

Supplementary data

Table 4. Patient characteristics in articles included in the review

Article	Mean age	Sex (female:male)	Diagnoses	Patient details
Lewinnek et al. (1978)	63.1	NA	Yes	Age, sex (D only)
Lindberg et al. (1982)	NA	0.60	Yes	Sex (D only)
Pierchon et al. (1994)	57	0.53	Yes	Age, sex (D only)
Pollard et al. (1995)	52	0.53	Yes (D only)	Age, sex
Paterno et al. (1997)	58.9	0.68	Yes	Sex, age, alcohol intake, obesity
Kennedy et al. (1998)	69	0.33	Yes	Age, sex
Woolson et al. (1999)	64.3	0.50	Yes	Age, sex, obesity
Li et al. (1999)	66	0.55	No	Age, sex, obesity
Jolles et al. (2002)	69	0.57	Yes	Age, sex, alcohol intake
Nishii et al. (2004)	53.7	0.82	Yes	Age, sex
Biedermann et al. (2005)	68	0.58	No	Age + sex (D only w/ revision)
Masaoka et al. (2005)	61.6	0.79	Yes	Age, sex, obesity
Minoda et al. (2006)	62.1	0.90	No	Age, sex, obesity
Rittmeister et al. (2006)	65 (median)	0.61	Yes	Age, sex
Kim et al. (2009)	57	0.37	Yes	Age, sex, obesity
Dudda et al. (2009)	70	0.66	Yes	Age, sex, obesity
Moskal et al. (2011)	59.1	0.42	Incomplete	Age, sex, obesity
Leichtle et al. (2013)	NA	NA	No	No
Jørgensen et al. (2014)	70.0 (median)	0.54	Yes (D only)	Age, sex, obesity, alcohol intake, social, walking aids, CVD, psychiatric, diabetes
Esposito et al. (2014)	66	0.58	Yes	Age, sex, obesity
Grammatopoulos et al. (2015)	37.5	0.62	Yes	Age, sex, obesity
McLawnhorn et al. (2015)	57.7	0.59	Yes	Age, sex, obesity
Fujishiro et al. (2015)	62.5	0.84	Yes	Age, sex
Danoff et al. (2015)	NA	0.57	Yes	Age, sex, obesity
García-Rey et al. (2015)	60.1	0.48	Yes (16% hip dysplasia)	Age, sex, obesity, physical activity
Opperer et al. (2015)	68.9	0.51	Yes	Age, sex
Abdel et al. (2016)	63	0.63	Yes	Age, sex, obesity
Timperley et al. (2016)	68.2	NA	Incomplete	Age

NA: not assessable; D: dislocators; CVD: cardiovascular disease.

