TABLE E-1 Design Features of Studies Included in the Systematic Review

Study	Year	Design	Generation of Control	Navigation	System§	Implant: Navigated§	Implant: Conventional§
Anderson et al.[14]	2005	Matched-pair	Historic control	Image-less	Stryker	Scorpio	Scorpio
Bäthis et al.[15]	2004	qRCT	Day of surgery	Image-less	BrainLab	PFC Sigma	PFC Sigma
Böhling et al.[16]*	2005	qRCT	Alternating	CT-based	Surgetics	Genia	Genia
Bolognesi and Hofmann[17]	2005	Retrospective cohort	Historic control	Image-less	Navitrack	Natural Knee II	Natural Knee II
Chauhan et al.[18]	2004	RCT	Block randomization	Image-less	Stryker	Duracon	Duracon
Chin et al.[19]	2005	RCT	Sealed envelopes	Image-less	BrainLab	PFC Sigma	PFC Sigma
Confalonieri et al.[20]	2005	Retrospective cohort	Historic control	Image-less	Orthopilot	Search	TriCCC, Scan Mitab
Cossey and Spriggins[21]‡	2005	Retrospective cohort	Historic control	Image-less	Stryker	EIUS	Allegretto
Daubresse et al.[22]	2005	Retrospective cohort	Historic control	Image-less	Orthopilot	Search	Search
Decking et al.[23]	2005	RCT	Sealed envelopes	Image-less	Orthopilot	Search	Search
Haaker et al.[24]	2005	Matched-pair	Historic control	Image-less	Orthopilot	Search	Search
Hart et al.[25]	2003	Prospective cohort	not specified	Image-less	Orthopilot	NS	NS
Hernandez-Vaquero et al.[26]	2004	RCT	not specified	Image-less	NS	NS	NS
Jenny and Boeri[27] (Jenny 1)‡	2003	Matched-pair	Historic control	Image-less	Orthopilot	Search	Search
Jenny et al.[28] (Jenny 2)	2005	Matched-pair	Historic control	Image-less	Orthopilot	Search	Search
Kalairajah et al.[29] (Kalairajah 1)	2005	RCT	Sealed envelopes	Image-less	Stryker	Scorpio	Scorpio
Kalairajah et al.[30] (Kalairajah 2)	2006	RCT	Toss of a coin	Image-less	Stryker	Scorpio	Scorpio
Keene et al.[31]‡	2006	RCT	Sealed envelopes	Image-less	BrainLab	Preservation	Preservation
Kim et al.[32]‡	2005	Retrospective cohort	Historic control	Image-less	Stryker	Duracon	Duracon
Matsumoto et al.[33]	2004	Matched-pair	Historic control	Image-less	BrainLab	PFC Sigma	PFC Sigma
Mielke et al.[34]	2001	Prospective cohort	Parallel cohort	Image-less	Orthopilot	Search	PFC Sigma
Oberst et al.[35]*	2003	qRCT	Alternating	CT-based	BrainLab	LCS Complete	LCS Complete
Perlick et al.[36] (Perlick 1)	2004	qRCT	Day of surgery	CT-based	BrainLab	PFC Sigma	PFC Sigma
Perlick et al.[37] (Perlick 2)	2004	qRCT	Day of surgery	Image-less			
Perlick et al.[38] (Perlick 3)‡	2004	qRCT	Day of surgery	Image-less	BrainLab	Preservation	Preservation
Perlick et al.[39] (Perlick 4)†	2005	qRCT	Day of surgery	Image-less	BrainLab	PFC Sigma	PFC Sigma
Saragaglia et al.[40]	2001	RCT	not specified	Image-less	Northern Digital	Search	Search
Seon and Song[41]	2005	Prospective cohort	not specified	Image-less	Orthopilot	e-motion	e-motion
Skowroński et al.[42]	2005	Retrospective cohort	Historic control	Image-less	Orthopilot	Search	Search
Sparmann et al.[43]*	2003	qRCT	Availability of equipment	CT-based	Stryker	Duracon	Duracon
Stöckl et al.[44]	2004	RCT	Block randomization	Image-less	Stryker	Duracon	Duracon
Victor and Hoste[45]	2004	RCT	Block randomization	Image-less	iON	Genesis II	Genesis II Smith
Zorman et al.[46]	2005	Retrospective cohort	Historic control	Image-less	BrainLab	LCS Complete	LCS Complete

