

Details of the Statistical Methods

Statistical Analysis

Given that the use of allograft has been shown to be associated with higher rates of graft failure, we thought that it was important to aggressively adjust for any confounding by indication regarding the use of allograft¹⁴. To that end, we calculated a propensity score for graft type, based on the predicted log odds of receiving an allograft, from a logistic regression model. We included this as a covariate in the outcome models, but removed it after observing that it had little effect on the estimated effect of using an allograft instead of an autograft. Restricted cubic splines were used to allow for nonlinear relationships between continuous covariates and the outcomes. We used multiple imputation via predictive mean matching to avoid casewise deletion of records that were missing any covariates³³. The predicted mean was calculated for the proportional-odds model by weighting category values by their predicted probability of category membership and summing.

We used bootstrap resampling with 100 bootstrap samples to internally validate each model. The bootstrap samples provided bias-corrected fit, calibration, and discrimination measures to help assess how the model might perform on other data³⁴.

Calibration or Validation of Models

To validate the proportional-odds models, we checked the summary indices for each model using the Somers D_{xy} rank correlation from the model fit and from a bootstrap training sample³³. From the model fit, the apparent Somers D_{xy} rank correlation between predicted and observed outcomes was 0.279 for the PCS model and 0.263 for the MCS model. The bootstrap bias-corrected (internally validated) predictive discrimination and D_{xy} correlation was 0.243 for the PCS model and 0.225 for the MCS model. ■

