Supplementary Material

Observed numbers of separation events were sufficient to demonstrate significant inter-subject variation (Fisher–Freeman–Halton exact tests) as follows: 0.5 mm detection threshold – significant variation between individual subjects both medially and laterally for all activities (p = 0.006 for med separation in hyperextension, p < 0.001 for lateral separation in hyperextension and both medially and laterally for other dynamic activities). Knee 5 performing the stepping and pivot flexion activities was the only time more episodes of medial than lateral separation were seen, but this was only evident at the 0.5 mm detection threshold and was not significant (p = 0.125 for pivot flexion; p 0.267 for stepping; McNemar's exact tests); 0.75 mm detection threshold – significant variation between individual subjects both medially and laterally was detected in both the pivot flexion (p = 0.002 lateral; p = 0.007 medial) and stepping activities (p < 0.001 lateral; p = 0.027 medial); 1.0 mm detection threshold – significant variation between individual subjects laterally during the stepping activity (p < 0.001).

Table i. Total separation events observed at each threshold

Threshold, mm	Number of instances of lateral surface separation (%)	Number of instances of medial surface separation (%)	p-value[*]
0.5	283 (16.5)	83 (4.8)	$\chi^2 = 150.00$; < 0.001[†]
0.75	107 (6.2)	15 (0.9)	$\chi^2 = 72.64$; < 0.001[†]
1.0	37 (2.2)	4 (0.2)	< 0.001[†]
2.4	7 (0.4)	2 (0.1)	0.180

*McNemar's test
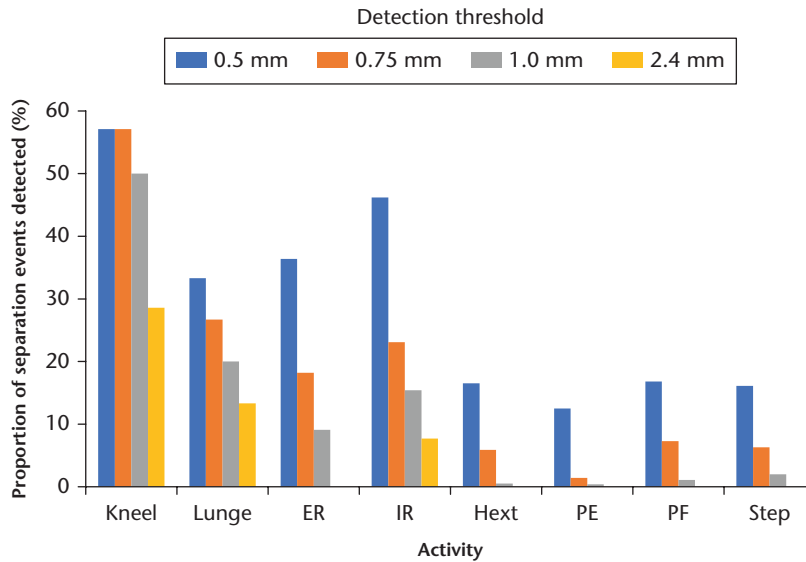†Statistically significant
χ^2, chi-squared

Fig. a

Proportion (%) of lateral separation events during each activity at each threshold. The proportion of observed lateral separations was seen to be activity-dependent at all thresholds tested (p < 0.001 for each threshold; Fisher–Freeman–Halton exact tests). ER, external rotation seated; IR, internal rotation seated; Hext, hyperextension; PE, pivoting extended; PF, pivoting flexed.

Fig. b

Proportion (%) of medial separation events during each activity at each threshold. The proportion of observed medial separations was seen to be activity-dependent at all thresholds tested (p < 0.001 for each threshold; Fisher–Freeman–Halton exact tests). ER, external rotation seated; IR, internal rotation seated; Hext, hyperextension; PE, pivoting extended; PF, pivoting flexed.
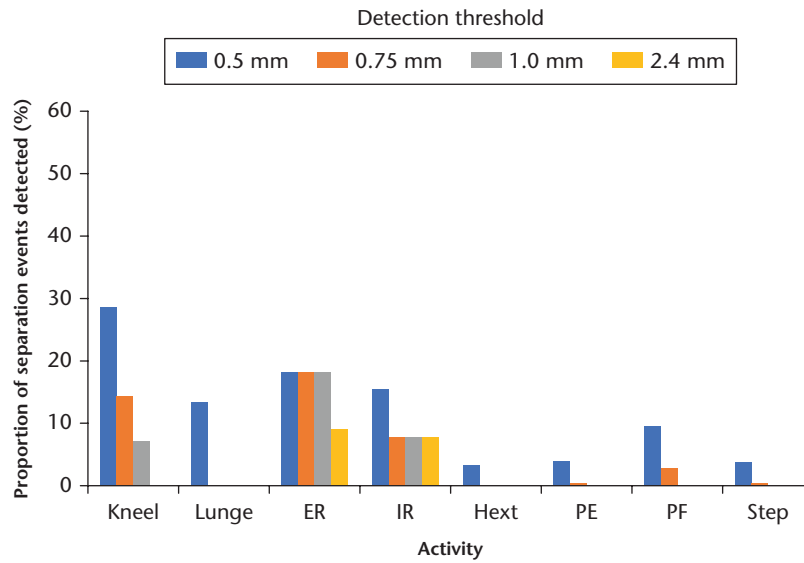
Table ii. Comparison of medial and lateral separation events at each detection threshold for each activity