*Study indexed as RCT, †revision arthroplasty, ‡unicompartimental replacement.
RCT = randomized controlled trial, qRCT = quasi-randomized controlled trial, CT = computed tomography, NS = not specified

§List of manufacturers: Stryker Knee Navigation System, Scorpio, Duracon, and EIUS (Stryker, Kalamazoo, MI, USA); Orthopilot, Search, and e-motion (Aesculap, Center Valley, PA, USA); BrainLab (BrainLab, Westchester, IL, USA); PFC Sigma, Preservation, and LCS Complete (DePuy Orthopaedics, Warsaw, IN, USA); Surgetics (Praxim Medivision, Walpole, MA, USA); Navitrack (Orthosoft, Montreal, Quebec, Canada); Natural Knee II (Zimmer, Warsaw, IN, USA); Northern Digital (Northern Digital, Waterloo, Ontario, Canada); iON (Medtronic SNT, Louisville, CO, USA); Genesis II (Smith & Nephew, Memphis, TN, USA); Genia (Eska, Lübeck, Germany); Allegretto (Sulzer Orthopedics, Freiburg, Germany); TriCCC (Dedienne Santé, Mauguio, France); Scan Mitab (Scandimed, Sjöbo, Sweden)

TABLE E-2 Details of Source Populations*

Author Study	Year	Sample size		Age, years		Gender				Patients with OA		Cementless fixation		Pre-op. mechanical axis, degrees	
		nav	conv	nav	conv	nav		conv		nav	conv	nav	conv	nav	conv
		n	n	Mean (SD)	Mean (SD)	f	m	f	m	n	n	n	n	Mean (SD)	Mean (SD)
Anderson et al.[14]	2005	118	50	68 (11)	67 (12)	69	49	29	21	114	48	NS	NS	184	183
Bäthis et al.[15]	2004	80	80	69 (9)	71 (9)	59	21	53	27	NS	NS	0	0	188 (5)	189 (4)
Böhling et al.[16]	2005	50	50	69 (11)	72 (11)	36	14	39	11	NS	NS	17	29	174 (11)	173 (11)
Bolognesi and Hofmann[17]	2005	50	48	NS	NS	26	24	27	21	NS	NS	13	15	NS	NS
Chauhan et al.[18]	2004	34	36	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Chin et al.[19]	2005	30	60	67 (8)	66 (7)	20	10	47	13	20	46	NS	NS	NS	NS
Confalonieri et al.[20]	2005	38	77	72 (7)	69 (12)	18	20	37	40	38	77	0	0	176 (7)	176 (7)
Cossey and Spriggins[21]	2005	14	14	55 (9)	57 (8)	8	6	10	4	14	14	0	0	NS	NS
Daubresse et al.[22]	2005	50	50	63	61	31	19	35	15	50	50	0	0	NS	NS
Decking et al.[23]	2005	27	25	65 (9)	67 (6)	18	9	17	8	18	21	0	0	NS	NS
Haaker et al.[24]	2005	100	100	68 (10)	69 (9)	34	66	26	74	85	85	0	0	186 (10)	184 (10)
