society International (OARSI) has developed a system for grading of the cartilage pathology, which is based on combined assessment of the depth of the lesion and the extent of the arthritic changes over the joint surface (Pritzker et al. 2006). We hypothesized that there is a correlation between OARSI score and AKP following total knee replacement with unresurfaced patella.

The aims of the study were (1) to estimate the prevalence of AKP following total knee replacement with unresurfaced patella, and (2) to determine whether there is a correlation between the condition of the cartilage of the unresurfaced patella at the time of knee replacement, as assessed by the OARSI score, and postsurgical AKP.

Patients and methods

We prospectively included 100 consecutive patients suffering from osteoarthritis and undergoing total knee replacement. The patients were operated by one surgeon (VM) in East-Tallinn Central Hospital between January 2011 and May 2012.

We inserted all implants through a standard medial parapatellar approach and cemented to bone. The patella was handled in a standardized way. We left the patella unresurfaced and

DOI 10.3109/17453674.2014.931198

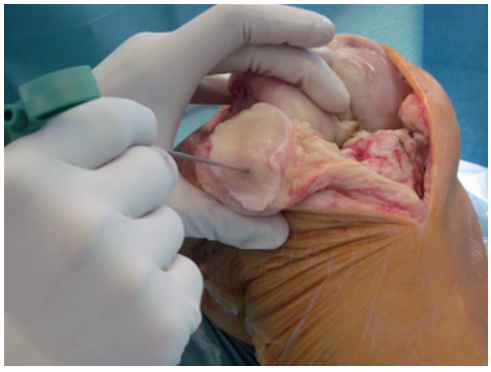

Figure 1. Obtaining the biopsy of the patella.

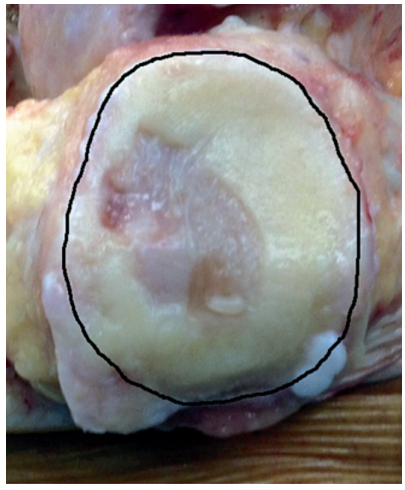

Figure 2. Delineation of the perimeter of the articular surface of the patella.

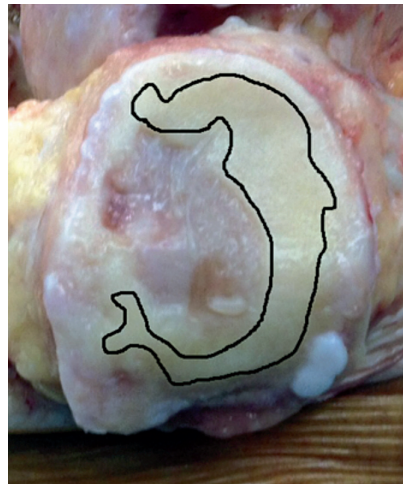

Figure 3. Marking of the normal cartilage of the patella.

resected only its osteophytes together with Hoffa's fat pad. We did not perform patellar rim electrocautery, but removed the synovial tissue around the margins of the patella. All patients received the Johnson and Johnson PFC Sigma posterior-stabilized (PS) mobile bearing implant. We aimed to place the femoral component parallel to the epicondylar axis and perpendicular to the Whiteside line.

Following eversion of the patella and before removal of the osteophytes, the operating surgeon evaluated the macroscopic impairment of the patellar cartilage according to the original Outerbridge classification (Outerbridge 1961): grade 1, softening and swelling of the cartilage; grade 2, fragmentation and fissuring in an area 13 mm or less in diameter; grade 3, fragmentation and fissuring in an area more than 13 mm in diameter; grade 4, erosion of cartilage down to bone. Intraoperative grading of the cartilage defects of the patella was necessary for location of the most damaged area in order to obtain the biopsy.

An operating theater nurse, specially trained in intraoperative photography, took pictures of the articular surface of the everted patella. The operating surgeon took 1 biopsy of the patella from the macroscopically most advanced area of chondromalacia, as assessed by the Outerbridge classification, using a 10G bone-biopsy kit (Figure 1). We excluded osteophytes from sampling.

The procedure resulted in a cylinder of 1.5 mm in diameter and 10–15 mm in length, extending from the articular surface of the patella to the subchondral bone. The tissue specimens were placed in a receptacle filled with 10% buffered formalin. In the laboratory, the histology technician applied the samples to a decalcifying solution for 30 min and then washed the samples in water for 15 min. We used conventional tissue processing and embedded the samples in paraffin blocks. 4-µm-thick serial sections were mounted on glass slides and stained with hematoxylin and eosin.

