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TABLE E-1 Various Short Stem and Conservative Implants Currently Marketed or in Clinical Trials

Type	Manufacturer	Implant Name*	Year Introduced	Surface Coating†	Stem Metal†	Stem Length†
Neck only design						
1A	CDD	TSI neck plug	—	NA	NA	NA
1B	Biomet	Primoris	—	NA	NA	NA
1B	DePuy	Silent Hip	2007	Hydroxyapatite coating; stem tip smooth	Ti-V alloy	NA
1B	DePuy	BMHR	—	Proximal porous and HA coating	Ti-V alloy	NA
1C	NA	Spiron	—	Calcium phosphate coating	Ti-V alloy	NA
Calcar loading						
2A	Zimmer	Mayo	1984	Fiber-mesh pads on grit-blasted Ti-Al-V alloy stem	T	81 to 107 mm
2A	Smith & Nephew	Nanos	2003	Proximal calcium phosphate coating (75% of surface) on Ti plasma-sprayed porous surface	Ti alloy	NA
2A	Permedica	PROMISE	—	Proximal HA coating	NA	NA
2A	Implantcast	Aida	2008	Proximal dual coat of Ti and HA	NA	NA
2A	Aesculap (B.Braun)	Metha	2007	20-μm surface proximal coating of calcium phosphate on a titanium plasma-sprayed porous surface in the proximal 2/3 of the stem	Ti alloy	97 to 122 mm
2A	OMNI life science	APEX ARC	2011	Pure Ti plasma-sprayed proximally coated	Ti alloy	NA
2A	Lima	COLLO-MIS	—	Proximal HA coating		NA
2B	Link	CFP	1996	70-mm microporous proximal surface; in addition, the microporous surface is provided with a 20-μm HA (calcium phosphate) coating; distal 1/3 is smooth	Ti alloy	95-135 mm

continued

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TABLE E-1 (*continued*)

Type	Manufacturer	Implant Name*	Year Introduced	Surface Coating†	Stem Metal†	Stem Length†
2B	Orthodynamics	ESKA-Cut	2000	Surface has a macroporous open-meshed metal surface structure to facilitate bone ingrowth	Co-Cr alloy	70 to 110 mm
2B	Corin	MiniHip		HA coating	Ti alloy	NA
2C	Gothenburg, Sweden	GOT	1992	All bone-contacting surfaces were ceramic bead blasted to surface roughness of 1 μm Ra	Titanium	40 mm
2D	—	TPP	—	All Ti surfaces in contact with bone are textured and sand blasted	Ti alloy; central bolt is Co-Cr-Mo alloy	NA
Calcar loading-lateral flare						
3	DePuy	PROXIMA	2006	Full HA coating	Ti alloy	NA
3	Permedica	Pegasus	–	Plasma-sprayed HA coating	NA	NA
3	Biomet	GTS	–	Grit-blasted Ti surface	Ti alloy	NA
Shortened tapered stem						
4	Biomet	TaperLoc Microplasty	2005	Proximal plasma-sprayed surface-coated porous	Ti alloy	96 to 132 mm
4	Biomet	Balance Microplasty	2007	Plasma-sprayed surface-coated fully porous-coated except distal tip	Ti alloy	80 mm
4	Zimmer	Fitmore	2008	Proximal Ti plasma coating	Ti alloy	44 to 60 mm
4	Smith & Nephew	SMF	2011	Proximal porous coating of pure Ti	Ti alloy	NA
4	Stryker	Citation	2000	Dual coat Ti plasma spray and HA	Ti alloy	70 to 125 mm

*CFP = collum femoris preserving, GOT = Gothenberg osseointegrated hip, BMHR = Birmingham Mid-Head Resection, TPP = thrust plate prosthesis, GTS = global tissue sparing, and SMF = short modular femoral hip system. †NA = not available, HA = hydroxyapatite, Co = cobalt, Cr = chromium, Mo = molybdenum, Ti = titanium, V = vanadium, Al = aluminum, and Ra = roughness parameter.

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TABLE E-2 Demographics and Complications Associated with Type-1B Stems*

Study by Stem Type	Level of Evidence	No. of Hips	Mean Age *(yr)*	Mean Follow-up (Range) *(yr)*	Periprosthetic Fracture (Intraop. and Immed. Postop.)
Type 1B - Silent Hip					
Waller[19] (2012)	IV	15	NR	2 (NR)	NR
Type 1B - BMHR					
McMinn et al.[14] (2011)	IV	156	57	3.5 (2 to 7.5)	0% intraop.; 1.2% postop. neck fractures
Rahman and Muirhead-Allwood[12] (2011)	IV	35	50.4	2.8 (2.1 to 4.1)	NR
Daniel et al.[13] (2008)	IV	60	58	2.1 (1.2 to 5.3)	0%

*BMHR = Birmingham Mid-Head Resection, NR = not reported, OHS = Oxford hip score, and HHS = Harris hip score.

TABLE E-2 (*continued*)

Dislocation *(%)*	Thigh Pain *(%)*	Mean HHS/OHS	Stem Subsidence of >2 mm *(%)*	Malalignment *(%)*	Improper Sizing *(%)*	Neck Resorption *(%)*
NR	NR	–/13.8	NR	NR	NR	NR
0	0	–/13	NR	NR	NR	NR
0	NR	96.1/14.2	NR	NR	NR	NR
0	NR	87/14	NR	NR	NR	0

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TABLE E-3 Design, Approach, Conflict of Interest, Funding, and Aseptic Survivorship of Type-1B Stems*

Study by Stem Type	Stem Design (No. of Stems)	Approach	Funding	Templating (Y/N)	Aseptic Survivorship of Stems *(%)*	Overall Survivorship *(%)*
Type 1B – Silent Hip						
Waller[19] (2012)	Straight	NR	NS	N	100	100
Type 1B - BMHR						
McMinn et al.[14] (2011)	Curved (13), straight (87), or VST (56)	Posterior	Grant support from Smith & Nephew; one author listed as consultant and non-executive director for Smith & Nephew	N	98.7	97.4
Rahman and Muirhead-Allwood[12] (2011)	Straight	Posterior	NS	Y†	100	100
Daniel et al.[13] (2008)	Curved (13) or straight (47)	Minimally invasive posterior	Institution of authors received royalties and funding from Smith & Nephew	N	100	100

*NR = not reported, NS = not specified, BMHR = Birmingham Mid-Head Resection, and VST = visual stop technology. †No details given regarding accuracy.