Table 5. Study characteristics for articles included in the review

Article	Study type	A	B	C	D	E	F	G	H
Lewinnek et al. (1978)	Case-Control	300 (122)		9	3	Posterolateral	Radiographic: AP	NA	NA
Lindberg et al. (1982)	Case-Control	1739 (295)		56	3.22	Posterolateral	Radiographic: AP - McLarren (A)	NA	NA
Pierchon et al. (1994)	Case-Control	NA (52)		38	NA	Posterolateral	Radiographic: AP, Anatomical: CT (A)	NA	NA
Pollard et al. (1995)	Retrospective Case-Control	97	74	7	7.21	Posterior (84%), direct lateral, transstrochanteric, anterolateral	Radiographic: AP + lateral	NA	≥ 2 y
Paterno et al. (1997)	Case-Control	391 (34)	317	17	4.34	Posterior (98%), transstrochanteric	Radiographic: AP + lateral	28 (98%)	Mean 5–6 y
Kennedy et al. (1998)	Retrospective Cohort Study	75		4	5.33	Posterolateral	Radiographic: AP + axiolateral - Engh et al. (I)	28mm	≥ 4 y
Woolson et al. (1999)	Case-Control		522	14	4.44	Posterior (298 hips) + lateral (228 hips)	Radiographic: AP	28	3 m
Li et al. (1999) Case-Control	Retrospective	812		24	2.96	Posterior (66%), transstrochanteric	Operative: goniometer Radiographic: AP	28	NA
Jolles et al. (2002)	Case-Control	2023 (42)		30 (21)	1.48	Posterolateral	Radiographic: AP + lateral - McCollum & Gray	28	NA
Nishii et al. (2004)	Case-Control	217 (191)	179 (156)	10	4.61	Posterolateral	Anatomical: CT - Mian et al. (A)	28	≥ 2 y
Biedermann et al. (2005)	Case-Control	3781 (433)		91	2.41	Transgluteal	Radiographic: AP (EBRA)	28 (94%)	NA
Masaoka et al. (2005)	Case-Control	317	266	10	3.15	Posterior	Radiographic: AP Lewinnek et al. (A)	28	≥ 5 y
Minoda et al. (2006) Case Series	Retrospective	834		28	3.36	Posterolateral	Radiographic: AP + Judet oblique - Lewinnek, Thoren & Sahlstedt	NA	≥ 3 m
Rittmeister et al. (2006)	Case Series	512 (361)	505	36	7.03	Anterolateral (76%), posterior	Radiographic: AP - Pradhan (A)	NA	18 m
Kim et al. (2009)	Prospective Case-Control	1648	1268	60	3.64	Posterolateral	Anatomical: CT - Mian et al. (A); Plain radiograph reconstruction (I)	28	≥ 2 y
Dudda et al. (2009)	Case-Control		36326	175	0.48	Anterolateral, lateral, posterior	NA	22– 37	NA
Moskal et al. (2011)	Literature Review	(826) 1479		25	1.69	No	NA	NA	NA
Leichtle et al. (2013)	Retrospective Case-Control	5205 (111)		91 (56)	1.75	Transgluteal	Radiographic: AP + 40° rotated tube - Lembeck et al.	NA	NA
Jørgensen et al. (2014)	Retrospective Review of Prospectively- Collected Data	2734		65	2.38	Posterolateral	Radiographic	M	≥ 3 m
Esposito et al. (2014)	Retrospective Case-Control from a Prospective Data Registry	7040 (294)		147	2.09	Posterolateral (98%)	Radiographic: AP + lateral (EBRA)	M	≥ 6 m
Grammatopoulos et al. (2015)	Case-Control	1070		22	2.06	Anterolateral (74%), posterior	Radiographic: AP + lateral (EBRA)	22, 26, 28	5 y
McLawnhorn et al. (2015)	Retrospective Case-Control	553	479	6	1.13	Posterolateral	Operative: CAS + Radiographic: AP (EBRA)	32, 36	≥ 6 m mean 2.4 y
Fujishiro et al. (2015) (71%)	Case-Control from a Data Registry	1555	1294	50	3.22	Posterolateral	Radiographic: AP (I), Anatomical: CT (A)	28	≥ 33 m
Danoff et al. (2015)	Prospective Cohort	1289		42	3.29	Posterior	Radiographic: AP + lateral (HAS)	32 (39%)	≥ 6 m
García-Rey et al. (2015)	Case-Control	1414	1318	38	2.69	Posterolateral	Radiographic: AP - Widmer (A)	28, 32	2

Opperer et al. (2015)	Retrospective Case-Control	1487 (148)	1334	38 (37)	2.56	Posterolateral	Radiographic: AP - (Sectra IDS7 PACS) Lewinnek et al. (A)	28, 32 mean 18 m	1-80 m
Abdel et al. (2016)	Retrospective Case Series	9784 (206)		206	2.11	Posterior (59%), anterolateral, extended troch. osteotomy	Radiographic: AP	NA	0-11 y mean 27 m
Timperley et al. (2016)	Retrospective Case-Control using Prospective Data	1578 (139)		51 (48)	3.23	Posterior (96%)	Radiographic: AP (OrthoView) - Murray	26 (73%), 30 (20%), 28, 22, 32	> 2 m

A Total THA (Study group size)
 B Patient no. (Study group size)
 C Dislocations (Study group size)
 D Dislocation rate (%)
 E Surgical approach
 F Measurement details - reference
 G Femoral head size, mm, M – multiple
 H Follow-up period: y – years, m – months
 AP: anteroposterior; A: anteversion; I: inclination; NA: not assessed; CAS: computer-assisted surgery; EBRA: Ein Bild Roentgen Analyse; HAS: Hip Analysis Suite.