Activity (total number of poses analyzed)	Threshold, mm	Number of instances of lateral surface separation (%)	Number of instances of medial surface separation (%)	p-value*
Kneeling (14)	0.5	8 (57.1)	4 (28.6)	0.125
	0.75	8 (57.1)	2 (14.3)	0.031†
	1.0	7 (50.0)	1 (7.1)	0.031†
	2.4	4 (28.6)	0 (0)	0.125
Lunging (15)	0.5	5 (33.3)	2 (13.3)	0.250
	0.75	4 (26.7)	0 (0)	0.125
	1.0	3 (20.0)	0 (0)	0.250
	2.4	2 (13.3)	0 (0)	0.500
External rotation (11)	0.5	4 (36.4)	2 (18.2)	0.687
	0.75	2 (18.2)	2 (18.2)	1.000
	1.0	1 (9.1)	2 (18.2)	1.000
	2.4	0 (0)	1 (9.1)	1.000
Internal rotation (13)	0.5	6 (46.2)	2 (15.4)	0.125
	0.75	3 (23.1)	1 (7.7)	0.625
	1.0	2 (15.4)	1 (7.7)	1.00
	2.4	1 (7.7)	1 (7.7)	1.00
Hyperextension (182)	0.5	30 (16.5)	6 (3.3)	$\chi^2 = 20.35$; p < 0.001†
	0.75	9 (5.9)	0 (0)	0.004†
	1.0	1 (0.5)	0 (0)	1
	2.4	0 (0)	0 (0)	N/A
Pivot extension (281)	0.5	35 (12.5)	11 (3.9)	$\chi^2 = 15.56$, p < 0.001†
	0.75	4 (1.4)	1 (0.4)	0.375
	1.0	1 (0.4)	0 (0)	1
	2.4	0 (0)	0 (0)	N/A
Pivot flexion (179)	0.5	30 (16.8)	17 (9.5)	0.015†
	0.75	13 (7.3)	5 (2.8)	0.077
	1.0	2 (1.1)	0 (0)	0.500
	2.4	0 (0)	0 (0)	N/A
Step up and down (1022)	0.5	165 (16.1)	39 (3.8)	$\chi^2 = 96.45$; p < 0.001†
	0.75	64 (6.3)	4 (0.4)	$\chi^2 = 52.74$; p < 0.001†
	1.0	20 (2.0)	0 (0)	< 0.001†
	2.4	0 (0)	0 (0)	N/A

*McNemar's test
†Statistically significant
χ^2, chi-squared
N/A, not applicable

Table iii. Correlation (Pearson's) between measured closest distances and implant position for individual knees during dynamic activities