TABLE E-4 Distribution of Diagnosis and Weight-Bearing Protocols in Studies on Type-1B Stems*

	Diagnosis *(no. of patients)*							
Study	Osteoarthritis	Osteonecrosis	Developmental Dysplasia of Hip	Legg-Calvé-Perthes	Rheumatoid Arthritis	Slipped Upper Femoral Epiphysis	Others	Weight-Bearing Protocol
Type 1B - Silent								
Waller[19] (2012)	NR	NR	NR	NR	0	NR	NR	NR
Type 1B - BMHR								
McMinn et al.[14] (2011)	109	4	15	8	0	15	0	50% PWB for 1 mo with 2 crutches; followed by FWB with 2 crutches for 1 mo; and FWB with stick for 1 mo
Rahman and Muirhead-Allwood[12] (2011)	29	4	0	0	0	0	2	PWB for 4 wk with 2 crutches; followed by FWB with assistive devices as tolerated
Daniel et al.[13] (2008)	40	10	7	2	0	1	0	50% PWB for 1 mo with 2 crutches; followed by FWB with 2 crutches for 1 mo; FWB with stick for 1 mo

*NR = not reported, FWB = full weight-bearing, and PWB = partial weight-bearing.

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TABLE E-5 Demographics and Complications Associated with Type-2 Stems*

Study by Stem Type and Design	Level of Evidence	No. of Hips	Mean Age *(yr)*	Duration of Follow-up† *(yr)*	Periprosthetic Fracture (Intraop. and Immed. Postop.)	Hip Dislocation *(%)*	Thigh Pain *(%)*	Mean HHS/OHS	Stem Subsidence of >2 mm *(%)*	Malalignment *(%)*	Improper Sizing *(%)*	Neck Resorption *(%)*
Type 2A – Nanos												
Ettinger et al.[23] (2011)	IV	72	63	5.2 ± 0.7	0%	0	2.8	97.6/–	NR	0	NR	NR
Type 2A – Metha												
Wittenberg et al.[55] (2013)	IV	250	60	4.9 (2.9 to 7.1)	0.8% calcar cracks‡	0	NR	97/–	0.4 (3.2% stem migration)	25.4	NR	2.5% (calcar atrophy)
Floerkemeier et al.[37] (2012)	IV	73	49.4	2.8 (NR)	Metaphyseal 2.7%	0	NR	90.6/–	1.3	NR	NR	NR
Lerch et al.[38] (2012)	IV	19	58.9	2 (NR)	0%	0	NR	94/–	0	NR	NR	Marked decrease in BMD in GT region
Schmidutz et al.[57] (2012)	IV	82	55	2.7 (2 to 4.2)	NR	NR	NR	93.6/–	3.9 (1.3§)	NR	NR	NR
Schmidutz et al.[58] (2012)	IV	76	55	2.7 (2 to 4.2)	NR	NR	NR	93.6/–	5.2	42	NR	NR
Braun and Sabah[56] (2009)	IV	48	54	2.4 (1.9 to 2.8)	2.1%	NR	NR	95/–	14.6	NR	14.6#	NR
Type 2A – Mayo												
Zeh et al.[62] (2011)	III	25	45	7.9 (NR)	NR	NR	NR	93.5/–	0	NR	NR	NR
Cruz-Vazquez et al.[63] (2011)	IV	42	52	5 (0.5 to 9)	7.1% calcar and 2.4% shaft	2.3	2.7	NR	NR	NR	NR	NR
Gagala and Mazurkiewicz[59] (2009)	IV	38	51	2 (1 to 4)	NR	2.6	NR	96/–	2.6	NR	NR	NR
Goebel and Schultz[60] (2009)	IV	30	57.4	6.8 (5.6 to 7.2)	No intraop; 3.3% immed. postop.	0	NR	16**	3.3	NR	3.3	6.7
Gilbert et al.[61] (2009)	IV	49	57.8	3.1 (2.3 to 4.7)	1 intraop. and 1 postop.††	2	2	–/ 19.6	2	68.2‡†	NR	4.1
Falez et al.[30] (2008)	IV	160	63.4	4.7 (1 to 7)	2.5% intraop.; 0.62% postop. due to unstable stem	NR	NR	NR	NR	NR	NR	NR
Morrey et al.[29] (2000)	IV	159	50.8	6.5 (2 to 13)	6.2% intraop. undisplaced calcar fractures	NR	0	90.4/–	7	NR	NR	6
Type 2B – CFP												
Kendoff et al.[64] (2013)	IV	149	63.8	11.2 (9.3 to 14.5)	NR	0.9	NR	93/–	NR	NR	NR	NR
Ghera and Bisicchia[65] (2013)	IV	150	NR	5.5 ± 1.7	0%	0	NR	NR	NR	NR	NR	NR
Li et al.[67] (2012)	IV	48	NR	6.4 (5 to 8)	13.3% lateral femoral wall	0	NR	NR	NR	NR	NR	NR
Kress et al.[66] (2012)	IV	38	59	7 (NR)	NR	NR	NR	NR	NR	NR	NR	NR
Briem et al.[68] (2011)	IV	115	59.3	6.2 ± 0.8	0%	2.6	0	96.3/–	0	5.2	7.8	NR
Nowak et al.[28] (2011)	IV	48	58	6.8 (6.1 to 7.4)	0%	NR	11	94/–	NR	NR	6.3	60.4
Molfetta et al.[69] (2011)	IV	153	NR	3.5 (1 to 12)	NR	0	0.6	92/–	0.6	14	20	5.2
Ding and Zheng[70] (2010)	IV	31	37	5.6 (5 to 8)	3.2%	NR	NR	91.3/–	NR	NR	NR	NR
Pons et al.[74] (2010)	IV	138	57.1	3.2 (0.1 to 8.1)	1.4% (1 metaphyseal and 1 diaphyseal fracture)	0	1.5	92/–	NR	7.2	9.4	8.2
Shang et al.[71] (2010)	IV	28	36	5.8 (5.3 to 7.1)	NR	NR	0	90.2/–	NR	NR	NR	NR
Gill et al.[72] (2008)	IV	75	52	3.6 (1 to 5)	1.3% lateral femoral cortical fracture	2.7	1.3	99/–	11	NR	NR	Calcar atrophy 66