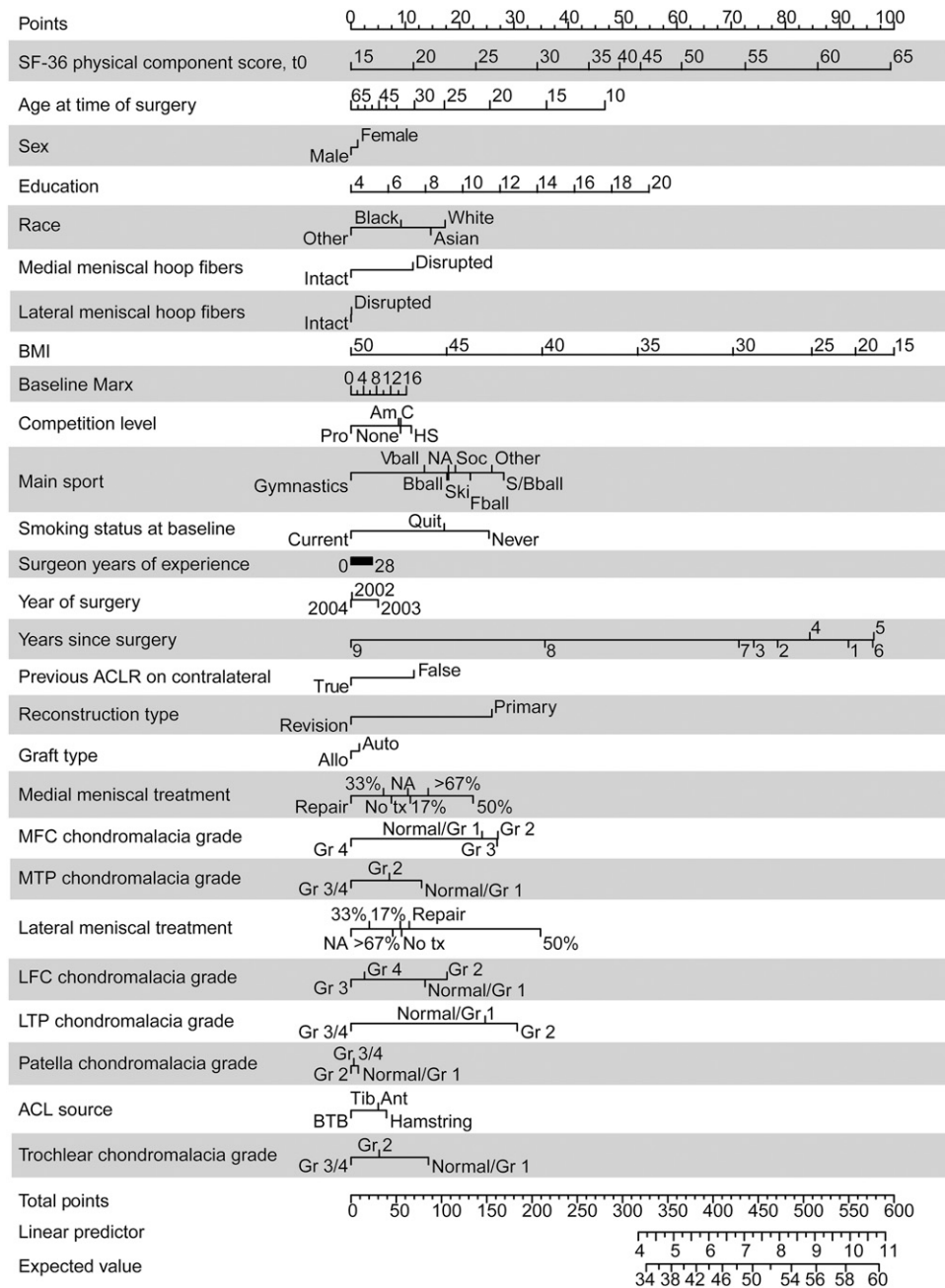


Fig. E-1

A nomogram for the SF-36 Physical Component Summary (PCS) score model. Use the top line to determine points for each individual predictor listed on the left side. Manually sum these points and then transfer the sum to the total points axis to determine the corresponding predicted PCS score on the bottom line of the nomogram. t0 = baseline, BMI = body mass index, Pro = professional, Am = amateur, C = college, HS = high school, VBall = volleyball, NA = not available, Soc = soccer, Bball = basketball, S/Bball = softball or baseball, Fball = football, ACLR = ACL reconstruction, tx = treatment, MFC = medial femoral condyle, Gr = grade, MTP = medial tibial plateau, LFC = lateral femoral condyle, LTP = lateral tibial plateau, and BTB = bone-tendon-bone.