Table 6. Comparison of mean cup placement angles in dislocating and non-dislocating hips

Article	Category	n	Inclination angle (SD) (range), degrees	p-value	Anteversión angle (SD) (range), degrees	p-value
Lewinnek et al. (1978)	Non-dislocators	113	44.4 (7.5)		15.6 (8.5)	
	Dislocators (anterior)	3	49.3	NS	33.0	0.01
Lindberg et al. (1982)	Dislocators (posterior)	5	44.4	NS	19.2	NS
	Non-dislocators	239	47 (8)		4.9 (8.9)	
	Dislocators (recurrent)	11	49 (13)	NS	1.4 (9.4)	NS
Pierchon et al. (1994)	Dislocators (non-recurrent)	34	49 (9)	NS	3.3 (11.8)	NS
	Non-dislocators	14	43.6		22.3	
Pollard et al. (1995)	Dislocators	38	44.5 (30–68)	NS	24.4 (–5 to 45)	NS
	Non-dislocators	90	45.9 (9.3)		17.6 (12.6)	
Paterno et al. (1997)	Dislocators	7	45.0 (7.2)	0.8	12.9 (7.5)	0.3
	Non-dislocators	17	42 (32–54)		NA	
Woolson et al. (1999)	Dislocators	17	44 (39–56)	0.3	NA	
	Non-dislocators	355	40 (8) (15–61)		20	
Li et al. (1999)	Dislocators	14	41 (11) (19–56)	0.7	17	NS
	Non-dislocators	788	43 (5–60)		34 (0–60)	
Jolles et al. (2002)	Dislocators	24	45 (35–68)	NS	35 (20–55)	NS
	Non-dislocators	21	48.6 (46.1–51.0)		29.9 (26.1–33.6)	
Nishii et al. (2004)	Dislocators	21	49.8 (47.1–52.4)	0.4	27.6 (22.2–33.0)	0.5
	Non-dislocators	181	40.5 (5.4)		29.1 (9.8)	
Biedermann et al. (2005)	Dislocators (posterior)	9	39.5 (7.9)	NS	18.1 (11.6)	< 0.005
	Non-dislocators	342	44 (6.9)		14.5 (4.9)	
	Dislocators (anterior)	38	47.9 (7.9)	< 0.05	16.8 (6.5)	< 0.05
Masaoka et al. (2006)	Dislocators (posterior)	37	42.4 (7.7)	0.3	11.0 (5.5)	< 0.01
	Non-dislocators	307	41.5 (8.7)		15.5 (11.9)	
	Dislocators (anterior)	2	47.0 (12.7)	NA	42.0 (12.7)	NA
Minoda et al. (2006)	Dislocators (posterior)	8	46.8 (6.5)	NS	4.5 (6.6)	< 0.01
	Non-dislocators	806	44.3 (6.5) (25–66)		17.9 (6.3) (0–37)	
Kim et al. (2009)	Dislocators	28	45.5 (6.5) (32–58)	0.3	17.6 (7.1) (4–57)	0.8
	Non-dislocators	1,588	42.5 (6.1) (35–58)		29.3 (8.11) (8–37)	
Leichtle et al. (2013)	Dislocators	60	47.3 (9.2) (33–64)	0.02	20.7 (12.8) (–8 to 45)	0.002
	Non-dislocators	55	43		15	
Grammatopoulos et al. (2015)	Dislocators	56	42	> 0.8	14.5	NS
	Non-dislocators	1,048	45.7 (21–74)		10.3 (–16 to 39)	
Fujishiro et al. (2015)	Dislocators	22	47.2 (37–64)	0.5	7.2 (–33 to 20)	0.3
	Non-dislocators	1,505	40.9 (6.05)		24.5 (11.3)	
Garcia-Rey et al. (2015)	Dislocators	50	43.2 (6.04)	NS	23.3 (15.3)	NS
	Dislocators (posterior)	41	42.8 (9.4)	NS	20.1 (13.8)	0.0002
	Dislocators (anterior)	9	40.9 (6.0)	NS	37.7 (14.3)	0.003
Opperer et al. (2015)	(vs. posterior dislocators)					
	(vs. non-dislocators)					
Timperley et al. (2016)	Non-dislocators	1,280	45.6 (6.1)		16.3 (6.7)	
	Dislocators	38	48.8 (10.9)	0.003	16.8 (9.1)	0.7
Timperley et al. (2016)	Non-dislocators	111	40.79 (4.31)		16.62 (5.07)	
	Dislocators	37	41.65 (4.08)	0.1	17.73 (5.77)	0.06
Timperley et al. (2016)	Non-Dislocators	91	45.0 (3.8) (34.8–53.9)		18.6 (9.2) (–0.1 to 45.5)	
	Dislocators	48	44.8 (5.2) (27.8–62.7)	0.8	18.9 (9.3) (3.9 – 38.5)	0.8