continued

http://dx.doi.org/10.2106/JBJS.M.00780

TABLE E-5 (*continued*)

Study by Stem Type and Design	Level of Evidence	No. of Hips	Mean Age *(yr)*	Duration of Follow-up† *(yr)*	Periprosthetic Fracture (Intraop. and Immed. Postop.)	Hip Dislocation *(%)*	Thigh Pain *(%)*	Mean HHS/OHS	Stem Subsidence of >2 mm *(%)*	Malalignment *(%)*	Improper Sizing *(%)*	Neck Resorption *(%)*
Röhrl et al.[73] (2006)	IV	26	54	2 (NR)	3.8% calcar fracture treated with cerclage wiring	0	NR	93/–	0	60	NR	NR
Pipino[75] (2004)§§	IV	353	60	NR (1-7)	0.5%	NR	2	NR	NR	NR	NR	NR
Pipino et al.[27] (2000)	IV	44	62.5	(13–17)	NR	NR	0	NR	NR	NR	NR	NR
Type 2B – CUT prosthesis												
Nieuwenhuijse et al.[82] (2012)	IV	39	37	5 (4.8 to 9.5)	NR	2.6	5.1	88	7.7	NR	NR	12.8
Steens et al.[76] (2010)	IV	99	50	5.5 (1.7 to 6.5)	1% intraop.	NR	1	98	NR	28	27.3	NR
Ishaque et al.[83] (2009)	IV	82	51.3	8 (1 to 10.2)	2.4% intraop. calcar fracture	NR	3.7	85.1/–	NR	NR	NR	NR
Ender et al.[77] (2007)	IV	123	53	5 (2.9 to 6.9)	0%	0	2.5	92/–	0.8	NR	NR	NR
Rudert et al.[79] (2007)	IV	49	45.1	3.1 (1 to 4.6)	0%	0	NR	95.7/–	NR	NR	NR	NR
Ender et al.[78] (2006)	IV	56	49	4.9 (2.9 to 6.9)	0%	NR	1.7	NR	NR	NR	NR	NR
Ender et al.[80] (2006)	IV	67	56	5.1 (3 to 7)	NR	NR	3.1	90.4/–	1.6	NR	NR	NR
Thomas et al.[81] (2004)	IV	136	55	3.5 (0.3 to 6)	0%	0.7 (1)	NR	NR	NR	NR	NR	NR
Type 2B – MiniHip												
Jerosch et al.[115] (2012)	IV	180	59.2	2.1 (NR)	NR	0	NR	95.7/–	1.7	NR	NR	NR
Type 2B – Delfi M prosthesis												
Budde et al.[116] (2012)	IV	15	51.1	3.1 ± 0.2	0%	0	NR	93.7/–	0	0	NR	NR
Type 2C –GOT												
Carlsson et al.[44] (2006)	II	53	58	3 (NR)	0%	1.9	NR	98/–	NR	NR	NR	4.1
Type 2D – TPP												
Yasunaga et al.[86] (OA group) (2012)	IV	87	55	8.1 (4.6 to 13.4)	0%	3.4	3.4	NR	NR	NR	NR	NR
Yasunaga et al.[86] (ON group) (2012)		92	47.4	8.7 (4.6 to 13.6)	2.2%	2.2	2.2##	NR	NR	NR	NR	NR
Gerich et al.[87] (2011)	IV	58	40.9	2.2 (NR)	NR	NR	NR	NR	NR	NR	NR	NR
Wienbeck et al.[96]§§ (2011)	III	149	<50	NR	0%; 0.6% postop. fracture	0.6	NR	NR	NR	NR	NR	NR
Wienbeck et al.[96]§§ (2011)		316	>50	NR	0%; 1.2% postop. fracture	NR	NR	NR	NR	NR	NR	NR
Karatosun et al.[98] (2010)	IV	15	56.4	6.7 (3 to 9.7)	0%; 6.7% posttraumatic fracture	0	0	92.7/–	NR	NR	NR	NR
Ishaque et al.[83] (2009)	IV	386	54	8 (NR)	0%; 1% postop. fractures	NR	NR	93.7/–	NR	NR	NR	NR
Steens et al.[84] (2009)	IV	53	50	8.1 (4.6 to 9.9)	1%	1.8	15.1	95/–	NR	7.5	NR	7.5
Corner et al.[85] (2008)	IV	41	56	5.9 (5 to 8)	0%; 2.4% prosthesis fracture after fall (1 patient)	0	19.5	88/–	NR	NR	NR	NR
Fink et al.[88] (2007)	IV	214	50	5.3 (0.9 to 4.1)	0.5% spontaneous postop. fracture	3.3	2.8	91.2/–	NR	NR	NR	20.6

continued

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TABLE E-5 (*continued*)