We evaluated the condition of the cartilage of the patella using the OARSI osteoarthritis cartilage histopathology assessment system (Pritzker et al. 2006), which includes 3 variables: the stage, the grade, and the score.

The stage is the horizontal extent of the lesion over the cartilage surface irrespective of the underlying grade. Surgeon VM measured the extent of the loss of surface integrity of the patellar cartilage on photographs taken intraoperatively, distinguishing normal cartilage from impaired cartilage using the original Outerbridge classification (Outerbridge 1961). We analyzed the photographs using Adobe Photoshop CS5 Extended software and its lasso tool functionality. The lasso tool enables selection of an irregular portion of an image and also counting of the pixels of the marked area. First, we delineated the imaginary perimeter of the articular surface of the patella as it would look after resecting the osteophytes. We excluded the osteophytes outside the perimeter from the analysis, and classified the osteophytes inside the perimeter as Outerbridge grade 4 chondromalacia (Figure 2). Second, we marked the area of normal cartilage (Figure 3). We added together discontinuous areas of undamaged cartilage if present. We considered areas with grades worse than Outerbridge grade 1 to be a lesion. We then recorded the numbers of pixels in the 2 delineated areas and calculated the percentage of the damaged articular surface area of the patella as follows:

$$100 - (\text{pixels of normal cartilage} / \text{pixels of perimeter} \times 100)$$

We categorized the extent of the cartilage involvement into 5 OARSI stages: stage 0, no involvement; stage 1, < 10%; stage 2, 10–25%; stage 3, 25–50%; stage 4, > 50%.

6 grades depict the histological progression of the lesion into the depth of the cartilage from intact cartilage morphology to subchondral bone remodeling. A pathologist, blind as to the patient's clinical information and the OARSI stage of the articular cartilage, performed the light-microscopic exami-

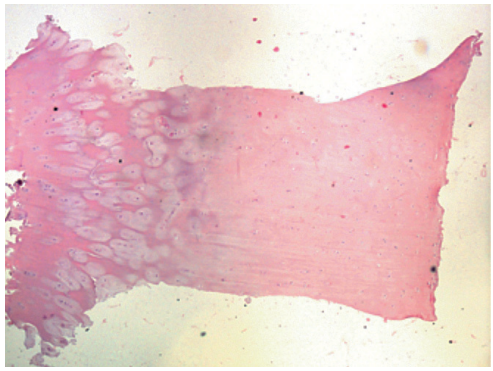

Figure 4. OARSI grade 2.

nation. The pathologist assigned the grade to all samples. A specimen of grade 1 had to have intact cartilage surface, grade 2 (Figure 4) denoted cartilage surface discontinuity, grade 3 vertical fissuring, grade 4 cartilage erosions, and grade 5 bone denudation. The biopsies were not informative enough to differentiate between grades 5 and 6, so all biopsies with denuded bone and reparative tissue were classified as grade 5. We did not use subgrading.

The OARSI score combines the grade with the stage of the cartilage lesion and it is calculated by using the formula: score = grade × stage. The score ranges from 0 to 24, with higher values indicating more advanced cartilage injury.

The same surgeon who performed the arthroplasties (VM) also reviewed the patients in the outpatient clinic 1 year after the knee replacement. At follow-up, we discriminated patients with AKP from symptomless ones using the HSS patella score (Baldini et al. 2006). This is a physician-administered multi-item questionnaire rating subjective and objective aspects of patellofemoral function on a scale from 0 to 100, with higher values indicating a better result. 2 items of the HSS questionnaire directly concern AKP: pain in the front part of the knee while rising from a low chair and tenderness to palpation of the medial or lateral facets of the patella. We diagnosed AKP if at least 1 of these 2 tests was painful.

All patients also underwent radiographic evaluation of the knee joint in AP and lateral projections to exclude periprosthetic osteolysis as a potential source of pain. We used Merchant patellofemoral axial views to determine whether patellofemoral malalignment had any correlation with AKP. Patellar shift index (PSI) (Metsna et al. 2013) was the measure of patellofemoral congruence in our study.

