Correlation of the condition of the patellar articular cartilage and patellofemoral symptoms and function in osteoarthritic patients undergoing total knee arthroplasty

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We sought to determine the degree of correlation between the condition of the patellar articular cartilage and patellofemoral symptoms and function in osteoarthritic patients undergoing total knee arthroplasty. The depth of the osteoarthritic lesion, as graded by the Outerbridge classification and its size and location were assessed to determine the condition of the patellar cartilage in 80 consecutive osteoarthritic knees undergoing total knee arthroplasty. The association between the condition of the cartilage and patellofemoral symptoms and function was investigated by correlation analysis.

The depth and size of the lesion had a significant but weak correlation with anterior knee pain ($r = -0.300$ and -0.289 ; $p = 0.007$ and 0.009 , respectively), whereas location had no significant association ($p > 0.05$). None had a significant association with patellofemoral functional parameters (chair-rising, stair-climbing, and quadriceps power) ($p > 0.05$).

Our study indicates that patellofemoral symptoms and function are not completely determined by the condition of the cartilage. Caution should be taken when the symptoms and functional limitations are attributed to a lesion in the patellofemoral joint in making a decision regarding patellar resurfacing in total knee arthroplasty.

Controversy remains as to whether or not to resurface the patella in total knee arthroplasty (TKA).¹⁻³ One strategy is to resurface the patella selectively based on several relevant factors and the condition of the patellar articular cartilage as assessed intra-operatively.⁴⁻⁸ This is based on the assumption that a lesion of the patellar cartilage contributes to patellofemoral symptoms and function in osteoarthritic patients. Previously, arthroscopic findings of the patellar cartilage have been found to correlate poorly with patellofemoral symptoms⁹ and there is little information on the relationship of the condition of the patellar cartilage to patellofemoral symptoms and function in patients with osteoarthritic knees warranting arthroplasty. Our aim therefore was to determine the degree of correlation between the condition of the patellar articular cartilage and patellofemoral symptoms and function in patients undergoing TKA.

Patients and Methods

We evaluated 87 knees in 58 consecutive patients who had underwent TKA for osteoarthritis. All the operations were performed by a single surgeon (TKK) between November 2003 and April 2004. Seven knees with a different diagnosis from osteoarthritis were ex-

cluded: five knees and three patients with rheumatoid arthritis, one with neuropathic arthropathy and one with post-infectious arthritis. Thus, we included 80 knees in 53 patients with the diagnosis of osteoarthritis. The mean age of the patients was 69 years (55 to 83) and 51 were female. Our study was approved by the institutional review board of the hospital.

Evaluation of patellofemoral symptoms and functions. We used the patellofemoral scoring system of Feller, Bartlett and Lang.¹⁰ This gives more points for less pain and better function, and allocates 15 points for anterior knee pain and 5 points each for: quadriceps strength, ability to rise from a chair and stair-climbing. The total score can range from 3 to 30 points.

An independent investigator (YGK) evaluated the patellofemoral symptoms and function in all patients before operation. In an effort to make the evaluation accurate and reliable, we provided the investigator with detailed guidelines for the collection of data as follows. The severity of anterior knee pain was graded as none (15 points), mild (10 points), moderate (5 points), and severe (0 points). Quadriceps strength was graded as good when complete movement was possible against maximal resistance (5 points); fair when it was pos-

sible against some resistance (3 points) and poor when it was less than that of fair (1 point). If able to rise from a chair with ease without using arms, the patient was graded as good (5 points); if able to rise with ease by using arms as fair (3 points) and if rising with difficulty as poor (1 point). If the patient was unable to rise from a chair no points were given. They were asked about how they climbed stairs and graded as follows; excellent (5 points) when they managed with hands-free reciprocating gait; good (4 points) when they reciprocated but required a hand rail; fair (3 points) when non-reciprocating without any support; and poor (2 points) when non-reciprocating and requiring support.