Study by Stem Type and Design	Level of Evidence	No. of Hips	Mean Age *(yr)*	Duration of Follow-up† *(yr)*	Periprosthetic Fracture (Intraop. and Immed. Postop.)	Hip Dislocation *(%)*	Thigh Pain *(%)*	Mean HHS/OHS	Stem Subsidence of >2 mm *(%)*	Malalignment *(%)*	Improper Sizing *(%)*	Neck Resorption *(%)*
Jacob et al.[48] (2007)	IV	102	50.5	12 (NR)	1%	0	NR (2##)	97.1/–	0	NR	NR	13
Karatosun et al.[89] (2006)	IV	19	49	3.7 (2 to 6)	0%	0	NR	97/–	NR	NR	NR	NR
Buergi et al.[90] (2005)	IV	102	50.5	4.8 (2 to 8)	0.9%	NR	NR (2##)	96/–	NR	NR	NR	14.2
Sharma et al.[91] (2005)	IV	63	42.3	4 (1 to 8.5)	NR	3.1	3.1	NR	NR	NR	NR	NR
Karatosun et al.[97] (2005)	IV	67	60	3.1 (2 to 6)	1.4% intraop.; 2.9% postop.	0	NR	NR	NR	NR	NR	NR
Zelle et al.[92] (2004)	IV	58	40.9	2.2 ± 0.9	NR	8.6	68.9##	73/–	NR	6	NR	NR
Yasunaga et al.[95] (2003)	IV	31	50	4.7 (3.2 to 6)	0%	0	NR	16.6**	NR	NR	NR	12.9% Grade 1
Steens et al.[94] (2003)	III	37	47.8	2.1 (0.8 to 5)	NR	1.9	NR	85.7/–	NR	NR	NR	21.5***
Type 2D – Custom Prosthesis												
Munting et al.[93] (1997)	IV	48	36	5.8 (4 to 6)	NR	NR	0	97.8/–	0	NR	NR	NR

*NR = not reported, CFP = collum femoris preserving, GOT = Gothenberg osseointegrated hip, TPP = thrust plate prosthesis, OA = osteoarthritis, ON = osteonecrosis, BMD = bone mineral density, and GT = greater trochanter. †The values are given as the mean and the standard deviation or the mean, with the range in parentheses. ‡Intraoperatively, 0.8% of hips had calcar fractures and 0.4% had a shaft fracture; the overall rate of intraoperative fractures was 1.2%. §Progressive subsidence. #Undersizing. **Merle D'Aubigne score. ††In one patient, fracture was recognized intraoperatively and treated with cerclage wiring, while in the second patient, fracture recognized on first postoperative day and required a stem revision. ‡‡Varus and valgus alignment. §§The study was excluded from the final review because of the lack of adequate data metrics reported. ##Leash pain (i.e., pain over the lateral plate). ***Osteolysis of the greater trochanter.

TABLE E-6 Design, Approach, Conflict of Interest, Funding, and Aseptic Survivorship of Type-2A Stems

Study by Stem Design*	Approach†	Funding†	Templating† (Y/N)	Aseptic Survivorship of Stem (%)	Overall Survivorship† (%)
Type 2A - Nanos					
Ettinger et al.[23] (2011)	Lateral	No funding and no COI		100	97.3
Type 2A - Metha					
Wittenberg et al.[55] (2013)	Anterolateral	Authors developed the investigated short hip-stem device with B.Braun-Aesculap (Tuttlingen, Germany)	N	98.5	92
Floerkemeier et al.[37] (2012)	Anterolateral, lateral, posterior	Three authors were paid instructors for B.Braun-Aesculap	N	100	96
Lerch et al.[38] (2012)	Lateral	German Research foundation (DFG) for financial support; no COI	N	100	NR
Schmidutz et al.[57] (2012)	Minimally invasive surgery, anterolateral	No funding; authors had research support and/or held paid lectures for B.Braun-Aesculap, not related to this study	Y; no details regarding accuracy	100	NR
Schmidutz et al.[58] (2012)	Minimally invasive surgery, anterolateral	One or more authors received reimbursement for attending a symposium, or received fees for speaking or organizing an educational program from B.Braun-Aesculap		100	NR
Braun and Sabah[56] (2009)	Anterolateral (n = 32) and posterior (n = 18)	Funding not specified; no COI	N	98	96
Type 2A – Mayo					
Zeh et al.[62] (2011)	NS	Funding not specified; no COI	N	100	100
Cruz-Vazquez et al.[63] (2011)	NS	No funding	N	100	97.7
Gagala and Mazurkiewicz[59] (2009)		NS	NS	97.4	NR
Goebel and Schultz[60] (2009)	Posterior	Funding not specified; no COI	N; advised that it should be used	100	90
Gilbert et al.[61] (2009)	Anterolateral	No funding	N	96	90
Falez et al.[30] (2008)	NS	NS	N	98.8	97.5
Morrey et al.[29] (2000)	Anterolateral	No funding	N	98.2	88

*The Nanos stem is a tapered wedge design, and the Metha and Mayo stems are a tapered wedge, angulated design. †COI = conflict of interest, NS = not specified, and NR = not reported.