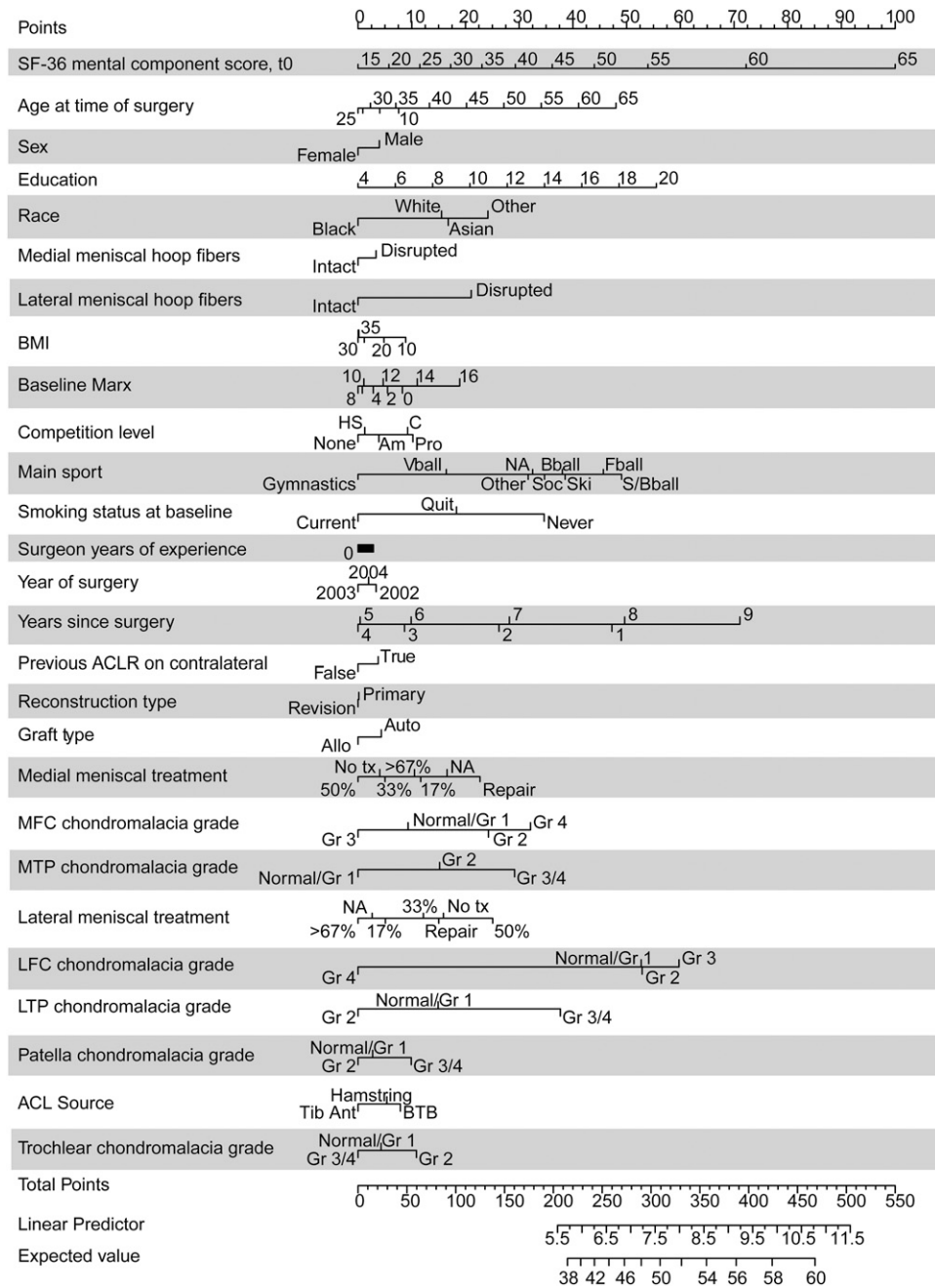


Fig. E-2

A nomogram for the SF-36 Mental Component Summary (MCS) score model. Use the top line to determine points for each individual predictor listed on the left side. Manually sum these points and then transfer the sum to the total points axis to determine the corresponding predicted MCS score on the bottom line of the nomogram. t0 = baseline, BMI = body mass index, HS = high school, C = college, Am = amateur, Pro = professional, VBall = volleyball, NA = not available, Soc = soccer, Bball = basketball, S/Bball = softball or baseball, Fball = football, ACLR = ACL reconstruction, tx = treatment, MFC = medial femoral condyle, Gr = grade, MTP = medial tibial plateau, LFC = lateral femoral condyle, LTP = lateral tibial plateau, and BTB = bone-tendon-bone.

