The Normal Patella—Does it Exist? A Histologic Analysis

Aravind Athiviraham, MD, FRCS(C), Joel Fechisin, MD, Aaron Hartman, MD, Samuel Wahl, MD, and Fred D. Cushner, MD

Abstract

It is unclear if healthy-appearing patellae in patients having total knee arthroplasty (TKA) can be selectively retained. In the study reported here, we hypothesized that grossly normal-appearing patellae in TKA candidates would show significant evidence of microscopic degeneration and thinning of the articular cartilage.

Ninety-six consecutive patients (110 knees) with primary degenerative osteoarthritis were recruited from a single institution between November 2010 and June 2011. Thirteen patellae (11 patients) had grossly normal-appearing cartilage. A pathologist measured patellar cartilage thickness in each quadrant and evaluated for evidence of microscopic degenerative change.

Mean cartilage thickness was 2.35 mm (range, 1.0-3.0 mm) for superomedial quadrant, 2.31 mm (range, 1.5-3.0 mm) for superolateral quadrant, 2.31 mm (range, 1.0-4.0 mm) for inferomedial quadrant, and 2.62 mm (range, 1.5-3.5 mm) for inferolateral quadrant. Four-point mean (SD) was 2.39 (0.79) mm. Each patella demonstrated at least 2 of the predefined histologic markers of degeneration: fibrillation, fibrosis, chondrocyte proliferation, cyst formation, and fissuring and/or thinning.

Even healthy-appearing patellae on gross examination have clear histologic markers of early to moderate articular degeneration.

Further comparisons of cartilage thickness using area measurements are needed before the significance of the effect of this deterioration on the technique of selective patellar retention during TKA can be known.

Despite the excellent clinical success of total knee arthroplasty (TKA), controversy remains regarding whether to resurface the patella routinely. Although the incidence of complications after patellar resurfacing is low with current surgical techniques and implant design, patellar implant–related complications include fracture (0.05%-25%), avascular necrosis (0.05%-2%), loosening (1%-25%), and patellar tendon injury (1%-2%).[1] Recent meta-analysis results supporting patellar resurfacing cite decreased relative risk for reoperation and anterior knee pain in the resurfaced group.[1-7] However, other recent studies have reported conflicting results and no superiority of resurfacing.[8-11] The question, therefore, is whether healthy-appearing patellar articular cartilage shows microscopic signs of degeneration at time of surgery. We hypothesized that, in TKA patients with an otherwise grossly normal-appearing patella (candidates for patellar retention), there would be significant evidence of microscopic degeneration and thinning of the articular cartilage.

Materials and Methods

Consecutive patients with a diagnosis of primary degenerative osteoarthritis, scheduled for TKA, were prospectively recruited from a single institution between November 2010 and June 2011. Age was not used as an exclusion criterion. Age range of the patients initially considered for the study was 42 to 90 years. Healthy-appearing patellae that would otherwise be considered for retention were selected by Dr. Cushner based on intraoperative assessment of the patellar articular cartilage as being grossly normal and demonstrating no signs of degeneration, tracking centrally, and having a congruent articular surface.

The patellar osteotomy was performed freehand with an oscillating saw. This osteotomy was started at the inferior pole of the patella just posterior to the insertion of the patellar tendon and was carried proximally posterior to the insertion of the quadriceps tendon.[12] The patellar resection was made to include the largest amount of articular cartilage and subchondral bone possible and was oriented with superior and lateral cautery marks.

Patellar specimens were then sent to the hospital pathology department for sectioning, cartilage measurement, and histologic evaluation. Patellae were received in the fresh state, oriented with cautery marks indicating superior and lateral. The specimens were fixed in formalin for at least 1 night. After fixation, the center of the patella was identified. Three-millimeter sections of the patella were made from superior

Authors' Disclosure Statement: The authors report no actual or potential conflict of interest in relation to this article.