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TABLE E-7 Distribution of Diagnosis and the Weight-Bearing Protocols in Studies on Type-2A Stems*

Study by Stem Design	Diagnosis (*no. of hips*)							Weight-Bearing Protocol
	Osteoarthritis	Osteonecrosis	Developmental Dysplasia of Hip	Legg-Calvé-Perthes	Rheumatoid Arthritis	Slipped Upper Femoral Epiphysis	Others	
Type 2A – Nanos								
Ettinger et al.[23] (2011)	56	5	9	0	0	0	2	Immed. FWB
Type 2A – Metha								
Wittenberg et al.[55] (2013)	195	5	40	0	0	0	10	NS
Floerkemeier et al.[37] (2012)	0	73	0	0	0	0	0	FWB
Lerch et al.[38] (2012)	Osteoarth. or osteonec.; distribution not defined		0	0	0	0	0	Immed. FWB
Schmidutz et al.[57] (2012)	34	20	24	0	3	0	1	PWB × 2 wk followed by FWB
Schmidutz et al.[58] (2012)	32	17	23	0	3	0	1	Restricted WB × 6 wk; details not provided
Braun and Sabah[56] (2009)	29	7	12	2	0	0	0	NS
Type 2A – Mayo								
Zeh et al.[62] (2011)	0	26	0	0	0	0	0	Immed. FWB with 2 crutches
Cruz-Vazquez et al.[63] (2011)	12	4	7	1	2	1	15	NS
Gagala and Mazurkiewicz[59] (2009)	17	17	4	0	0	0	0	NS
Goebel and Schultz[60] (2009)	Primary or secondary osteoarth.; distribution not specified	NS	NS	NS	NS	NS	NS	FWB after 10 days
Gilbert et al.[61] (2009)	44	0	0	0	5	0	0	NS
Falez et al.[30] (2008)	129	15	3	0	0	0	13	NS
Morrey et al.[29] (2000)	99	23	14	0	13	5	7	NS

*WB = weight-bearing, FWB = full weight-bearing, PWB = partial weight-bearing, and NS = not specified.

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TABLE E-8 Design, Approach, Conflict of Interest, Funding, and Aseptic Survivorship of Type-2B Stems

Study by Stem Design*	Approach†	Funding†	Templating† (Y/N)	Aseptic Survivorship of Stems *(%)*	Overall Survivorship† *(%)*
Type 2B - CFP					
Kendoff et al.[64] (2013)	Posterior	One author on speakers bureau for Waldemeyer Link	Y; details not provided	96.6	91.5
Ghera and Bisicchia[65] (2013)	Posterolat. or anterior	No benefits or funding and no COI	Y; details not provided	100	100
Li et al.[67] (2012)	NS	NS	N	100	100
Kress et al.[66] (2012)	NS	NS	N	98	NR
Briem et al.[68] (2011)	Posterior	Authors received funding for scientific presentations for Waldemeyer Link (Hamburg, Germany)	N	99.4	94.2
Nowak et al.[28] (2011)	Lateral	Study supported by grant from Link (Hamburg, Germany); no COI	N	98	98
Molfetta et al.[69] (2011)	Lateral or anterolat.	No benefits or funding and no COI	N	98.7	98.7
Ding and Zheng[70] (2010)	NR	NR	N	100	NR
Pons et al.[74] (2010)	Posterolat.	No benefits or funding and no COI	N	100	97.9
Shang et al.[71] (2010)	NR	NR	N	100	NR
Gill et al.[72] (2008)	Posterior	No funds or benefits and no COI	N	100	97
Röhrl et al.[73] (2006)	Posterolat.	One or more of the authors received funding from Link	N	100	100
Pipino[75] (2004)	Lateral	NA	N	100	NR
Pipino et al.[27] (2000)	Lateral	NA	N	100	80
Type 2B – CUT					
Nieuwenhuijse et al.[82] (2012)	Lateral	Funded by European Information and Communication Technologies Community Seventh Framework Program	Y; details not provided	100	95
Steens et al.[76] (2010)	Anterolat. or posterior	Funding not reported and no COI	N	98	93.9
Ishaque et al.[83] (2009)	NR	Funding not reported and no COI	N	69.6	57.3
Ender et al.[77] (2007)	Anterolat.	No benefits or funding and no COI	N	94.3	89.4
Rudert et al.[79] (2007)	Posterior or anterolat.	NS	Y; details not provided	95.9	91.9
Ender et al.[78] (2006)	Anterolat.	No benefits or funding and no COI	Y; details not provided	92.9	89.3
Ender et al.[80] (2006)	Anterolat.	NS	Y; details not provided	95.3	89
Thomas et al.[81] (2004)	Lateral	No funding; COI as author in scientific advisor panel for ESKA implants	Y; details not provided	97.1	96.4
Type 2B – MiniHip					
Jerosch et al.[115] (2012)	NS	NS	N	98	NR
Type 2B – Custom					
Budde et al.[116] (2012)	Lateral	NS	N	93.4	86.7

*The CFP (collum femoris preserving) and CUT designs are cylindrical calcar-loading prostheses. †NS = not specified, and NR = not reported. ‡COI = conflict of interest.

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TABLE E-9 Distribution of Diagnosis and Weight-Bearing Protocols in Studies on Type-2B Stems