Assessment of the condition of the patellar articular cartilage. Photographs of the patellar articular cartilage were taken intra-operatively to test the intra- and inter-observer reliability of its gross assessment. The photographs were taken in the operating theatre as the patella was everted using a routine medial parapatellar arthrotomy. The angle of the camera was set perpendicular to the articular surface of the patella so that the articular surface could be visualised without distortion of the image. The centre of the patella was used as the point of focus for each photograph. Any blood or debris on the surface of the patella was removed to improve visualisation before taking the photographs. Two exposures were taken of each patella to ensure the quality of the photographs. The same digital camera (Sony Cybershot DSC-585, 4.1 megapixels; Sony, Tokyo, Japan) was used to take all the photographs with a resolution of 2400 x 1800 pixels, by the same investigator who had been trained in taking intra-operative photographs.

The patellar cartilage was assessed by the depth, size, and location of lesions. Depth was determined using the Outerbridge classification.¹¹ The three observers reached a consensus on the application of the grading system after studying five sets of photographs. Grading was as follows: 1, normal cartilage or softening and swelling of the cartilage; 2, a partial-thickness defect which did not reach the subchondral bone and was less than 1.3 cm in diameter; 3, a partial-thickness defect which did not reach the subchondral bone and was more than 1.3 cm in diameter; and 4, exposed subchondral bone and visible reactive tissue formation. When lesions of more than one size were present those more severe than Outerbridge grade 1 were used to determine the category.

When there were multiple lesions of different grades of the Outerbridge classification the sizes of the lesions were added up. The size of the lesion was classified into four grades according to the proportion of the lesion on the total surface of the cartilage as follows: grade 1, less than 25%; grade 2, between 25% and 50%; grade 3, between 50% and 75%; and grade 4, more than 75%.

The location of the lesion was classified according to the involvement of the medial facet, lateral facet, and the central ridge. The lesion was defined as the area with grades worse than Outerbridge grade 1. This classification gave

seven types of lesion: type 1, no or a minimal lesion; type 2, a medial facet lesion without involvement of the ridge; type 3, a lateral facet lesion without involvement of the ridge; type 4, a lesion involving the ridge only; type 5, a medial facet lesion with involvement of the ridge; type 6, a lateral facet lesion with involvement of the ridge; and type 7, a global lesion.

Validation of the photographic assessment was performed on a separate group of 30 knees comparing the photographs and intra-operative findings. The Outerbridge classification was applied independently by two of the three examiners blinded to the clinical information. The photographs were taken intra-operatively with the same protocol used in the initial examination and examined by the two examiners after an interval of three weeks. The intra-observer reliabilities between the intra-operative assessment and the photographs produced kappa coefficients of the two examiners for the assessments of size, depth and location of 0.82, 0.76 and 0.72, respectively. This degree of agreement (substantial to almost perfect) verified the validity of the assessment using the photographs in evaluating the condition of the cartilage.¹²

Additionally, three orthopaedic surgeons (IH, CBC, TKK) independently examined the photographs without any knowledge of the patient. A second viewing was held after an interval of three weeks with the photographs presented in a different order and given new identification numbers. The examiners were blinded to the results of previous assessment. The senior examiner (examiner A; TKK) had 12 years of clinical experience as an orthopaedic surgeon and the other two (examiners B and C; IH, CBC) had five and four years of experience, respectively.

Intra- and interobserver reliabilities of the assessment of the condition of the cartilage from the photographs were also evaluated using kappa statistics. The percentage of agreement between the examinations was also calculated. The mean intra- and interobserver reliabilities were moderate to substantial for all aspects of the grading of the lesion using the Outerbridge classification as follows: depth, $k = 0.77$ and 0.54 , respectively,¹² size, $k = 0.71$ and 0.58 , respectively and location, $k = 0.70$ and 0.45 , respectively. The mean percentages of inter- and the intra-observer agreement for the Outerbridge classification and the grading of the size of the lesion were 88%, 73% and 78%, 58%, respectively. The mean percentages of inter- and intra-observer agreement for determining the location of the lesion were 66% and 77%.