TABLE E-1 Baseline Cohort Descriptive Statistics			
Statistics	Male Patients (N = 785)	Female Patients (N = 626)	Combined Patients (N = 1411)
Follow-up*			
Contributed a two-year and six-year follow-up pair	654 (83.3%)	550 (87.9%)	1204 (85.3%)
Contributed only a two-year follow-up	72 (9.2%)	32 (5.1%)	104 (7.4%)
Contributed only a six-year follow-up	59 (7.5%)	44 (7.0%)	103 (7.3%)
Age at the time of surgery*			
Ten to nineteen years	290 (36.9%)	299 (47.8%)	589 (41.7%)
Twenty to twenty-nine years	222 (28.3%)	137 (21.9%)	359 (25.4%)
Thirty to thirty-nine years	158 (20.1%)	91 (14.5%)	249 (17.6%)
Forty to forty-nine years	104 (13.2%)	80 (12.8%)	184 (13.0%)
Fifty years or more	11 (1.4%)	19 (3.0%)	30 (2.1%)
Mean age (yr)			
25th percentile	18	17	17
50th percentile	25	21	23
75th percentile	36	34	35
Race*			
White	667 (85.0%)	538 (85.9%)	1205 (85.4%)
Black	53 (6.8%)	49 (7.8%)	102 (7.2%)
Asian	31 (3.9%)	21 (3.4%)	52 (3.7%)
Other	30 (3.8%)	16 (2.6%)	46 (3.3%)
Unreported	4 (0.5%)	2 (0.3%)	6 (0.4%)
BMI† (kg/m ²)			
25th percentile	23.6	21.1	22.3
50th percentile	25.8	23.0	24.8
75th percentile	28.6	25.8	27.8
Smoking status*			
Never	619 (78.9%)	504 (80.5%)	1123 (79.6%)
Quit	78 (9.9%)	59 (9.4%)	137 (9.7%)
Current	77 (9.8%)	58 (9.3%)	135 (9.6%)
Unreported	11 (1.4%)	5 (0.8%)	16 (1.1%)
Education‡ (yr)			
25th percentile	12	11	11
50th percentile	14	13	14
75th percentile	16	16	16
Marx score§ (points)			
25th percentile	8	8	8
50th percentile	12	13	12
75th percentile	16	16	16
Main sport*			
Unreported	4 (0.5%)	0 (0.0%)	4 (0.3%)
None	51 (6.5%)	65 (10.4%)	116 (8.2%)
Basketball	179 (22.8%)	131 (20.9%)	310 (22.0%)
Football	144 (18.3%)	8 (1.3%)	152 (10.8%)
Gymnastics	2 (0.3%)	10 (1.6%)	12 (0.9%)
Volleyball	16 (2.0%)	54 (8.6%)	70 (5.0%)
Baseball	83 (10.6%)	42 (6.7%)	125 (8.9%)

continued

TABLE E-1 (continued)

Statistics	Male Patients (N = 785)	Female Patients (N = 626)	Combined Patients (N = 1411)
Skiing	32 (4.1%)	39 (6.2%)	71 (5.0%)
Soccer	95 (12.1%)	97 (15.5%)	192 (13.6%)
Other	179 (22.8%)	180 (28.8%)	359 (25.4%)
Competition level*			
Unreported	5 (0.6%)	1 (0.2%)	6 (0.4%)
None	84 (10.7%)	93 (14.9%)	177 (12.5%)
Recreational	283 (36.1%)	189 (30.2%)	472 (33.5%)
Amateur (team or club)	114 (14.5%)	79 (12.6%)	193 (13.7%)
High school	199 (25.4%)	194 (31.0%)	393 (27.9%)
College, not NCAA# Division I	38 (4.8%)	36 (5.8%)	74 (5.2%)
College, NCAA# Division I	47 (6.0%)	23 (3.7%)	70 (5.0%)
Semiprofessional	10 (1.3%)	6 (1.0%)	16 (1.1%)
Professional	5 (0.6%)	5 (0.8%)	10 (0.7%)
Year of surgery*			
2002	219 (27.9%)	177 (28.3%)	396 (28.1%)
2003	273 (34.8%)	229 (36.6%)	502 (35.6%)
2004	293 (37.3%)	220 (35.1%)	513 (36.4%)
Reconstruction type*			
Primary	703 (89.6%)	575 (91.9%)	1278 (90.6%)
Revision	82 (10.4%)	51 (8.1%)	133 (9.4%)
Graft type*			
Autograft	577 (73.5%)	478 (76.4%)	1055 (74.8%)
Allograft	208 (26.5%)	148 (23.6%)	356 (25.2%)
ACL source*			
Bone-tendon-bone	409 (52.1%)	311 (49.7%)	720 (51.0%)
Hamstring	238 (30.3%)	211 (33.7%)	449 (31.8%)
Tibialis anterior	138 (17.6%)	104 (16.6%)	242 (17.2%)
Previous ACL reconstruction on contralateral knee*			
Yes	68 (8.7%)	58 (9.3%)	126 (8.9%)
No	717 (91.3%)	568 (90.7%)	1285 (91.1%)
Medial meniscal treatment*			
No tear	462 (58.8%)	407 (65.0%)	869 (61.6%)
No treatment for tear	62 (7.9%)	40 (6.4%)	102 (7.2%)
Repair	96 (12.2%)	81 (12.9%)	177 (12.5%)
17% excised	21 (2.7%)	18 (2.9%)	39 (2.8%)
33% excised	68 (8.7%)	51 (8.1%)	119 (8.4%)
50% excised	29 (3.7%)	12 (1.9%)	41 (2.9%)
>67% excised	47 (6.0%)	17 (2.7%)	64 (4.5%)
Medial hoop fibers**			
Intact	268 (88.4%)	193 (94.1%)	461 (90.7%)
Disrupted	35 (11.6%)	12 (5.9%)	47 (9.3%)
Lateral meniscal treatment*			
No tear	363 (46.2%)	331 (52.9%)	694 (49.2%)
No treatment for tear	128 (16.3%)	121 (19.3%)	249 (17.6%)
Repair	50 (6.4%)	32 (5.1%)	82 (5.8%)