Table. Patient and Patella Characteristics

Case No.	Age, y	Sex	Side	Quadrant, mm				Comments
				SL	SM	IL	IM	
1	55	M	R	3	3	3	4	Mild fibrillation, patchy proliferation
2	50	F	L	2.5	2	2	2.5	Mild fibrillation, mild proliferation
3	56	F	R	2.5	2	1.5	3	Fibrillation, proliferation, osteophyte formation at periphery, thinning of cartilage
4	57	F	L	2	3	3	4	Fibrillation, proliferation, splitting of cartilage
5	57	F	R	2.5	2.5	3.5	2.5	Mild peripheral proliferation
6	51	F	L	2.5	1	2	1	Early cyst formation, fibrillation, fibrosis, proliferation, splitting, bony sclerosis, medullary fibrosis
7	60	F	R	2	2	1.5	1	Fibrillation, fibrosis
8	67	F	R	1.5	2	3	1	Fibrillation, fibrosis, mild peripheral proliferation, osteophyte formation
9	52	F	L	2.5	2	3	1.5	Fibrillation, fibrosis, proliferation, fibrocartilaginous degeneration, splitting, osteophyte formation
10	48	F	R	2.5	2	2	2	Fibrillation, proliferation, splitting of cartilage
11	49	F	R	2	3	3	1.5	Mild fibrillation, proliferation, splitting, osteophyte formation
12	61	M	L	2.5	3	3	3	Fibrillation, proliferation, osteophyte formation
13	61	M	R	2	3	3.5	3	Fibrillation, osteophyte formation

Abbreviations: SL, superolateral; SM, superomedial; IL, inferolateral; IM, inferomedial.

to inferior located 1 cm medial and 1 cm lateral from the center of the patella. The patellar cartilage thickness in the superomedial, superolateral, inferomedial, and inferolateral quadrants was measured. The sections were then submitted for histologic examination and were evaluated for evidence of cartilage fibrillation, fibrosis, chondrocyte proliferation, subchondral cyst formation, fissuring, and thinning.

Results

Ninety-six consecutive patients (110 knees) were initially considered for the study. There were 46 men and 50 women. Age range was 44 to 82 years (mean, 60.9 years). Of the 110 possible knees, only 13 patellae (11 patients), or 11.8% of eligible knees, had no gross signs of articular degeneration and were deemed eligible for the study. Age range of the selected patients was 48 to 67 years (mean, 55.7 years). Of the patients eligible for the study, 2 were men (4.3% of all men) and 9 were women (18% of all women). Eight knees were right knees, and 5 were left knees. The **Table** lists patient characteristics (age, sex, side), patellar articular cartilage characteristics (thickness in the quadrants), and pathologist comments on articular degeneration. Mean cartilage thickness was 2.35 mm (range, 1.0-3.0 mm) in the superomedial quadrant, 2.31 mm (range, 1.5-3.0 mm) in the superolateral quadrant, 2.31 mm (range, 1.0-4.0 mm) in the inferomedial quadrant, and 2.62 mm (range, 1.5-3.5 mm) in the inferolateral quadrant. Four-point mean (SD) was 2.39 (0.79) mm. All the patellae that appeared grossly normal demonstrated at least 2 of the predefined histologic markers of degeneration (**Figure**): fibrillation, fibrosis, chondrocyte proliferation, cyst formation, fissuring, thinning. On microscopic examination, the majority of the patellae had a combination of fibrillation (92% of patellae), proliferation (85%), osteophyte formation (38%), fissuring (38%), and fibrosis (31%).

Discussion

Routine resurfacing of grossly normal-appearing patellae during TKA remains controversial. Insall[13] favored routine resurfacing in the elderly and more selective resurfacing in younger or overweight patients. Bourne and Burnett[14] proposed a selective resurfacing algorithm based on patient age, preoperative presence or absence of patellofemoral symptoms, intraoperative appearance of patella, etiology of arthritis, patellar tracking, and whether a patella-friendly femoral component is used. Using criteria similar to those for patella retention, Kim and colleagues[15] found 97.5% survival of unresurfaced patellae at 10-year follow-up. The absence of advanced cartilage changes noted intraoperatively was found to be more reliable than relying on radiographic changes alone.[16-18] Only patellar translation and obliteration of the joint space had a statistically significant association with anterior knee pain.[19] However, more recent studies supporting routine patellar resurfacing have cited de-

creased relative risk for reoperation and anterior knee pain in the resurfaced group.[1-7]