Hart et al.[25]	2003	60	60	69 (8)	69 (7)	50	10	44	16	39	39	NS	NS	185 (8)	184 (9)
Hernandez-Vaquero et al.[26]	2004	20	20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Jenny and Boeri[27] (Jenny 1)	2003	30	30	67 (9)	67 (9)	12	18	12	18	30	30	0	0	188 (3)	188 (3)
Jenny et al.[28] (Jenny 2)	2005	235	235	70 (18)	70 (18)	128	107	128	107			0	0	NS	NS
Kalairajah et al.[29] (Kalairajah 1)	2005	30	30	66 (12)	66 (11)	19	11	18	12	30	30	30	30	NS	NS
Kalairajah et al.[30] (Kalairajah 2)	2006	10	14	64 (10)	63 (10)	4	6	10	4	10	14	10	14	NS	NS
Keene et al.[31]	2006	10	10	60 (7)	60 (7)	3	7	2	8	10	10	NS	NS	NS	NS
Kim et al.[32]	2005	69	78	68 (8)	70 (8)	46	23	52	26	64	77	0	0	NS	NS
Matsumoto et al.[33]	2004	30	30	75 (10)	73 (11)	25	5	25	5	30	30	NS	NS	NS	NS
Mielke et al.[34]	2001	30	30	69	62	17	13	21	9	19	15	NS	NS	NS	NS
Oberst et al.[35]	2003	12	13	NS	NS	NS	NS	NS	NS	12	13	NS	NS	184 (3)	178 (7)
Perlick et al.[36] (Perlick 1)	2004	50	50	66 (13)	72 (9)	40	10	42	8	NS	NS	0	0	187 (5)	189
Perlick et al.[37] (Perlick 2)	2004	40	40	63	64	26	14	28	12	0	0	NS	NS	187	187
Perlick et al.[38] (Perlick 3)	2004	20	20	65 (6)	67 (7)	14	6	12	8	NS	NS	NS	NS	185	186
Perlick et al.[39] (Perlick 4)	2005	25	25	72 (6)	74 (6)	16	9	14	11	NS	NS	NS	NS	NS	NS
Saragaglia et al.[40]	2001	25	25	67 (8)	72 (5)	18	7	17	8	NS	NS	NS	NS	175 (10)	175 (7)
Seon and Song[41]	2005	47	50	67 (11)	65 (9)	NS	NS	NS	NS	NS	NS	0	0	174 (7)	175 (6)
Skowroński et al.[42]	2005	100	100	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sparmann et al.[43]*	2003	120	120	67	66	88	32	79	41	73	69	0	0	NS	NS
Stöckl et al.[44]†	2004	32	32	68 (8)	72 (9)	23	9	22	10	NS	NS	0	0	183 (8)	184 (8)
Victor and Hoste[45]	2004	50	50	72 (7)	70 (11)	37	13	37	13	NS	NS	0	0	180 (10)	182 (9)
Zorman et al.[46]	2005	71	64	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	184 (5)	184 (7)

*SD = standard deviation, f = female, m = male, OA = osteoarthritis, NS = not specified. †Study was terminated early because surgeons did not comply with the protocol (according to author).

TABLE E-3 Patient Flow and Indicators of Violations to the Intent-to-Treat Principle*