continued

TABLE E-1 (continued)

Statistics	Male Patients (N = 785)	Female Patients (N = 626)	Combined Patients (N = 1411)
17% excised	85 (10.8%)	72 (11.5%)	157 (11.1%)
33% excised	105 (13.4%)	53 (8.5%)	158 (11.2%)
50% excised	23 (2.9%)	8 (1.3%)	31 (2.2%)
>67% excised	31 (3.9%)	9 (1.4%)	40 (2.8%)
Lateral hoop fibers††			
Intact	330 (91.4%)	239 (96.8%)	569 (93.6%)
Disrupted	31 (8.6%)	8 (3.2%)	39 (6.4%)
Medial femoral condyle chondromalacia grade*			
Normal or grade 1	595 (75.8%)	489 (78.1%)	1084 (76.8%)
Grade 2	113 (14.4%)	83 (13.3%)	196 (13.9%)
Grade 3	57 (7.3%)	40 (6.4%)	97 (6.9%)
Grade 4	20 (2.5%)	14 (2.2%)	34 (2.4%)
Medial tibial plateau chondromalacia grade*			
Normal or grade 1	739 (94.1%)	601 (96.0%)	1340 (95.0%)
Grade 2	31 (3.9%)	17 (2.7%)	48 (3.4%)
Grade 3 or 4	15 (1.9%)	8 (1.3%)	23 (1.6%)
Patellar chondromalacia grade*			
Normal or grade 1	627 (79.9%)	510 (81.5%)	1137 (80.6%)
Grade 2	103 (13.1%)	67 (10.7%)	170 (12.0%)
Grade 3 or 4	55 (7.0%)	49 (7.8%)	104 (7.4%)
Trochlear chondromalacia grade*			
Normal or grade 1	702 (89.4%)	588 (93.9%)	1290 (91.4%)
Grade 2	47 (6.0%)	26 (4.2%)	73 (5.2%)
Grade 3 or 4	36 (4.6%)	12 (1.9%)	48 (3.4%)
Lateral femoral condyle chondromalacia grade*			
Normal or grade 1	627 (79.9%)	546 (87.2%)	1173 (83.1%)
Grade 2	105 (13.4%)	56 (8.9%)	161 (11.4%)
Grade 3	43 (5.5%)	18 (2.9%)	61 (4.3%)
Grade 4	10 (1.3%)	6 (1.0%)	16 (1.1%)
Lateral tibial plateau chondromalacia grade*			
Normal or grade 1	711 (90.6%)	574 (91.7%)	1285 (91.1%)
Grade 2	57 (7.3%)	42 (6.7%)	99 (7.0%)
Grade 3 or 4	17 (2.2%)	10 (1.6%)	27 (1.9%)
Surgeon experience (yr)			
25th percentile	10.7	10.6	10.7
50th percentile	12.3	12.1	12.2
75th percentile	13.5	14.6	13.5

