

## Supplementary data

Table 1. Quality assessment using criteria from MINORS score and the Downs and Black checklist

Question (see below):	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL
DeVos 2014	1	1	1	1	0	0	0	0	1	0	1	1	1	1	9
Hansen 2010	1	1	0	0	0	0	0	0	1	0	1	0	1	1	6
Hansen 2011	1	1	0	0	0	0	0	0	1	1	0	1	1	1	7
Hansen 2013	1	1	0	1	1	1	1	1	1	1	1	1	1	1	13
Jonsson 1990	0	0	0	0	0	0	0	0	1	0	1	1	0	0	3
Mechlenburg 2014	1	1	0	1	1	1	1	1	1	1	1	1	1	1	13
Nagels 2002	0	0	1	1	0	0	0	0	1	0	1	1	1	1	7
Nutall 2007	0	0	0	1	1	1	1	1	0	0	1	1	1	1	9
Nutall 2009	1	1	0	1	1	0	0	1	0	0	1	1	1	0	8
Nutall 2012	1	1	0	1	0	0	0	0	0	0	1	1	1	1	7
Nutall 2014	1	0	0	1	1	1	1	1	1	0	1	0	1	1	10
Ooms 2015	1	1	0	0	0	0	0	0	0	0	1	1	1	1	6
Rahme 2004	1	1	0	1	0	0	1	0	1	0	1	1	1	1	9
Rahme 2005	1	1	1	1	0	0	0	0	1	1	1	1	1	1	10
Rahme 2006	1	1	1	1	1	1	1	0	1	1	1	1	1	1	13
Rahme 2009	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
Sköldenberg 2011	1	1	0	0	0	0	0	0	1	0	1	1	1	1	7
Stilling 2012	1	1	1	1	1	1	1	1	1	0	1	1	1	1	13
Streit 2015	1	1	0	1	0	0	0	0	0	0	1	1	1	1	7
Szerlip 2012	1	0	0	0	0	0	0	0	1	0	1	0	1	1	5
Ten Brinke 2016	1	1	1	0	0	0	0	0	1	0	1	1	1	1	8
Valstar 2002	1	1	0	1	0	0	0	0	1	0	1	1	1	1	8
Van der Lugt 2010	0	1	1	1	0	0	0	0	1	0	1	1	1	1	8

  

1	Is the aim of the study clearly described?
2	Are the endpoints appropriate to the aim of the study?
3	Does the study note the inclusion of consecutive patients?
4	Are the characteristics of the patients included clearly described?
5	Did the authors select an adequate control group?
6	Did the authors study contemporary groups?
7	Were the patients in different intervention groups or were the cases and controls recruited from the same population?
8	Is the baseline equivalence of groups clearly described?
9	Have the characteristics of patients who were lost to follow-up been described?
10	Is the prospective calculation of study size described?
11	Is the follow-up time appropriate to the aim of the study?
12	Were the statistical tests that were used to assess the main outcome appropriate?
13	Were the interventions of interest clearly described?
14	Did the study provide estimates of the random variability in the data for the main outcome?

Table 2. RSA-specific quality assessment using criteria from the ISO standard (ISO 16087:2013(E))

Criteria (see below):	1A	1B	2A	2B	2C	2D	3	4	5A	5B	6A	6B	7	8	9A	9B	10A	10B	11A	11B	TOTAL
DeVos 2014	1	1	0	1	1	0	0	1	1	1	1	1	1	1	0	0	1	1	1	1	15
Hansen 2010	1	1	1	1	0	1	1	0	1	1	1	1	1	1	0	0	1	1	1	1	16
Hansen 2011	1	0	0	1	1	0	0	0	0	0	1	1	1	1	0	0	1	1	0	0	9
Hansen 2013	1	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	16
Jonsson 1990	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Mechlenburg 2014	1	1	0	1	1	1	1	0	1	1	1	1	0	1	0	0	1	1	1	0	14
Nagels 2002	1	0	0	1	1	0	1	1	1	1	1	0	1	1	0	0	1	1	1	0	13
Nutall 2007	1	1	0	1	1	1	0	1	0	0	1	1	1	1	0	0	1	1	1	1	14
Nutall 2009	1	1	0	0	1	1	0	1	0	0	1	1	1	1	0	0	0	0	0	1	10
Nutall 2012	1	1	0	0	1	1	0	1	0	0	1	1	1	1	0	0	0	0	0	1	10
Nutall 2014	1	0	0	0	1	1	0	0	1	1	1	0	0	1	0	0	0	0	0	0	7
Ooms 2015	1	1	0	1	1	1	1	0	0	0	1	1	1	1	0	0	1	1	1	1	14
Rahme 2004	1	1	0	1	1	0	1	1	0	0	1	0	1	1	0	0	1	1	1	1	13
Rahme 2005	1	1	0	1	1	0	1	1	0	0	1	0	1	1	0	0	1	1	1	1	13
Rahme 2006	1	1	0	1	1	0	1	1	0	0	1	0	1	1	0	0	1	1	1	1	13
Rahme 2009	1	1	0	1	1	0	1	1	0	0	1	0	1	1	0	0	1	1	1	1	13
Sköldenberg 2011	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	1	1	1	17
Stilling 2012	1	1	0	1	1	1	1	0	1	1	1	1	0	1	0	0	1	1	1	0	14
Streit 2015	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	17
Szerlip 2012	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Ten Brinke 2016	1	1	1	0	1	0	0	0	0	0	1	0	1	1	0	0	0	0	1	1	9
Valstar 2002	1	1	0	1	1	0	1	1	1	1	1	0	1	1	0	1	0	0	1	1	14
Van der Lugt 2010	1	1	0	0	1	0	0	1	1	1	1	0	1	1	0	1	0	0	1	1	12
1A	Translation is expressed in millimetres																				
1B	Rotation is expressed in degrees																				
2A	Accuracy values are presented																				
2B	Precision values are presented																				
2C	Follow-up intervals are mentioned																				
2D	Type of cage and use of reference plates are given																				
3	Experimental setup is standardized or described in detail																				
4	The coordinate systems are described																				
5A	Method of image acquisition is described																				
5B	Scanner or system details are described																				
6A	Software name is stated																				
6B	Software version is stated																				
7	Size of marker beads used are given																				
8	Method of determining the position of implant (marker/model-based) is stated																				
9A	Cutoff level for condition number is stated																				
9B	Cutoff level for rigid body fitting error is stated																				
10A	Precision by double examination is presented																				
10B	Double examinations are performed in a sufficient number of patients																				
11A	Migration data are given in terms of translation (3 degrees of freedom)																				
11B	Migration data are given in angular rotations (3 degrees of freedom)																				