Author Study	Year	IRB	Size	Reasons for excluding patients from the final analysis	Patient Flow S	I	D
Anderson et al.[14]	2005	yes	NS	"In the conventional group, 10 patients were excluded because of unsatisfactory radiographs … In the navigation group, 23 patients were excluded because of previous TKA or unsatisfactory radiographs"	NS	203	NS
Bäthis et al.[15]	2004	NS	NS		NS	160	0
Böhling et al.[16]	2005	NS	NS		NS	100	NS
Bolognesi and Hofmann[17]	2005	NS	NS		NS	98	NS
Chauhan et al.[18]	2004	yes	yes		NS	70	NS
Chin et al.[19]	2005	yes	NS		NS	90	NS
Confalonieri et al.[20]	2005	NS	NS	"In order to avoid a surgeon-related bias related to learning curves, the first 10 cases of each of the three different implants have been excluded of the 126 knees in this study, acceptable both pre-operative and post-operative films were available for 115"	389	126	NS
Cossey and Spriggins[21]	2005	NS	NS		NS	29	NS
Daubresse et al.[22]	2005	NS	NS		NS	100	NS
Decking et al.[23]	2005	yes	NS		60	52	0
Haaker et al.[24]	2005	NS	NS	"In the conventional group . . . , a long-leg standing radiograph was available only for the last 120 TKAs"	513	200	NS
Hart et al.[25]	2003	NS	NS		NS	120	NS
Hernandez-Vaquero et al.[26]	2004	NS	NS		NS	40	NS
Jenny and Boeri[27] (Jenny 1)	2003	NS	NS		286	60	NS
Jenny et al.[28] (Jenny 2)	2005	NS	NS		821	470	NS
Kalairajah et al.[29] (Kalairajah 1)	2005	yes	yes		NS	60	NS
Kalairajah et al.[30] (Kalairajah 2)	2006	yes	yes		NS	24	NS
Keene et al.[31]	2006	yes	NS		NS	20	NS
Kim et al.[32]	2005	yes	NS	For the computer group, of the 91 long-standing x-rays, 22 were excluded, whereas for the manual group, of the 122 long-standing x-rays, 42 were excluded	213	147	NS
Matsumoto et al.[33]	2004	NS	NS		NS	66	NS
Mielke et al.[34]	2001	NS	NS	"Two cases were excluded because navigation had to be stopped because of technical difficulties"	NS	62	2
Oberst et al.[35]	2003	NS	NS	"Several cases had to be excluded because of poor quality of CT-scans"	36	25	NS
Perlick et al.[36] (Perlick 1)	2004	NS	NS		NS	100	0
Perlick et al.[37] (Perlick 2)	2004	NS	NS		NS	80	NS
Perlick et al.[38] (Perlick 3)	2004	NS	NS		NS	40	0
Perlick et al.[39] (Perlick 4)	2005	NS	NS		NS	50	0
Saragaglia et al.[40]	2001	NS	NS		NS	50	NS
Seon and Song[41]	2005	yes	NS	"Three knees in the navigation-assisted minimally invasive TKA were excluded due to conversion to conventionally performed TKA (two due to registration failure of the navigation system and one due to surgical exposure difficulties). Two knees in the navigation-assisted minimally invasive group and three knees in the conventionally performed group were lost to follow-up"	NS	92	3
Skowroński et al.[42]	2005	NS	NS		NS	200	NS
Sparmann et al.[43]	2003	yes	NS	"The study excluded 133 cases because a primary, hinged arthroplasty was required to treat 63 patients with severe deformity or instability, or revisions were undertaken because of septic (23) or aseptic (43) loosening. Four patients who were originally allocated to the hand-guided group requested a navigated operation and were therefore also excluded."	373	133	NS
Stöckl et al.[44]	2004	yes	yes	"One patient [in the navigated group] was excluded because of safety concerns"	NS	65	1
Victor and Hoste[45]	2004	NS	yes	"One patient in the CAS group died from unrelated causes, another patient in the CAS group was changed to conventional instrumentation because of a lead failure intraoperatively, and one patient in the conventional group had a hip fracture postoperatively and was excluded"	NS	100	1
Zorman et al.[46]	2005	NS	NS		NS	134	NS

*IRB: institutional review board approval, size: sample size estimation, S: screened, I: included, D: dropped. NS: not specified.