*The values are given as the number of patients, with the percentage in parentheses. †Height and weight were unreported on twenty-three patients. ‡Years of schooling were unreported on thirty-two patients. §The baseline Marx scale was not scorable on thirteen patients, so only 1398 patients were evaluated for this category. #NCAA = National Collegiate Athletic Association. **Medial hoop fiber status was not reported on 903 patients. The values are given as the number of patients, with the percentages in parentheses; the percentages were based on 303 male patients, 205 female patients, and 508 combined patients. ††Lateral hoop fiber status was not reported on 803 patients. The values are given as the number of patients, with the percentages in parentheses; the percentages were based on 361 male patients, 247 female patients, and 608 combined patients.

TABLE E-2 Modeled Data Descriptive Statistics			
Statistics	Male Patients (N = 1439)	Female Patients (N = 1176)	Combined Patients (N = 2615)
Follow-up*			
Part of a two-year and six-year follow-up pair	1308 (90.9%)	1100 (93.5%)	2408 (92.1%)
Only a two-year follow-up	72 (5.0%)	32 (2.7%)	104 (4.0%)
Only a six-year follow-up	59 (4.1%)	44 (3.7%)	103 (3.9%)
Years since surgery†			
Overall (n = 2555)			
25th percentile	2.1	2.1	2.1
50th percentile	6.1	6.2	6.1
75th percentile	6.7	6.7	6.7
At the two-year follow-up (n = 1248)			
25th percentile	2.1	2.0	2.1
50th percentile	2.1	2.1	2.1
75th percentile	2.3	2.2	2.3
At the six-year follow-up (n = 1307)			
25th percentile	6.5	6.5	6.5
50th percentile	6.7	6.7	6.7
75th percentile	6.8	6.8	6.8
Age at the time of surgery*			
Ten to nineteen years	515 (35.8%)	560 (47.6%)	1075 (41.1%)
Twenty to twenty-nine years	409 (28.4%)	262 (22.3%)	671 (25.7%)
Thirty to thirty-nine years	296 (20.6%)	167 (14.2%)	463 (17.7%)
Forty to forty-nine years	198 (13.8%)	151 (12.8%)	349 (13.3%)
Fifty years or more	21 (1.5%)	36 (3.1%)	57 (2.2%)
Mean age (yr)			
25th percentile	18	17	17
50th percentile	25	21	23
75th percentile	36	34	35
Race*			
White	1238 (86.0%)	1017 (86.5%)	2255 (86.2%)
Black	87 (6.1%)	84 (7.1%)	171 (6.5%)
Asian	57 (4.0%)	42 (3.6%)	99 (3.8%)
Other	52 (3.6%)	30 (2.6%)	82 (3.1%)
Unreported	5 (0.3%)	3 (0.3%)	8 (0.3%)
BMI‡ (kg/m ²) (n = 2589)			
25th percentile	24.4	21.5	22.8
50th percentile	26.4	23.5	25.3
75th percentile	29.0	26.7	28.3
Smoking status*			
Never	1066 (74.1%)	901 (76.6%)	1967 (75.2%)
Quit	183 (12.7%)	152 (12.9%)	335 (12.8%)
Current	162 (11.3%)	107 (9.1%)	269 (10.3%)
Unreported	28 (1.9%)	16 (1.4%)	44 (1.7%)
Education§ (n = 2561) (yr)			
25th percentile	12	11	11