Study by Stem Design†	Diagnosis* *(no. of hips)*						Weight-Bearing Protocol†
	Osteoarthritis	Osteonecrosis	Developmental Dysplasia of Hip	Legg-Calvé-Perthes	Rheumatoid Arthritis	Slipped Upper Femoral Epiphysis	
Type 2B – CFP							
Kendoff et al.[64] (2013)	NS	NS	NS	NS	NS	NS	PWB for 3 wk followed by FWB
Ghera and Bisicchia[65] (2013)	NS	NS	NS	NS	NS	NS	TTWB for 3 wk; 50% PWB for 2 wk followed by FWB
Li et al.[67] (2012)	20	13	4	1	3	0	NS
Kress et al.[66] (2012)	NS	NS	NS	NS	NS	NS	PWB with 15-kg weight-bearing; FWB after 6 wk
Briem et al.[68] (2011)	85	22	23	1	3	0	PWB with 30 kg for 3 wk followed by progression to FWB
Nowak et al.[28] (2011)	21	6	22	0	0	0	Postop. PWB for 6 wk; FWBAT after 3 mo.
Molfetta et al.[69] (2011)	128	5	11	0	6	0	PWB with 2 crutches for 20 days followed by FWB
Ding and Zheng[70] (2010)	9	7	3	0	2	0	NS
Pons et al.[74] (2010)	117	Remaining not defined	NS	NS	NS	NS	Immed. PWB followed by FWB at 3 wk with 1 crutch or cane
Shang et al.[71] (2010)	0	28	0	0	0	0	NR
Gill et al.[72] (2008)	56	3	1	2	8	2	Immediate FWBAT
Röhrl et al.[73] (2006)	24	0	1	1	0	0	PWB for 6 wk
Pipino[75] (2004)§	NA	NA	NA	NA	NA	NA	NA
Pipino et al.[27] (2000)	NA	NA	NA	NA	NA	NA	NA
Type 2B – CUT							
Nieuwenhuijse et al.[82] (2012)	9	9	4	0	6	1	Minimal WB with 2 crutches for 3 wk, PWB with 1 crutch for 3 wk, and then FWB
Steens et al.[76] (2010)	41	6	52	0	0	0	FWB for 71 hips; remaining 28 hips had PWB for 6 wk
Ishaque et al.[83] (2009)	52	14	7	0	5	1	PWB with 10 kg for 6 wk followed by FWB
Ender et al.[77] (2007)	91	24	8				Immed. FWB or PWB after surgery
Rudert et al.[79] (2007)	17	22	8	1	0	0	10-kg partial loading for 4 wk
Ender et al.[78] (2006)	35	15	6	0	0	0	FWBAT from postop. day 1
Ender et al.[80] (2006)	56	2	9	0	0	0	50% PWB immed. after surgery; duration NS
Thomas et al.[81] (2004)	NS	NS	NS	NS	NS	NS	NWB for 6 wk then 10 kg every 2 days to FWB
Type 2B – MiniHip							
Jerosch et al.[115] (2012)	NS	NS	NS	NS	NS	NS	NS
Type 2B – Custom							
Budde et al.[116] (2012)	NS	NS	NS	NS	NS	NS	NS

*NS = not specified, and NA = not available. †CFP = collum femoris preserving. ‡FWB = full weight-bearing, FWBAT = full weight-bearing as tolerated, PWB = partial weight-bearing, TTWB = toe-touch weight-bearing, and WB = weight-bearing. §Excluded from final analysis because of a lack of adequate data.

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TABLE E-10 Design, Approach, Conflict of Interest, Funding, and Aseptic Survivorship of Type-2C Stems

Study	Stem Design	Stem Name*	Approach	Funding	Templating	Aseptic Survivorship of Stems *(%)*	Overall Survivorship *(%)*
Carlsson et al.[44] (2006)	Collared calcar loading design, which has a differential threaded design (17 to 24 mm proximally and 10 mm distally)	GOT	Anterolat.	Authors designed GOT hip; funding not specified	No	96.3	92.5

*GOT = Gothenberg osseointegrated hip.

TABLE E-11 Distribution of Diagnosis and Weight-Bearing Protocols in Studies on Type-2C Stems

	Diagnosis*							
Study	Osteoarthritis	Osteonecrosis	Developmental Dysplasia of Hip	Legg-Calvé-Perthes	Rheumatoid Arthritis	Slipped Upper Femoral Epiphysis	Other	Weight-Bearing Protocol†
Carlsson et al.[44] (2006)	NS	NS	NS	NS	NS	NS	NS	PWB for 6 wk and then FWB

*NS = not specified. †PWB = partial weight-bearing, and FWB = full weight-bearing.

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TABLE E-12 Design, Approach, Conflict of Interest, Funding, and Aseptic Survivorship of Type-2D Stems

Study by Stem Design and Name*	Approach†	Funding†	Templating (Y/N)	Aseptic Survivorship of Stems *(%)*	Overall Survivorship *(%)*
Type 2D – TPP					
Yasunaga et al.[86] (OA group) (2012)	Posterior	No benefits or funding and no COIs	N	97.8	97.8
Yasunaga et al.[86] (ON group) (2012)	Posterior	No benefits or funding and no COIs	N	98.9	94.6
Gerich et al.[87] (2011)	NA	NA	N	93.1	NA
Wienbeck et al.[96]‡ (2011)	Lateral	NA	N	97.4	96
Wienbeck et al.[96]‡ (2011)	Lateral	NA	N	93.4	87.4
Karatosun et al.[98] (2010)	Lateral	NA	N	93.3	93.3
Ishaque et al.[83] (2009)	NA	NA	N	96.9	92.3
Steens et al.[84] (2009)	Posterolat.	NA	N	100	100
Corner et al.[85] (2008)	Posterior	No benefits or funding and no COI	Y (details not specified)	97.6	92.7
Fink et al.[88] (2007)	Anterolat.; posterolat.	No benefits or funding and no COI	N	95.8	89.7
Jacob et al.[48] (2007)	NA	NA	Y (details not specified)	98	96.1
Karatosun et al.[89] (2006)	NA	No benefits or funding and no COI	N	100	100
Buergi et al.[90] (2005)	Posterolat; lateral	No benefits or funding and no COI	N	98.1	96.1
Ishaque et al.[99] (2005)	NA	NA	N	95.7	94.3
Sharma et al.[91] (2005)	Posterolat.	NA	N	92.6	92.1
Karatosun et al.[97] (2005)	NA	NA	N	100	92.6
Zelle et al.[92] (2004)	NA	NA	N	94.9	93.1
Yasunaga et al.[95] (2003)	Posterior	NA	N	96.8	96.8
Steens et al.[94] (2003)	NA	NA	N	94.6	91.9
Type 2D – Custom design by authors					15
Munting et al.[93] (1997)	NA	NA	N	83.3	83.3

*All stems were TPP (thrust plate prosthesis) stems, except for the custom prosthesis used in Munting et al., which was a custom design similar to a thrust plate prosthesis. OA = osteoarthritis, and ON = osteonecrosis. †NA = not available, and COI = conflict of interest. ‡Excluded from final analysis because of a lack of adequate data.