Statistics

We used descriptive statistics including mean, standard deviation (SD), and range for continuous variables. We give percentages and absolute frequencies for categorical variables. We used the Student's t-test to determine whether the OARSI score of painless patients differed significantly from the OARSI score of patients experiencing postsurgical AKP, and for the comparison of PSI. We assessed the relationship between Outerbridge grade-4 cartilage defects and AKP using the Spearman correlation coefficient. We divided the patients into 2 groups based on the OARSI score and analyzed the difference in AKP prevalence between these groups by calculating the prevalence ratio (PR) together with 95% confidence intervals (CIs) using the Poisson regression with robust variance. We considered the differences to be statistically significant if p-values were less than 0.05. The data were analyzed with Stata 9 software.

Ethics

We obtained approval for the study from the Tallinn Medical Research Ethics Committee (no. 2230, 20.12.2010) and the East-Tallinn Central Hospital Medical Review Board. All the patients signed an informed consent document.

Results

95 of the 100 patients were available for follow-up 1 year after surgery. 2 patients died for reasons unrelated to TKA, 1 patient was revised due to infection, and 2 patients withdrew their consent. Mean age was 66 (45–79) years for the 15 male patients and 69 (49–87) years for the 80 female patients. 38 of the patients reviewed were symptomless and 57 had pain in the front part of the knee. Of these 57 patients, 3 had AKP when rising from a low chair, 38 had pain on palpation of the patella, and in 16 cases the patients experienced pain in both tests.

We classified the extent of the damage of the surface area of the cartilage as OARSI stage 3 in 7 patellas and stage 4 in 88 patellas.

Histological assessment of the biopsies of the patella revealed the following OARSI grades: grade 2 in 13 knees, grade 3 in 19 knees, grade 4 in 47 knees, and grade 5 in 11 knees. Due to shortfall in histological processing of the biopsies, we were unable to determine the histological grade of cartilage impairment in 5 patellas.

The mean OARSI score was 14 (6–20) (SD 3.8). Due to the missing histological grades of 5 patients, we only managed to calculate scores for 90 patellas, 36 of which were painless and 54 of which gave AKP. The mean OARSI score of painless patients was 13 (6–20) and that of patients with AKP was 15 (6–20). The difference was statistically significant ($p = 0.04$). Macroscopic Outerbridge grade-4 cartilage defects did not correlate with postsurgical AKP (Spearman $\rho = 0.1$; $p = 0.5$).

We estimated AKP in 2 groups of patients according to the OARSI score. The first group had scores from 0 to 12 and the second group had scores from 13 to 24 (Table). The second group of patients had a 50% higher risk of AKP, with borderline significance (PR = 1.5, CI: 1.0–2.3).

Assessment of the conventional radiographs did not reveal periprosthetic osteolysis in any of the operated knees. The patellofemoral congruence in axial radiographs measured by

Anterior knee pain (AKP) status and OARSI score

	OARSI 0–12 n	OARSI 13–24 n
No AKP	18	18
AKP	15	39
Total	33	57

the PSI method was similar in the symptomless patients and in those who had painful knees.

Discussion

The 2 most important findings of our study are the 60% prevalence of AKP following posterior-stabilized total knee replacement with unresurfaced patella and the higher risk of AKP in patients with further impaired cartilage of the patella, as expressed by the OARSI score. Although the lower limit of the confidence interval of the prevalence ratio (1.0) was at the borderline-significance level, we conclude that there is probably an effect of the patellar cartilage on postsurgical AKP.

Clinicians should inform patients undergoing total knee replacement with posterior-stabilized implant and unresurfaced patella about the high probability of experiencing pain in the front part of the knee after the surgery. We found that the more impaired the cartilage of the patella, the greater was the incidence of postsurgical AKP. Unfortunately, we cannot suggest an algorithm for handling of the patella based on the intraoperative condition of the cartilage, as it is impossible to carry out histological grading of the patellar cartilage for calculation of the OARSI score during the knee replacement.

AKP is a much discussed topic, but at the same time it is not unambiguously defined. Diagnosing AKP with patient-administered questionnaires only provides data about patients' subjective perceptions about their knee; patient interviews supplemented with patella-specific questions and manual tests, such as palpation of the patella, detect both subjective and objective information. Studies relying only on patients' subjective symptoms usually report lower rates of AKP (Burnett et al. 2007, Epinette and Manley 2008, Smith et al. 2008) than studies using both subjective and objective data (Baldini et al. 2006, Campbell et al. 2006). We diagnosed AKP using the HSS patella score, containing patella-specific and manual tests, which is perhaps the reason for the high prevalence of pain in the front part of the knee (60%)—compared to previous reports of 13–50% (Baldini et al. 2006, Campbell et al. 2006, He et al. 2011, Li et al. 2011, Meftah et al. 2011, Pilling et al 2012).