In the present study, healthy-appearing patellae on gross examination had clear histologic markers of early to moderate articular degeneration. In fact, all patellae had at least 2 of the predefined markers of histologic degeneration. In previous studies, we had shown that the majority of patients with osteoarthritis had histologic degeneration of the anterior cruciate ligament.[20,21] Although it is clear that a proportion of patients with grossly normal patellae have anterior knee pain,[1-5] it is unclear if this finding is directly related to the microscopic signs of degeneration observed in our study. Previous studies have attempted to correlate the condition of patellar articular cartilage with patellofemoral pain, with mixed results.[22-24] Han and colleagues[22] evaluated the condition of the patellar cartilage in 80 consecutive osteoarthritic knees. They were unable to find an association between the condition of patellar cartilage and patellofemoral symptoms or patient function. Another study was unable to find a significant association between osteophyte formation and patellofemoral function or symptoms.[25]

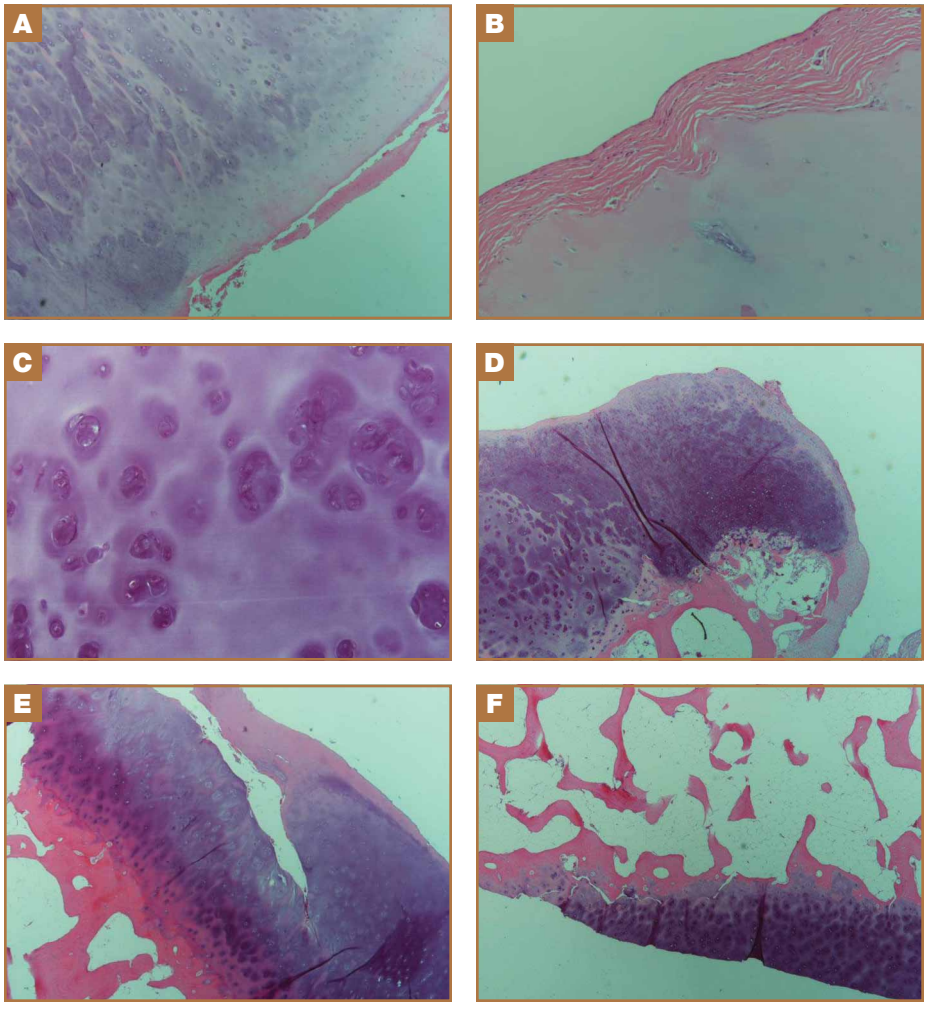

Figure. Histologic slides showing (A) fibrillation, (B) fibrosis, (C) chondrocyte proliferation, (D) cyst formation, (E) fissuring, and (F) thinning.