Activity	Number of poses	Lateral closest distance/flexion angle, r; p-value	Medial closest distance/flexion angle, r; p-value	Lateral closest distance/rotation, r; p-value	Medial closest distance/rotation, r; p-value
Hyperextension					
Knee 1	Not performed	N/A	N/A	N/A	N/A
Knee 2	Not performed	N/A	N/A	N/A	N/A
Knee 3	Not performed	N/A	N/A	N/A	N/A
Knee 4	16	-0.817; < 0.001*	0.432; 0.095	N/A	N/A
Knee 5	18	0.302; 0.223	0.641; 0.004*	N/A	N/A
Knee 6	24	-0.901; < 0.001*	-0.834; < 0.001*	N/A	N/A
Knee 7	28	0.651; < 0.001*	-0.138; 0.484	N/A	N/A
Knee 8	7	0.334; 0.464	-0.205; 0.659	N/A	N/A
Knee 9	27	-0.430; 0.025*	0.058; 0.775	N/A	N/A
Knee 10	8	0.304; 0.464	-0.462; 0.249	N/A	N/A
Knee 11	Not performed	N/A	N/A	N/A	N/A
Knee 13	Not performed	N/A	N/A	N/A	N/A
Knee 14	14	0.055; 0.853	-0.308; 0.284	N/A	N/A
Knee 15	Not performed	N/A	N/A	N/A	N/A
Knee 16 Left	22	-0.284; 0.200	-0.260; 0.242	N/A	N/A
Knee 16 Right	18	-0.160; 0.526	-0.157; 0.533	N/A	N/A
Pivot extension					
Knee 1	31	-0.373; 0.039*	-0.183; 0.324	0.122; 0.512	0.070; 0.710
Knee 2	16	-0.052; 0.849	0.121; 0.656	0.650; 0.006*	-0.253; 0.345
Knee 3	30	-0.307; 0.099	0.183; 0.334	-0.370; 0.044*	0.230; 0.221
Knee 4	24	-0.416; 0.043*	-0.606; 0.002*	0.292; 0.166	0.396; 0.055
Knee 5	Not performed	N/A	N/A	N/A	N/A
Knee 6	27	-0.259; 0.192	0.562; 0.002*	-0.075; 0.710	-0.831; < 0.001*
Knee 7	37	0.445; 0.006*	0.116; 0.495	-0.438; 0.007*	-0.158; 0.349
Knee 8	27	0.081; 0.688	0.186; 0.353	0.406; 0.035*	0.022; 0.913
Knee 9	27	-0.140; 0.488	0.061; 0.761	-0.252; 0.205	-0.056; 0.782
Knee 10	13	-0.451; 0.122	-0.421; 0.152	0.348; 0.243	0.397; 0.179
Knee 11	6	0.175; 0.740	0.475; 0.341	-0.175; 0.740	-0.369; 0.472
Knee 13	4	0.185; 0.815	0.759; 0.241	0.602; 0.398	0.774; 0.226
Knee 14	13	-0.125; 0.685	-0.173; 0.572	0.371; 0.212	0.314; 0.297
Knee 15	9	0.493; 0.177	0.424; 0.256	0.409; 0.275	0.363; 0.337
Knee 16 Left	17	-0.302; 0.239	-0.411; 0.101	-0.260; 0.314	-0.297; 0.246
Knee 16 Right	Not performed	N/A	N/A	N/A	N/A
Pivot flexion					
Knee 1	Not performed	N/A	N/A	N/A	N/A
Knee 2	Not performed	N/A	N/A	N/A	N/A
Knee 3	Not performed	N/A	N/A	N/A	N/A
Knee 4	15	0.300; 0.278	-0.255; 0.358	-0.171; 0.542	0.137; 0.627
Knee 5	27	0.554; 0.003*	0.123; 0.541	-0.767; < 0.001*	0.004; 0.985
Knee 6	16	0.779; < 0.001*	0.844; < 0.001*	-0.707; 0.002*	-0.727; 0.001*
Knee 7	Not performed	N/A	N/A	N/A	N/A
Knee 8	11	0.415; 0.205	-0.675; 0.023*	0.465; 0.150	-0.559; 0.074
Knee 9	Not performed	N/A	N/A	N/A	N/A
Knee 10	9	-0.504; 0.167	0.519; 0.152	0.351; 0.354	-0.542; 0.131
Knee 11	25	0.220; 0.291	0.206; 0.324	0.344; 0.092	-0.495; 0.012*
Knee 13	Not performed	N/A	N/A	N/A	N/A
Knee 14	15	-0.319; 0.246	0.017; 0.952	-0.396; 0.144	-0.254; 0.361
Knee 15	24	0.444; 0.030*	0.602; 0.002*	-0.430; 0.036*	-0.646; 0.001*
Knee 16 Left	13	-0.530; 0.062	-0.096; 0.756	0.717; 0.006*	0.077; 0.802
Knee 16 Right	24	-0.044; 0.837	-0.457; 0.025*	-0.108; 0.614	0.097; 0.652
Step up and down					
Knee 1	26	-0.049; 0.810	0.115; 0.575	N/A	N/A
Knee 2	92	-0.076; 0.470	-0.350; 0.001*	N/A	N/A
Knee 3	63	0.444; < 0.001*	0.242; 0.056	N/A	N/A
Knee 4	141	-0.070; 0.407	-0.156; 0.064	N/A	N/A
Knee 5	36	0.605; < 0.001*	-0.460; 0.005*	N/A	N/A
Knee 6	89	-0.194; 0.069	-0.621; < 0.001*	N/A	N/A
Knee 7	79	0.538; < 0.001*	-0.171; 0.133	N/A	N/A
Knee 8	82	-0.095; 0.394	-0.180; 0.107	N/A	N/A
Knee 9	59	0.661; < 0.001*	0.262; 0.045*	N/A	N/A
Knee 10	23	0.414; 0.049*	-0.038; 0.862	N/A	N/A
Knee 11	52	0.646; < 0.001*	0.092; 0.516	N/A	N/A
Knee 13	40	0.306; 0.055	-0.042; 0.796	N/A	N/A
Knee 14	70	0.477; < 0.001*	0.040; 0.740	N/A	N/A
Knee 15	61	0.508; < 0.001*	-0.008; 0.949	N/A	N/A
Knee 16 Left	61	0.093; 0.474	-0.091; 0.488	N/A	N/A
Knee 16 Right	48	0.124; 0.399	-0.279; 0.054	N/A	N/A