Table 3. Precision and accuracy data from the RSA studies included

Author (year)	Type of implant	Study design	RSA method	Months of follow-up			Precision <sup>b</sup>		Accuracy	
				n	follow-up	CN <sup>a</sup>	trans. (mm)	rotation (°)	trans. (mm)	rotation (°)
<b>Shoulder (glenoid component)</b>										
Nagels et al. (2002)	Polyethylene glenoid comp. (Biomet Inc, Warsaw, Indiana)	Cohort study	Not described	5	36	n/a	0.35	n/a	n/a	n/a
Rahme et al. (2004)	3M Modular (Smith & Nephew, Memphis, Tennessee)	Cohort study	Marker-based	14	24	n/a	0.08-0.15	0.74-0.92	n/a	n/a
Nutall et al. (2007)	Global shoulder arthroplasty system (DePuy, Leeds, UK)	RCT	Marker-based	20	24	n/a	0.13	1.2	n/a	n/a
Rahme et al. (2009)	Bigliani/Flatow total shoulder prosthesis (Zimmer, Warsaw, Indiana)	RCT	Marker-based	26	24	n/a	0.07-0.14	0.68-0.93	n/a	n/a
Nutall et al. (2012)	Global shoulder arthroplasty system (DePuy, Leeds, UK)	Cohort study	Marker-based	11	24	n/a	Nutall (2007)	Nutall (2007)	n/a	n/a
Streit et al. (2015)	Polyethylene glenoid comp. (Arthrex, Naples, USA) or pegged glenoid comp. (Tornier, Edina, USA)	Cohort study	Model-based	11	36	n/a	0.06-0.13	0.48-0.77	n/a	n/a
<b>Shoulder (humeral component)</b>										
Jonsson et al. (1990)	Scan Shoulder cups (MITAB, Sjöbo, Sweden)	Cohort study	Model-based	12	12	n/a	n/a	n/a	n/a	n/a
Rahme et al. (2006)	3M Modular (Smith & Nephew, Memphis, Tennessee)	RCT	Marker-based	25	24	RM: 72 (48-132) IM: 86 (63-139)	0.09-0.49	0.49-0.85	n/a	n/a
Nutall et al. (2009)	Global shoulder arthroplasty system (DePuy, Leeds, UK)	RCT	Marker-based	22	24	n/a	Nutall (2007)	Nutall (2007)	n/a	n/a
Sköldenberg et al. (2011)	Copeland HHRI (Biomet, Warsaw, Indiana)	Phantom study	Marker-based	3	-	n/a	0.02-0.11	0.05-0.33	n/a	n/a
		Phantom study	Marker-free	3	-	n/a	0.15-0.22	0.62-1.73	0.22-0.47	0.92-1.56
Stilling et al. (2012)	Copeland HHRI (Biomet, Warsaw, Indiana) and Global CAP HHRI (DePuy, Leeds, UK)	RCT	Model-based	21	6	n/a	0.60-0.88	10.67	n/a	n/a
Szerlip et al. (2012)	Aequalis Press-Fit Shoulder Prosthesis (Tornier, Edina, USA) and Univers II (Arthrex, Naples, USA)	Cohort study	Marker-based	29	24	n/a	n/a	n/a	n/a	n/a
Nutall et al. (2014)	Global CAP HHRI (DePuy, Leeds, UK)	RCT	Model-based	20	24	n/a	0.16	n/a	n/a	n/a
Mechlenburg et al. (2014)	Copeland HHRI (Biomet, Warsaw, Indiana) and Global CAP HHRI (DePuy, Warsaw, Indiana)	RCT	Model-based	32	24	n/a	0.24-0.45	4.51	n/a	n/a
<b>Elbow (humeral component)</b>										
Valstar et al. (2002)	Souter-Strathclyde (Stryker, Kalamazoo, USA)	Cohort study	Marker-based	18	24	n/a	0.13-0.34	0.23-0.56	n/a	n/a
Van der Lugt et al. (2010)	Souter-Strathclyde (Stryker, Kalamazoo, USA)	Cohort study	Marker-based	18	98 (12-136)	n/a	Valstar (2002)	Valstar (2002)	n/a	n/a
DeVos et al. (2014)	IBP (Biomet, Bridgend, UK)	Cohort study	Marker-based	16	24	n/a	0.08-0.23	0.38-0.76	n/a	n/a
<b>Elbow (ulnar component)</b>										
Valstar et al. (2002)	Souter-Strathclyde (Stryker, Kalamazoo, USA)	Cohort study	Marker-based	15	24	n/a	0.05-0.17	0.16-0.68	n/a	n/a
Rahme et al. (2005)	Kudo (Biomet, South Glamorgan, UK)	Cohort study	Marker-based	13	24	n/a	0.05-0.06	0.30-0.44	n/a	n/a
Van der Lugt et al. (2010)	Souter-Strathclyde (Stryker, Kalamazoo, USA)	Cohort study	Marker-based	15	98 (12-136)	n/a	Valstar (2002)	Valstar (2002)	n/a	n/a