In a recent study, Farrokhi and colleagues[24] found that patients with patellofemoral pain had a 14.1% reduction in baseline cartilage thickness for total patellar cartilage. In the present study, we divided the patella into quadrants to help determine in which regions the thinning was most significant. Our mean patellar articular cartilage thickness was 2.39 mm, which is less than the range (2.79-3.33 mm) reported in the literature.[23,24,26,27] However, magnetic resonance imaging and stereographic imaging have since shown considerable variation in the thickness of articular cartilage over the patellar surface, making single-point comparisons difficult to interpret.[28,29] Thus, limitations of this study include use of topographic point selection (vs area measurement), small sample size, and lack of clinical correlation.

Conclusion

Given that histologic examination and evaluation of well-appearing patellae suggest more advanced degeneration of the articular cartilage than one might expect on gross examination, it is unclear if retaining patellae with early degenerative changes is a viable option for the long term. However, further studies using area measurements to correlate the condition and thickness of patellar cartilage with patellofemoral symptoms and function are needed to elucidate the clinical significance of early histologic degeneration for selective patellar retention during TKA.

Dr. Athiviraham is Assistant Professor, Department of Orthopedic Surgery, Baylor College of Medicine, Houston, Texas. Dr. Fechisin is Orthopedic Surgeon, Seaview Orthopaedics, Barnegat, New Jersey. Dr. Hartman is Resident, and Dr. Wahl is Chairman, Department of Pathology, Lenox Hill Hospital, New York, New York. Dr. Cushner is Director, Insall Scott Kelly Institute, New York, New York, and Chairman, Division of Orthopedics, Southside Hospital, Bayshore, New York.

Address correspondence to: Aravind Athiviraham, MD, FRCS(C), Baylor College of Medicine, 7200 Cambridge Street, Suite 10A, Houston, TX 77030 (tel, 713-986-5430; fax, 713-986-5791; e-mail, aravind.athiviraham@bcm.edu).

Am J Orthop. 2014;43(8):370-373.

References

1. Parvizi J, Rapuri VR, Saleh KJ, Kuskowski MA, Sharkey PF, Mont MA. Failure to resurface the patella during total knee arthroplasty may result in