NA: not assessed; NS, not significant.

Table 7. Target zone analysis

Article	Total no. of THAs or patients (Study group size)	Dislocations assessed	Inclination, degrees	Anteversion, degrees	Statistical significance for target zone p-value	Other statistical assessment
Lewinnek et al. (1978)	300 (122)	9	30–50	5–25	< 0.045	
Paterno et al. (1997)	391 (34)	17	35–45	NA	0.3	
Woolson et al. (1999)	315	14	35–45	NA	0.5	
Jolles et al. (2002)	2023 (42)	21	NA	< 50	NS	
Nishii et al. (2004)	217 (191)	9	NA	> 20		83% ND vs. 22% D in target zone
Biedermann et al. (2005)	3,781 (433)	91	35–55	5–25	< 0.01	93% ND vs. 67% D in target zone
Masaoka et al. (2006)	317	10	NA	20–30		
Rittmeister et al. (2006)	512 (361)	36	35–55	5–25	0.4	
Kim et al. (2009)	1648	60	NA	10–35		
Dudda et al. (2010)	36,326 (826)	175	45–50	10–15	NS	
Jørgensen et al. (2014)	2734	43	36–60	10–15	0.4	D outside vs. inside: OR 1.52, 95% CI 0.54–4.26
Esposito et al. (2015)	7,040 (294)	147	38–58	14–34		OR 0.70 (D vs. ND inside)
Grammatopoulos et al. (2015)	1070	22	27–57	–3 to 27	0.01	Dislocation rate: 1.8% inside vs. 7% outside
McLawnhorn et al. (2015)	533	6	30–50	15–35	0.3	
Fujishiro et al. (2015)	1,555	50	NA	10–30	0.03 (MV)	D outside vs. inside: MV: OR 1.9, 95% CI 1.08–3.36
Danoff et al. (2015)	1,289	42	30–50	10–25	0.007 (UV) 0.009 (MV)	D outside vs. inside: UV: OR 2.69, 95% CI 1.31–5.52 MV: OR 2.57, 95% CI 1.28–5.56
Garcia-Rey et al. (2015)	1,414	38	35–50 35–50	5–25 15–25	0.001 (UV) < 0.001 (MV) 0.001	D outside vs. inside: UV: 95% CI 2.19–7.83 MV: 95% CI 1.78–6.55

NA: not assessed; NS: not significant; UV: univariate analysis; MV: multivariate analysis; D: dislocators; ND: non-dislocators; OR: odds ratio; CI: confidence interval.