continued

TABLE E-2 (continued)			
Statistics	Male Patients (N = 1439)	Female Patients (N = 1176)	Combined Patients (N = 2615)
50th percentile	15	13	14
75th percentile	16	16	16
Marx activity rating scale# (n = 2593) (points)			
25th percentile	8	8	8
50th percentile	12	13	12
75th percentile	16	16	16
Main sport*			
Unreported	6 (0.4%)	0 (0.0%)	6 (0.2%)
None	93 (6.5%)	116 (9.9%)	209 (8.0%)
Basketball	320 (22.2%)	246 (20.9%)	566 (21.6%)
Football	258 (17.9%)	16 (1.4%)	274 (10.5%)
Gymnastics	3 (0.2%)	18 (1.5%)	21 (0.8%)
Volleyball	31 (2.2%)	105 (8.9%)	136 (5.2%)
Baseball	157 (10.9%)	80 (6.8%)	237 (9.1%)
Skiing	61 (4.2%)	74 (6.3%)	135 (5.2%)
Soccer	182 (12.6%)	184 (15.6%)	366 (14.0%)
Other	328 (22.8%)	337 (28.7%)	665 (25.4%)
Competition level*			
Unreported	7 (0.5%)	2 (0.2%)	9 (0.3%)
None	150 (10.4%)	170 (14.5%)	320 (12.2%)
Recreational	527 (36.6%)	358 (30.4%)	885 (33.8%)
Amateur (team or club)	215 (14.9%)	149 (12.7%)	364 (13.9%)
High school	356 (24.7%)	363 (30.9%)	719 (27.5%)
College, not NCAA** Division I	70 (4.9%)	69 (5.9%)	139 (5.3%)
College, NCAA** Division I	84 (5.8%)	44 (3.7%)	128 (4.9%)
Semiprofessional	20 (1.4%)	11 (0.9%)	31 (1.2%)
Professional	10 (0.7%)	10 (0.9%)	20 (0.8%)
Year of surgery*			
2002	404 (28.1%)	333 (28.3%)	737 (28.2%)
2003	505 (35.1%)	430 (36.6%)	935 (35.8%)
2004	530 (36.8%)	413 (35.1%)	943 (36.1%)
Reconstruction type*			
Primary	1287 (89.4%)	1081 (91.9%)	2368 (90.6%)
Revision	152 (10.6%)	95 (8.1%)	247 (9.4%)
Graft type*			
Autograft	1058 (73.5%)	898 (76.4%)	1956 (74.8%)
Allograft	381 (26.5%)	278 (23.6%)	659 (25.2%)
ACL source*			
Bone-tendon-bone	739 (51.4%)	585 (49.7%)	1324 (50.6%)
Hamstring	444 (30.9%)	395 (33.6%)	839 (32.1%)
Tibialis anterior	256 (17.8%)	196 (16.7%)	452 (17.3%)
Previous ACL reconstruction on contralateral knee*			
Yes	125 (8.7%)	107 (9.1%)	232 (8.9%)
No	1314 (91.3%)	1069 (90.9%)	2383 (91.1%)

continued

TABLE E-2 (continued)