TABLE E-4 Summary of Results, Subgroup Analyses, and Adjusted Estimates*

	Mechanical axes		3° malalignment		2° malalignment	
Subset analyses	WMD (95% confidence interval)	p	RR (95% confidence interval)	p	RR (95% confidence interval)	p
All studies	-0.18 (-0.53 – 0.17)	0.308	0.79 (0.71 – 0.87)	<0.001	0.76 (0.71 – 0.82)	<0.001
Primary surgery	-0.18 (-0.54 – 0.17)	0.316	0.78 (0.71 – 0.87)	<0.001	0.76 (0.71 – 0.82)	<0.001
Revision	-0.10 (-1.42 – 1.22)	0.882	0.83 (0.64 – 1.06)	0.132	NS	–
Total knee replacement	-0.25 (-0.65 – 0.14)	0.209	0.77 (0.68 – 0.87)	<0.001	0.75 (0.70 – 0.82)	<0.001
Hemiarthroplasty	0.19 (-0.25 – 0.63)	0.387	0.92 (0.86 – 0.98)	0.006	0.80 (0.71 – 0.92)	0.001
RCTs only	-0.14 (-1.31 – 1.03)	0.818	0.68 (0.49 – 0.94)	0.019	0.74 (0.58 – 0.93)	0.009
RCTs + qRCTs	-0.18 (-0.91 – 0.55)	0.627	0.76 (0.67 – 0.87)	<0.001	0.78 (0.71 – 0.86)	<0.001
Studies other than RCT	-0.23 (-0.55 – 0.09)	0.157	0.80 (0.72 – 0.89)	<0.001	0.76 (0.71 – 0.82)	<0.001
Image-free navigation	-0.18 (-0.56 – 0.21)	0.367	0.80 (0.74 – 0.86)	<0.001	0.75 (0.70 – 0.81)	<0.001
CT-based navigation	-0.14 (-1.33 – 1.05)	0.821	0.74 (0.39 – 1.41)	0.359	0.87 (0.78 – 0.97)	0.011
Navigation vs extramedullary	0.02 (-2.63 – 2.67)	0.988	0.68 (0.54 – 0.86)	0.002	NS	–
Navigation vs intramedullary	-0.48 (-2.63 – 1.68)	0.663	0.87 (0.67 – 1.14)	0.322	NS	–
Orthopilot (Aesculap, Center Valley, Pennsylvania)	-0.17 (-0.60 – 0.27)	0.451	0.75 (0.69 – 0.81)	<0.001	0.75 (0.69 – 0.81)	<0.001
BrainLab (BrainLab, Westchester, Illinois)	-0.72 (-1.28 – -0.16)	0.012	0.79 (0.74 – 0.85)	<0.001	0.67 (0.54 – 0.82)	<0.001
Random-effects meta-regression	beta (95% confidence interval)	p	beta (95% confidence interval)	p	beta (95% confidence interval)	p
Publication year	0.00 (-0.15 – 0.14)	0.965	-0.02 (-0.09 – 0.04)	0.483	-0.06 (-0.13 – 0.01)	0.071
Mean age, navigated group	0.03 (-0.02 – 0.07)	0.250	-0.01 (-0.04 – 0.02)	0.525	0.00 (-0.03 – 0.03)	0.961
Mean age, conventional group	-0.01 (-0.05 – 0.03)	0.532	-0.02 (-0.04 – 0.01)	0.208	0.00 (-0.03 – 0.02)	0.752
Mean pre-op. mech. axis, navigated group	-0.03 (-0.07 – 0.01)	0.106	0.02 (0.00 – 0.04)	0.102	0.00 (-0.03 – 0.03)	0.986
Mean pre-op. mech. axis, conventional group	-0.03 (-0.06 – 0.01)	0.106	0.02 (0.00 – 0.04)	0.062	0.00 (-0.03 – 0.03)	0.856
Mean BMI, navigated group	0.14 (-0.12 – 0.41)	0.291	0.04 (-0.07 – 0.16)	0.471	0.05 (-0.06 – 0.15)	0.357
Mean BMI, conventional group	0.11 (-0.08 – 0.30)	0.241	0.03 (-0.06 – 0.13)	0.468	0.04 (-0.05 – 0.12)	0.394
Proportion of						
patients with primary OA, navigated group	0.39 (-0.16 – 0.94)	0.163	-0.17 (-0.59 – 0.25)	0.431	-0.04 (-0.44 – 0.35)	0.825
patients with primary OA, conventional group	0.28 (-0.26 – 0.82)	0.316	-0.17 (-0.57 – 0.23)	0.403	-0.11 (-0.49 – 0.27)	0.576

*Beta denotes the slope derived from meta-regression. Mean differences and risk ratios increase with any single unit of the variable of interest. WMD = weighted mean difference, RR = risk ratio, RCT = randomized controlled trial, qRCT = quasi-randomized controlled trial, CT = computed tomography, BMI = body mass index, OA = osteoarthritis, NS = not specified.