more knee pain and secondary surgery. *Clin Orthop*. 2005;(438):191-196.
2. Li S, Chen Y, Su W, Zhao J, He S, Luo X. Systematic review of patellar resurfacing in total knee arthroplasty. *Int Orthop*. 2011;35(3):305-316.
3. Pakos EE, Ntzani EE, Trikalinos TA. Patellar resurfacing in total knee arthroplasty. A meta-analysis. *J Bone Joint Surg Am*. 2005;87(7):1438-1445.
4. Nizard RS, Biau D, Porcher R, et al. A meta-analysis of patellar replacement in total knee arthroplasty. *Clin Orthop*. 2005;(432):196-203.
5. Meneghini RM. Should the patella be resurfaced in primary total knee arthroplasty? An evidence-based analysis. *J Arthroplasty*. 2008;23(7 suppl):11-14.
6. Waters TS, Bentley G. Patellar resurfacing in total knee arthroplasty. A prospective, randomized study. *J Bone Joint Surg Am*. 2003;85(2):212-217.
7. Mayman D, Bourne RB, Rorabeck CH, Vaz M, Kramer J. Resurfacing versus not resurfacing the patella in total knee arthroplasty: 8- to 10-year results. *J Arthroplasty*. 2003;18(5):541-545.
8. Campbell DG, Duncan WW, Ashworth M, et al. Patellar resurfacing in total knee replacement: a ten-year randomised prospective trial. *J Bone Joint Surg Br*. 2006;88(6):734-739.
9. Burnett RS, Boone JL, McCarthy KP, Rosenzweig S, Barrack RL. A prospective randomized clinical trial of patellar resurfacing and nonresurfacing in bilateral TKA. *Clin Orthop*. 2007;(464):65-72.
10. Smith AJ, Wood DJ, Li MG. Total knee replacement with and without patellar resurfacing: a prospective, randomised trial using the Profix total knee system. *J Bone Joint Surg Br*. 2008;90(1):43-49.
11. Wood DJ, Smith AJ, Collopy D, White B, Brankov B, Bulsara MK. Patellar resurfacing in total knee arthroplasty: a prospective, randomized trial. *J Bone Joint Surg Am*. 2002;84(2):187-193.
12. Lombardi AV Jr, Mallory TH, Maitino PD, Herrington SM, Kefauver CA. Freehand resection of the patella in total knee arthroplasty referencing the attachments of the quadriceps tendon and patellar tendon. *J Arthroplasty*. 1998;13(7):788-792.
13. Insall J. The patella in total knee replacement: does it matter? *Knee Surg Sports Traumatol Arthrosc*. 2001;9(suppl 1):S2.
14. Bourne RB, Burnett RS. The consequences of not resurfacing the patella. *Clin Orthop*. 2004;(428):166-169.
15. Kim BS, Reitman RD, Schai PA, Scott RD. Selective patellar nonresurfacing in total knee arthroplasty. 10 year results. *Clin Orthop*. 1999;(367):81-88.
16. Rodriguez-Merchan EC, Gomez-Cardero P. The Outerbridge classification predicts the need for patellar resurfacing in TKA. *Clin Orthop*. 2010;468(5):1254-1257.
17. Han I, Chang CB, Kang YG, Yoon SW, Seong SC, Kim TK. Intraobserver and interobserver reliability of the assessment of the patellar articular cartilage in osteoarthritic patients undergoing total knee arthroplasty. *J Arthroplasty*. 2006;21(4):567-571.
18. Chang CB, Seong SC, Kim TK. Evaluations of radiographic joint space—do they adequately predict cartilage conditions in the patellofemoral joint of the patients undergoing total knee arthroplasty for advanced knee osteoarthritis? *Osteoarthritis Cartilage*. 2008;16(10):1160-1166.
19. Chang CB, Han I, Kim SJ, Seong SC, Kim TK. Association between radiological findings and symptoms at the patellofemoral joint in advanced knee osteoarthritis. *J Bone Joint Surg Br*. 2007;89(10):1324-1328.
20. Cushner FD, La Rosa DF, Vigorita VJ, Scuderi GR, Scott WN, Insall JN. A quantitative histologic comparison: ACL degeneration in the osteoarthritic knee. *J Arthroplasty*. 2003;18(6):687-692.
21. Lee GC, Cushner FD, Vigoritta V, Scuderi GR, Insall JN, Scott WN. Evaluation of the anterior cruciate ligament integrity and degenerative arthritic patterns in patients undergoing total knee arthroplasty. *J Arthroplasty*. 2005;20(1):59-65.
22. Han I, Chang CB, Lee S, Lee MC, Seong SC, Kim TK. Correlation of the condition of the patellar articular cartilage and patellofemoral symptoms and function in osteoarthritic patients undergoing total knee arthroplasty. *J Bone Joint Surg Br*. 2005;87(8):1081-1084.
23. Draper C, Fiene A, Besier T, Gold G, Beaupre G, Delp S. Is patellar cartilage thickness reduced in individuals with patellofemoral pain? Paper presented at: 29th Annual Meeting of the American Society of Biomechanics; July 31–August 5, 2005; Cleveland, OH.
24. Farrokhi S, Colletti PM, Powers CM. Differences in patellar cartilage thickness, transverse relaxation time, and deformational behavior: a comparison of young women with and without patellofemoral pain. *Am J Sports Med*. 2011;39(2):384-391.
25. Han I, Chang CB, Choi JA, Kang YG, Seong SC, Kim TK. Is the degree of osteophyte formation associated with the symptoms and functions in the patellofemoral joint in patients undergoing total knee arthroplasty? *Knee Surg Sports Traumatol Arthrosc*. 2007;15(4):372-377.
26. Meachim G, Bentley G, Baker R. Effect of age on thickness of adult patellar articular cartilage. *Ann Rheum Dis*. 1977;36(6):563-568.
27. Ateshian GA, Soslowsky LJ, Mow VC. Quantitation of articular surface topography and cartilage thickness in knee joints using stereophotogrammetry. *J Biomech*. 1991;24(8):761-776.
28. Sittek H, Eckstein F, Gavazzeni A, et al. Assessment of normal patellar cartilage volume and thickness using MRI: an analysis of currently available pulse sequences. *Skeletal Radiol*. 1996;25(1):55-62.
29. Cohen ZA, McCarthy DM, Kwak SD, et al. Knee cartilage topography, thickness, and contact areas from MRI: in-vitro calibration and in-vivo measurements. *Osteoarthritis Cartilage*. 1999;7(1):95-109.