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TABLE E-13 Distribution of Diagnosis and Weight-Bearing Protocols in Studies on Type-2D Stems

Study by Stem Design†	Diagnosis* *(no. of hips)*							Weight-Bearing Protocol‡
	Osteoarthritis	Osteonecrosis	Developmental Dysplasia of Hip	Legg-Calvé-Perthes	Rheumatoid Arthritis	Slipped Upper Femoral Epiphysis	Others	
Type 2D – TPP								
Yasunaga et al.[86] (OA group) (2012)	87	0	0	0	0	0	0	TWB within 7 days and FWB after 8 wk
Yasunaga et al.[86] (ON group) (2012)	0	92	0	0	0	0	0	TWB within 7 days and FWB after 8 wk
Gerich et al.[87] (2011)	NA	NA	NA	NA	NA	NA	NA	NS
Wienbeck et al.[96]§ (2011)	40	45	35	0	4	8	17	NS
Wienbeck et al.[96]§ (2011)	229	31	36	0	8	1	11	NS
Karatosun et al.[98] (2010)	0	0	0	0	0	0	15	PWB for 6 wk followed by FWB for 7 patients; immed. FWB allowed for 8 patients
Ishaque et al.[83] (2009)	221	60	63	5	0	8	29	NS
Steens et al.[84] (2009)	18	15	17	0	2	0	1	Immed. FWB
Corner et al.[85] (2008)	NS	NS	NS	NS	NS	NS	NS	NS
Fink et al.[88] (2007)	104	36	30	0	44	0	0	NS
Jacob et al.[48] (2007)	73	12	3	2	4	3	5	NS
Karatosun et al.[89] (2006)	0	19	0	0	0	0	0	FWB allowed on second day for some patients and at 6 to 8 wk for others
Buergi et al.[90] (2005)	73	11	3	2	4	3	5	PWB for 6 wk
Ishaque et al.[99] (2005)	NS	NS	NS	NS	NS	NS	NS	NS
Sharma et al.[91] (2005)	23	7	8	4	2	1	5	NS
Karatosun et al.[97] (2005)	47	0	5	0	0	2	13	NS
Zelle et al.[92] (2004)	10	13	8	0	2	0	25	15-kg PWB for 6 wk
Yasunaga et al.[95] (2003)	0	31	0	0	0	0	0	TTWB within 7 days and FWB after 8 wk
Steens et al.[94] (2003)	9	15	5	3			1	NS
Type 2D – Custom design by authors								
Munting et al.[93] (1997)	6	12	6	0	4	0	20	NS

*NA = not available, and NS = not specified. †OA = osteoarthritis, and ON = osteonecrosis. ‡TWB = touch weight-bearing, FWB = full weight-bearing, PWB = partial weight-bearing, and TTWB = toe-touch weight-bearing. §Excluded from final analysis because of a lack of adequate data.

TABLE E-14 Demographics and Complications Associated with Type-3 Stems

Study by Stem Design	Level of Evidence	No. of Hips	Mean Age	Mean Follow-up (Range) *(yr)*	Periprosthetic Fracture* (Intraop. and Immed. Postop.)
Type 3 – Proxima					
Kim et al.[101] (2012)	III	256	65	5.6 (5 to 7)	0
Kim et al.[102] (2012)	II	70	74.9	4.1 (2 to 5)	1.4% intraop. fractures treated with cerclage wiring; (1.4% postop. fractures)
Kim et al.[100] (2011)	IV	84	78.9	4.6 (4 to 5)	1.4% intraop. calcar fracture; ORIF with cerclage cables
Kim et al.[103] (2012)	IV	144	53.9	4.5 (4 to 5)	0
Toth et al.[105] (2010)	IV	41	49	2.2 (1.1 to 3.7)	2.4% intraop. fractures; ORIF with plates and screws
Type 3 – Custom made design					
Santori and Santori[104] (2010)	IV	129	51	8 (4.9 to 14.1)	5.4% intraop. fractures; in each case, stem was extracted and cerclage wiring done, after which same implant reinserted

*ORIF = open reduction and internal fixation. †NR = not reported. ‡Stress-shielding in all hips, with grading according to the Engh and Bobyn classification system (Engh CA, Bobyn JD. The influence of stem size and extent of porous coating on femoral bone resorption after primary cementless hip arthroplasty. Clin Orthop Relat Res. 1988 Jun; [231]:7-28). §Nine percent had discomfort around the greater trochanter.

TABLE E-14 (*continued*)

Dislocation *(%)*	Thigh Pain† *(%)*	Mean Harris Hip Score	Stem Subsidence of >2 mm *(%)*	Malalignment *(%)*	Improper Sizing† *(%)*	Neck Resorption‡
0.8	0	93	0.8	5.4	NR	Grade 1
1.4	0§	85.7	0	7	NR	Grade 1
0	0	89	0	5	NR	Grade 1
2.4	0	96	0	6	NR	NR
2.4	NR	88	0	24.3	NR	NR
1.5	0	95	0	11	23.1	8.5%

TABLE E-15 Design, Approach, Conflict of Interest, Funding, and Aseptic Survivorship of Type-3 Stems

Study by Stem Design	Approach	Funding†	Templating (Y/N)	Aseptic Survivorship of Stems *(%)*	Overall Survivorship *(%)*
Type 3 – Proxima*					
Kim et al.[101] (2012)	Posterolat.	Funding not specified; Received royalties from DePuy Johnson & Johnson	N	100	98.9
Kim et al.[102] (2012)	Posterolat.	No funding ; COI not reported	N	100	98.6
Kim et al.[100] (2011)	Posterolat.	Author received benefits from a commercial organization	N	100	98.9
Kim et al.[103] (2012)	Posterolat.	NS	N	100	100
Toth et al.[105] (2010)	Anterolat.	No funding or benefits; COI not reported	N	100	98.6
Type 3 – Custom-made design (Stanmore)‡					
Santori and Santori[104] (2010)	Anterolat. or posterolat.	Author received benefits from a commercial organization	Implants designed on basis of proximal femoral geometry; no details of templating provided	100	96.2

*The Proxima prosthesis is a lateral flare design. †NS = not specified, and COI = conflict of interest. ‡The custom-made prosthesis was a lateral flare design with a titanium-hydroxyapatite coating (a 55-μm layer).