*Statistically significant
N/A, not applicable

Table iv. Separation events for individual knees during dynamic activities

Separation event	Number of poses	Number of captured instances of separation							
		0.5 mm		0.75 mm		1.0 mm		2.4 mm	
		Lateral	Medial	Lateral	Medial	Lateral	Medial	Lateral	Medial
Hyperextension									
Knee 1	Not performed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Knee 2	Not performed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Knee 3	Not performed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Knee 4	16	1	0	0	0	0	0	0	0
Knee 5	18	0	1	0	0	0	0	0	0
Knee 6	24	18	5	6	0	0	0	0	0
Knee 7	28	7	0	3	0	1	0	0	0
Knee 8	7	3	0	0	0	0	0	0	0
Knee 9	27	0	0	0	0	0	0	0	0
Knee 10	8	0	0	0	0	0	0	0	0
Knee 11	Not performed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Knee 13	Not performed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Knee 14	14	0	0	0	0	0	0	0	0
Knee 15	Not performed	N/A	N/A	N/A	N/A	N/A	0	0	0
Knee 16 Left	22	0	0	0	0	0	0	0	0
Knee 16 Right	18	1	0	0	0	0	0	0	0
Pivot extension									
Knee 1	31	0	0	0	0	0	0	0	0
Knee 2	16	0	0	0	0	0	0	0	0
Knee 3	30	1	0	0	0	0	0	0	0
Knee 4	24	1	2	0	0	0	0	0	0
Knee 5	Not performed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Knee 6	27	19	9	4	1	1	0	0	0
Knee 7	37	3	0	0	0	0	0	0	0
Knee 8	27	5	0	0	0	0	0	0	0
Knee 9	27	2	0	0	0	0	0	0	0
Knee 10	13	0	0	0	0	0	0	0	0
Knee 11	6	0	0	0	0	0	0	0	0
Knee 13	4	0	0	0	0	0	0	0	0
Knee 14	13	0	0	0	0	0	0	0	0
Knee 15	9	3	0	0	0	0	0	0	0
Knee 16 Left	17	1	0	0	0	0	0	0	0
Knee 16 Right	Not performed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pivot flexion									
Knee 1	Not performed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Knee 2	Not performed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Knee 3	Not performed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Knee 4	15	0	0	0	0	0	0	0	0
Knee 5	27	9	14	7	5	0	0	0	0
Knee 6	16	7	2	3	0	1	0	0	0
Knee 7	Not performed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Knee 8	11	1	0	0	0	0	0	0	0
Knee 9	Not performed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Knee 10	9	2	0	0	0	0	0	0	0
Knee 11	25	2	0	0	0	0	0	0	0
Knee 13	Not performed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Knee 14	15	1	0	0	0	0	0	0	0
Knee 15	24	8	1	3	0	1	0	0	0
Knee 16 Left	13	0	0	0	0	0	0	0	0
Knee 16 Right	24	0	0	0	0	0	0	0	0
Step up and down									
Knee 1	26	2	0	0	0	0	0	0	0
Knee 2	92	3	0	0	0	0	0	0	0
Knee 3	63	6	0	1	0	0	0	0	0
Knee 4	141	6	0	1	0	0	0	0	0
Knee 5	36	5	10	1	2	0	0	0	0
Knee 6	89	50	18	27	0	7	0	0	0
Knee 7	79	12	7	2	1	0	0	0	0
Knee 8	82	8	0	1	0	0	0	0	0
Knee 9	59	21	2	15	1	7	0	0	0
Knee 10	23	7	0	2	0	1	0	0	0
Knee 11	52	11	0	3	0	1	0	0	0
Knee 13	40	7	1	5	0	2	0	0	0
Knee 14	70	10	0	1	0	0	0	0	0
Knee 15	61	13	0	5	0	2	0	0	0
Knee 16 Left	61	1	1	0	0	1	0	0	0
Knee 16 Right	48	3	0	0	0	1	0	0	0

N/A, not applicable