The optimal follow-up period for AKP studies is difficult to determine. There is evidence that AKP may decrease almost 3-fold 10 years after knee replacement compared to the 1-year follow-up (Meftah et al. 2011). However, a meta-analysis suggests that the relationship between AKP and time of assessment is inconclusive (van Jonbergen et al. 2012). We believe that the follow-up of 1 year is suitable for the assessment of the correlation between the status of the cartilage of the patella at the time of knee replacement and postsurgical AKP. By this time, the pain caused by the surgical trauma has settled and the condition of the cartilage of the patella resembles the situation recorded at surgery more closely than after a longer follow-up period. Furthermore, it is difficult to relate the state of the cartilage of the patella recorded at surgery to subjective symptoms at medium- or long-term follow-up, because degeneration of the cartilage of the patella may occur already shortly after total knee arthroplasty (Kumahashi et al. 2013).

Although observer-dependent and subjective, the OARSI scoring system combined with photographic assessment is a reliable way of grading cartilage changes (Han et al. 2005, Pearson et al. 2011, Pauli et al. 2012). The advantage of the OARSI score lies in the complex morphological analysis of the cartilage, integrating the extent and the severity of the disease into one variable—an overall score (Pauli et al. 2012). The cartilage lesion may cover different histological grades: lower at the periphery and more pronounced at the center. We took the biopsy from the most damaged cartilage area, as assessed macroscopically. In this way, only the histological grade of the most damaged cartilage area is used for calculation of the OARSI score, which biases the assessment towards more advanced arthritis (Pritzker et al. 2006).

Photographic cartilage assessment is comparable to the situation experienced at surgery, with the exception of the absence of tactile feedback. We had 2 tasks when assessing the photographs of the articular surface of the patella: to mark the area of normal cartilage and to delineate the presumptive boundary line of the patellar articular surface as it would look after resecting the osteophytes. The original Outerbridge classification was a suitable tool for discrimination between normal cartilage (grade 1) and damaged cartilage (grades 2–4), as the signs of cartilage damage from fissures to subchondral bone exposure were clearly seen on the photographs. The study protocol did not allow distinguishing between Outerbridge grades 2, 3, and 4. The marking of the virtual resection line of the patellar osteophytes on the photographs resembles the situation experienced at surgery, and is therefore not difficult for surgeons accustomed to total knee replacements. To date, conclusions regarding any correlation between the state of the cartilage of the patella at the time of arthroplasty and postsurgical AKP have been drawn based on macroscopic evaluation. Visual assessment does not estimate the depth of the lesion adequately (Acebes et al. 2009), as microscopic indicators of cartilage degeneration usually precede the macroscopic degradation of the articular surface (Bentley and Hill 2007). In contrast to Rodríguez-Merchán and Gómez-Cardero (2010), we did not find an association between Outerbridge grade-4 defects and postsurgical AKP. Histopathological assessment

is the most precise way of evaluating the internal architecture of the cartilage, and the current study has shown its correlation with postsurgical AKP.

Pain in the front part of the knee may be evoked by multiple causes, and impairment of the cartilage of the patella is only one of them. We assessed conventional radiographs and excluded periprosthetic osteolysis as a confounder in the current study. The statistically insignificant difference in the measurements of patellofemoral congruence between the symptomatic group and the painless group of patients supports previously published research (Baldini et al. 2007, Wilson 2007). We would like to emphasize that we used a standard Merchant view. The hospital routine did not allow us to capture patellofemoral axial weight-bearing views, which have been shown to correlate with AKP (Baldini et al. 2007).

Our study had some limitations. The study protocol did not cover elimination of such confounders as patella baja, knee instability, component malposition, and infection. As the methodology of the cartilage assessment was subjective and observer-dependent, we may have mis-estimated the reliability of staging and histological grading. The 10% dropout rate in patients regarding histological analysis may have caused selection bias.

In summary, we found a 60% prevalence of AKP at short-term follow-up of total knee replacement with posterior-stabilized mobile bearing implant and unresurfaced patella. We found a correlation between the impairment of the cartilage of the patella, as assessed by combining the histological severity of the disease with the macroscopic severity, and postsurgical AKP. Patients with higher patellar OARSI scores had a higher risk of experiencing AKP after total knee replacement.

VM designed the study, performed the arthroplasties, collected data, and wrote the first draft of the manuscript. SV supervised the data collection and planned and performed the data analysis. KL supervised the work of the histology technicians in the pathology lab and microscopically examined the histological sections of the biopsies of the patella. AM designed the study and assisted in interpreting the results. All the authors contributed to revision of the manuscript and approved the final version.

The study was supported by the East-Tallinn Central Hospital and the Seventh EU RTD Framework Program (project no. 602398 HypOrth.).

No competing interests declared.

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