Table 3. Continued

Author (year)	Type of implant	Study design	RSA method	Months of follow-up		CN <sup>a</sup>	Precision <sup>b</sup>		Accuracy	
				n			trans. (mm)	rotation (°)	trans. (mm)	rotation (°)
<b>TMC joint (trapezium component)</b>										
Hansen et al. (2010)	Elektra screw cup (Small Bone Innovations, Les Bruyères, France)	Phantom study Cohort	Model-based	10	-	RM: 121	0.06-0.26	2.32-18.3	n/a	n/a
				5	0	RM: 111 (±76)	0.28-0.45	43.3-124	n/a	n/a
	DLC all-polyethylene cup (Small Bone Innovations, Les Bruyères, France)	Phantom study Cohort	Marker-based	10	-	RM: 86 IM: 180	0.06-0.16	0.77-1.28	n/a	n/a
				6	0	RM: 98 (±47) IM: 198 (±51) n/a	0.89-1.83	70.15-116	n/a	n/a
Hansen et al. (2011)	Elektra screw cup, DLC polyethylene cup (Small Bone Innovations, Les Bruyères, France) and MOTEC screw cup (Swemac AB, Linköping, Sweden)	Animal study	Marker and model-based	36	-	n/a	n/a	n/a	n/a	n/a
Hansen et al. (2013)	Elektra screw cup (Small Bone Innovations, Les Bruyères, France)	RCT	Model-based	10	24	RM: 95 (±32)	0.16-0.73	n/a	n/a	n/a
	DLC all-polyethylene cup (Small Bone Innovations, Les Bruyères, France)	RCT	Marker-based	10	24	RM: 95 (±32) IM: 184 (±48)	0.26-0.59	n/a	n/a	n/a
Ooms et al. (2015)	SR TMC prosthesis (Avanta, San Diego, USA)	Cadaver study	Model-based	5	-	n/a	0.11-0.29	1.47-3.59	n/a	n/a
Ten Brinke et al. (2016)	SR TMC prosthesis (Avanta, San Diego, USA)	Cohort study	Model-based	9	60	n/a	Ooms (2015)	Ooms (2015)	n/a	n/a
<b>TMC joint (metacarpal component)</b>										
Hansen et al. (2010)	Elektra metacarpal stem (Small Bone Innovations, Les Bruyères, France)	Phantom study Cohort	Model-based	10	-	RM: 29	0.18-1.52	0.85-25.7	n/a	n/a
				11	0	RM: 37 (±5.7)	0.22-0.50	10.8-24.9	n/a	n/a
Ooms et al. (2015)	SR TMC prosthesis (Avanta, San Diego, USA)	Cadaver study	Model-based	5	-	n/a	0.19-0.35	2.10-3.45	n/a	n/a

<sup>a</sup> CN: mean condition number (range/SD); RM: reference (bone) markers; IM: implant markers.

<sup>b</sup> Precision values are given as  $1.96 \times SD$ ; trans.: translation

n: number of participants;

n/a: not available;

RCT: randomized controlled trial;

TMC: trapeziometacarpal.