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TABLE E-16 Distribution of Diagnosis and Weight-Bearing Protocols in Studies on Type-3 Stems

Study	Diagnosis *(no. of hips)*							Weight-Bearing Protocol*
	Osteoarthritis	Osteonecrosis	Developmental Dysplasia of Hip	Legg-Calvé-Perthes	Rheumatoid Arthritis	Slipped Upper Femoral Epiphysis	Others	
Type 3 – Proxima								
Kim et al.[101] (2012)	62	120	23	0	0	0	21	Mobilized with frame and progressed from PWB to FWB in immed. postop. period; for the first 6 wk advised use of walking aid
Kim et al.[102] (2012)	0	0	0	0	0	0	All femoral neck fractures	Mobilized with frame and progressed from PWB to FWB in immed. postop. period; for the first 6 wk advised use of walking aid
Kim et al.[100] (2011)	55	17	0	0	0	0	12	Gradual progression from PWB to FWB with crutches in first 6 wk
Kim et al.[103] (2012)	28	88	23	0	0	0	5	Gradual progression from PWB to FWB with crutches in first 6 wk
Toth et al.[105] (2010)	17	16	5	1	0	0	1	PWB with crutches for 4 wk followed by FWB for 2 wk with canes
Type 3 – Custom-made design (Stanmore)								
Santori and Santori[104] (2010)	113	9	0	0	2	0	5	PWB for 2 wk; followed FWB for 2 wk with 2 crutches followed by single crutch for 4 wk

*FWB = full weight-bearing, and PWB = partial weight-bearing.

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TABLE E-17 Demographics and Complications Associated with Type-4 Stems*

Study	Level of Evidence	No. of Hips	Mean Age *(yr)*	Mean Follow-up (Range) *(yr)*	Periprosthetic Fracture (Intraop. and Immed. Postop) *(%)*
Type 4 – Custom					
Patel et al.[106] (2013)	IV	69	56	5.5 (5 to 6.8)	0
Patel et al.[50] (2012)	IV	160	—	2.9 (2 to 5)	0.6†
Stulberg and Dolan[53] (2008)	IV	65	56	2.7 (2 to 3.7)	0
Type 4 – Taperloc Microplasty					
Molli et al.[51] (2012)	III	269	63	2.5 (0.8 to 5.2)	0.4

*NR = not reported. †Intraoperative fracture. ‡The scores are given for patients who were seventy years of age and older and patients who were less than seventy years, respectively.

TABLE E-17 (*continued*)

Dislocation *(%)*	Thigh Pain *(%)*	Mean Harris Hip Score	Stem Subsidence of >2 mm *(%)*	Malalignment *(%)*	Improper Sizing *(%)*	Neck Resorption *(%)*
2.9	0	96	0	0	NR	28.9
NR	0	88 and 93‡	0.6	9.9	NR	NR
3.1	NR	93	NR	NR	NR	0
NR	NR	83.1	NR	NR	NR	NR

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TABLE E-18 Design, Approach, Conflict of Interest, Funding, and Aseptic Survivorship of Type-4 Stems*

Study	Stem Design	Stem Name	Approach	Funding	Templating	Aseptic Survivorship of Stems *(%)*	Overall Survivorship *(%)*
Type 4 – Custom							
Patel et al.[106] (2013)	Shortened conventional stem; custom made	Custom design	Minimally invasive surgery; posterolat.	No benefits or funding and no COI	NA	100	97.1
Patel et al.[50] (2012)	Shortened conventional design	Custom design	Minimally invasive surgery; posterolat.	One author had stock options in Stryker and was a paid consultant of Stryker	NA	100	100
Stulberg and Dolan[53] (2008)	Shortened conventional stem; custom made	Custom design	Posterolat.	No disclosures and no funding for study	CT to generate the customized design	100	96.9
Type 4 – Taperloc Microplasty							
Molli et al.[51] (2012)	Shortened conventional design; flat tapered wedge geometry	Taperloc Microplasty	Minimally invasive surgery lateral; anterior; anterolat.	One or more authors received royalties and institutional support from Biomet	NA	99.6	98.9

*CT = computed tomography, NA = not available, and COI = conflict of interest.

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TABLE E-19 Distribution of Diagnosis and Weight-Bearing Protocols in Studies on Type-4 Stems*

Study	Diagnosis *(no. of patients)*							Weight-Bearing Protocol
	Osteoarthritis	Osteonecrosis	Developmental Dysplasia of Hip	Legg-Calvé-Perthes	Rheumatoid Arthritis	Slipped Upper Femoral Epiphysis	Others	
Type 4 – Custom								
Patel et al.[106] (2013)	NS	NS	NS	NS	NS	NS	NS	Immed. FWB
Patel et al.[50] (2012)	NS	NS	NS	NS	NS	NS	NS	FWB immed. after surgery
Stulberg and Dolan[53] (2008)	62	3	0	0	0	0	0	Immed. FWB
Type 4 – Taperloc Microplasty								
Molli et al.[51] (2012)	209	27	12	1	3	3	14	FWB as tolerated with a frame or crutch

*NS = not specified, and FWB = full weight-bearing.