Statistics	Male Patients (N = 1439)	Female Patients (N = 1176)	Combined Patients (N = 2615)
Medial meniscal treatment*			
No tear	850 (59.1%)	759 (64.6%)	1609 (61.5%)
No treatment for tear	114 (7.9%)	79 (6.7%)	193 (7.4%)
Repair	169 (11.7%)	152 (12.9%)	321 (12.3%)
17% excised	40 (2.8%)	33 (2.8%)	73 (2.8%)
33% excised	126 (8.8%)	99 (8.4%)	225 (8.6%)
50% excised	54 (3.8%)	21 (1.8%)	75 (2.9%)
>67% excised	86 (6.0%)	33 (2.8%)	119 (4.5%)
Medial hoop fibers††			
Intact	488 (88.4%)	368 (94.4%)	856 (90.9%)
Disrupted	64 (11.6%)	22 (5.6%)	86 (9.1%)
Lateral meniscal treatment			
No tear	677 (47.1%)	620 (52.7%)	1297 (49.6%)
No treatment for tear	230 (16.0%)	230 (19.6%)	460 (17.6%)
Repair	91 (6.3%)	59 (5.0%)	150 (5.7%)
17% excised	155 (10.8%)	138 (11.7%)	293 (11.2%)
33% excised	187 (13.0%)	98 (8.3%)	285 (10.9%)
50% excised	40 (2.8%)	15 (1.3%)	55 (2.1%)
>67% excised	59 (4.1%)	16 (1.4%)	75 (2.9%)
Lateral hoop fibers‡‡			
Intact	598 (91.4%)	451 (97.0%)	1049 (93.7%)
Disrupted	56 (8.6%)	14 (3.0%)	70 (6.3%)
Medial femoral condyle chondromalacia grade			
Normal or grade 1	1089 (75.7%)	918 (78.1%)	2007 (76.8%)
Grade 2	203 (14.1%)	159 (13.5%)	362 (13.8%)
Grade 3	110 (7.6%)	72 (6.1%)	182 (7.0%)
Grade 4	37 (2.6%)	27 (2.3%)	64 (2.4%)
Medial tibial plateau chondromalacia grade			
Normal or grade 1	1353 (94.0%)	1129 (96.0%)	2482 (94.9%)
Grade 2	57 (4.0%)	34 (2.9%)	91 (3.5%)
Grades 3 or 4	29 (2.0%)	13 (1.1%)	42 (1.6%)
Patellar chondromalacia grade			
Normal or grade 1	1148 (79.8%)	958 (81.5%)	2106 (80.5%)
Grade 2	189 (13.1%)	127 (10.8%)	316 (12.1%)
Grades 3 or 4	102 (7.1%)	91 (7.7%)	193 (7.4%)
Trochlear chondromalacia grade			
Normal or grade 1	1289 (89.6%)	1106 (94.1%)	2395 (91.6%)
Grade 2	84 (5.8%)	49 (4.2%)	133 (5.1%)
Grades 3 or 4	66 (4.6%)	21 (1.8%)	87 (3.3%)
Lateral femoral condyle chondromalacia grade			
Normal or grade 1	1151 (80.0%)	1023 (87.0%)	2174 (83.1%)
Grade 2	190 (13.2%)	109 (9.3%)	299 (11.4%)
Grade 3	80 (5.6%)	32 (2.7%)	112 (4.3%)
Grade 4	18 (1.3%)	12 (1.0%)	30 (1.1%)

continued

TABLE E-2 (continued)			
Statistics	Male Patients (N = 1439)	Female Patients (N = 1176)	Combined Patients (N = 2615)
Lateral tibial plateau chondromalacia grade			
Normal or grade 1	1307 (90.8%)	1079 (91.8%)	2386 (91.2%)
Grade 2	102 (7.1%)	79 (6.7%)	181 (6.9%)
Grades 3 or 4	30 (2.1%)	18 (1.5%)	48 (1.8%)
Surgeon experience (yr)			
25th percentile	10.7	10.6	10.7
50th percentile	12.3	12.1	12.2
75th percentile	13.5	14.6	14.6
<p>*The values are given as the number of patients, with the percentage in parentheses. †These values were based on the date the survey was filled out; sixty subjects did not report at the two-year follow-up. ‡Height and weight were unreported on twenty-six patients. §Years of schooling were unreported on fifty-four patients. #The baseline Marx scale was not scorable on twenty-two patients. **NCAA = National Collegiate Athletic Association. ††Medial hoop fiber status was not reported on 1673 patients. The values are given as the number of patients, with the percentages in parentheses; the percentages were based on 552 male patients, 390 female patients, and 942 combined patients. ‡‡Lateral hoop fiber status was not reported on 1496 patients. The values are given as the number of patients, with the percentages in parentheses; the percentages were based on 654 male patients, 465 female patients, and 1119 combined patients.</p>			