Statistical analysis. Correlations of the depth, size and location of the lesion with patellofemoral symptoms and function were determined using Spearman's correlation coefficient. In the analysis, the intra-observer reliabilities of first and second sessions of assessment of the patellar cartilage were compared and the results of the session with a higher interobserver reliability were used in the analysis. The results of the three observers were compared and the grades (for depth and size) or types (for location) which

Table I. Details (mean; SD) of the 53 patients (80 knees)

Age (yrs)	69.4 (6.7)
Female/male*	76/4
Height (cm)	152.7 (5.4)
Weight (kg)	62.1 (9.8)
BMI (kg/m ²)	26.6 (4.1)
Radiological data	
Tibiofemoral angle (varus °)	5.5 (5.7)
Severity of tibiofemoral osteoarthritis (Ahlback score) ¹³	5.2 (1.4)

* the data are given as the number of knees

were agreed by more than two observers were used in the analysis. In the case of disagreement, the results of the other session (with lower intra-observer reliability) were used. The association of location of the lesion with patellofemoral symptoms and function was analysed according to the medial or lateral location (types 2 and 5 *vs* types 3 and 6) and the absence or presence of involvement of the median ridge (types 2 and 3 *vs* type 4).

When a significant correlation between two variables was found, partial rank correlation coefficients were calculated to adjust for the possible confounders. They included age, gender, height, weight, body mass index (BMI), tibiofemoral alignment and radiological severity of the osteoarthritis (Table I). The BMI was calculated as weight (kg)/height (m)². The severity of osteoarthritis was assessed using the modified Ahlback scoring system.¹³

Statistical analysis was performed using the SPSS for Windows statistical package (version 11.5; SPSS, Chicago, Illinois).

Results

The depth and size of the three parameters indicating the condition of the patellar cartilage had a significant but weak association with anterior knee pain and the patellar score ($r = 0.300$ and 0.298 ; $p = 0.007$ and 0.009 , respectively) (Table II). These significant associations remained even after adjustment for confounding factors. There was no significant association of the depth and the size with patellofemoral functions (chair-rising, stair-climbing and quadriceps power) ($p > 0.05$). The variables of size and depth were highly correlated with each other ($r = 0.608$, $p < 0.001$). There was no significant association between the

location of the lesion and any of the parameters of patellofemoral symptoms and functions ($p > 0.05$).

Discussion

We used the Outerbridge classification as originally described because it could provide more reproducibility of the assessment of the cartilage without tactile feedback. The original Outerbridge classification is simpler with respect to the depth of a lesion since it is classified as normal or no loss (grade 1); loss of partial thickness (grades 2 and 3); and loss of full thickness and exposure of subchondral bone (grade 4). This is in contrast to most other classification systems which require information as to whether a lesion extends to more than half of the thickness of the cartilage.^{14,15} We thought this to be inaccurate when assessed using photographs. We believe that the original Outerbridge classification made our photographic assessment without tactile feedback satisfactorily reliable as evidenced by the kappa scores.

The association between the condition of the cartilage and the patellofemoral symptoms has not been fully elucidated in osteoarthritic patients undergoing TKA. Ayral et al¹⁶ reported a significant correlation between loss of cartilage and the clinical variable of pain and functional disability in patients undergoing arthroscopy of the knee. However, their study was in patients undergoing arthroscopy and the clinical variables analysed in the study were not specific to the patellofemoral joint. Hunter, March and Sambrook¹⁷ calculated the volume of the cartilage by MRI and showed that alterations in the volume were significantly associated with pain, function and the global scores of the Western Ontario McMaster Universities osteoarthritis index. Their study was also in an unselected community-based population and symptoms and functions specific to the patellofemoral joint were not considered. Our study is the first to document the significant association between the condition of the cartilage and patellofemoral symptoms (anterior knee pain) in patients with severe osteoarthritis warranting TKA. Surgeons may wish to take this significant correlation as evidence on which the decision of patellar resurfacing in TKA can be made, but its low degree of correlation ($r = 0.300$) indicates that other factors should be considered before taking such a step.

Table II. Results of the correlation analyses between the condition of the cartilage and patellofemoral symptoms and function

Parameters	Correlation coefficient (p value)*			
	Depth	Size	Location	
			Medial vs lateral	Ridge involvement
Anterior knee pain	-0.300 (0.007)	-0.289 (0.009)	0.114 (0.454)	0.103 (0.639)
Ability to rise from a chair	0.054 (0.634)	-0.094 (0.409)	-0.020 (0.896)	-0.109 (0.621)
Stair-climbing	0.038 (0.739)	0.077 (0.497)	†	†
Quadriceps strength	0.066 (0.563)	-0.025 (0.823)	†	†
Patellar score	-0.252 (0.024)	-0.253 (0.023)	0.131 (0.391)	0.044 (0.842)

* negative numbers indicate a negative association meaning that a lesion of higher grade has lower score in anterior knee pain or the functional parameters (more anterior knee pain or poor functional status)

† unavailable for the correlation analyses since all the knees had the same score

No significant association was found between the three parameters of the condition of the cartilage and functional parameters for the patellofemoral joint. It leads us to speculate that the functional status of the patellofemoral joint is determined not only by anterior knee pain or the condition of the cartilage but also by other factors.

We found a significant association between the variables of depth and size of the lesion, which was in line with our expectation since it is legitimate that a deeper lesion is wider. Each parameter lost its significant association with anterior knee pain when adjusted for each other as a confounder. This finding indicates that the depth and size of a lesion need to be considered together when we determine the implication of a lesion.

We have attempted to determine the correlation between the condition of the cartilage and patellofemoral symptoms and function in osteoarthritic patients undergoing TKA. We found that the depth and size of a lesion were significantly associated with anterior knee pain but that the strength of the correlation was weak. No significant association was found between the condition of the cartilage and patellofemoral functional parameters. Our findings suggest that caution should be taken when attributing patellofemoral symptoms merely to a lesion or deciding on patellar resurfacing. Other relevant factors which may influence patellofemoral symptoms and function remain to be determined.

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References

1. Barrack RL, Bertot AJ, Wolfe MW, et al. Patellar resurfacing in total knee arthroplasty: a prospective, randomized, double-blind study with five to seven years of follow-up. *J Bone Joint Surg [Am]* 2001;83-A:1376-81.
2. Waters TS, Bentley G. Patellar resurfacing in total knee arthroplasty: a prospective, randomized study. *J Bone Joint Surg [Am]* 2003;85-A:212-17.
3. Wood DJ, Smith AJ, Collopy D, et al. Patellar resurfacing in total knee arthroplasty: a prospective, randomized trial. *J Bone Joint Surg [Am]* 2002;84-A:187-93.
4. Boyd AD Jr, Ewald FC, Thomas WH, Poss R, Sledge CB. Long-term complications after total knee arthroplasty with or without resurfacing of the patella. *J Bone Joint Surg [Am]* 1993;75-A:674-81.
5. Burnett RS, Bourne RB. Indications for patellar resurfacing in total knee arthroplasty. *Instr Course Lect* 2004;53:167-86.
6. Kim BS, Reitman RD, Schai PA, Scott RD. Selective patellar nonresurfacing in total knee arthroplasty: 10 year results. *Clin Orthop* 1999;367:81-8.
7. Levitsky KA, Harris WJ, McManus J, Scott RD. Total knee arthroplasty without patellar resurfacing: clinical outcomes and long-term follow-up evaluation. *Clin Orthop* 1993;286:116-21.
8. Rand JA. The patellofemoral joint in total knee arthroplasty. *J Bone Joint Surg [Am]* 1994;76:612-20.
9. Leslie IJ, Bentley G. Arthroscopy in the diagnosis of chondromalacia patellae. *Ann Rheum Dis* 1978;37:540-7.
10. Feller JA, Bartlett RJ, Lang DM. Patellar resurfacing versus retention in total knee arthroplasty. *J Bone Joint Surg [Br]* 1996;78-B:226-8.
11. Outerbridge RE. The etiology of chondromalacia patellae. *J Bone Joint Surg [Br]* 1961;43-B:752-7.
12. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977;33:159-74.
13. Mont MA, Haas S, Mullick T, Hungerford DS. Total knee arthroplasty for patellofemoral arthritis. *J Bone Joint Surg [Am]* 2002;84-A:1977-81.
14. Brittberg M, Winalski CA. Evaluation of cartilage injuries and repair. *J Bone Joint Surg [Am]* 2003;85-A(Suppl 2):58-69.
15. Dougados M, Ayral X, Llistrat V, et al. The SFA system for assessing articular cartilage lesions at arthroscopy of the knee. *Arthroscopy* 1994;10:69-77.
16. Ayral X, Dougados M, Llistrat V, et al. Arthroscopic evaluation of chondropathy in osteoarthritis of the knee. *J Rheumatol* 1996;23:698-706.
17. Hunter DJ, March L, Sambrook PN. The association of cartilage volume with knee pain. *Osteoarthritis Cartilage* 2003;11:725-9.