

## APPENDIX E-1 Methodological Details

The effect of each risk factor on the rate is summarized in Table E-2 as the regression coefficient (slope) for that risk in the meta-regression of the rate on the risk factor. A zero value of the slope signifies no association between the factor and the rate. A p value for the null hypotheses of no association and the 95% confidence interval for the slope are also presented.

The interpretation of the magnitude of the slope depends on the type of the risk factor. There are three situations: (1) The risk factor is a binary indicator, such as disclosure of conflict of interest (coded as either 0 or 1, indicating either the absence or the presence of the characteristic, respectively). In this case, the slope represents the difference in the mean rate between studies without and studies with the given characteristic. (2) The risk factor is either a proportion of study subjects with a given characteristic (e.g., the percentage of male subjects within a study) or the mean value for a study (e.g., mean age). The slope for this type of risk factor describes the expected (i.e., mean) difference in the rate between two studies that differ by a specified increment of the risk factor (e.g., a difference of 50% in male participation or a difference of ten years in age). (3) The risk factor is a set of proportions for a mutually exclusive set of subject characteristics. For example, we calculated the percentage of subjects with keeled glenoids, with pegged glenoids, and with metal-backed glenoids in each study. These three percentages add up to 100%. A proportion variable for one of the groups (e.g., keeled glenoids) is dropped from the meta-regression model, allowing this group to serve as the reference group. Each model is then characterized by two or more slopes (number of slopes = number of groups – 1). Each slope for this type of risk factor describes the expected difference in the rate between two studies that differ by a specified percentage for a given group at the expense of the reference group while the percentages for the remaining groups remain constant. For example, the slope presented for the pegged glenoid type shows the expected difference between two studies that differ by 100% in the pegged glenoid proportion. Since all percentages add up to 100%, this is the expected difference in annualized rate between a study with only keeled glenoids and a study with only pegged glenoids. The slopes can be also presented for a smaller difference in the risk factor. For example, for the Walch class, there are five proportion variables that add up to 100%. Walch class A1 serves as the reference group. We do not present the slopes for a 100% difference in Walch class because there are no studies in which the class differs this much. Instead, the slopes are presented per 10% difference, which is a more typical difference in Walch class percentages between studies. The slopes in this situation represents the expected difference in annualized rate between two studies that differ by 10% in the percentage of a given group (e.g., Walch class A2) at the expense of the reference group (Walch class A1) while all of the other percentages (Walch classes B1, B2, and C) are constant in the two studies. ■

**TABLE E-1 Study Characteristics\***

Study	Study Year Range	Follow-up (yr)	N	Male (%)	Mean Age (yr)	Fellowship Trained	ASES	No. of Centers	Origin	LOE
Arnold <sup>51</sup>	2003-2007	3.6	35	57	70	Y	Y	1	U.S.	IV
Bartelt <sup>26</sup>	1986-2005	10	46	72	49	Y	Y	1	U.S.	IV
Betts <sup>52</sup>	1979-1985	9.5	12	8	48	N	N	1	EU	IV
Castagna <sup>37</sup>	1996-2005	6.3	35	46	63	N	N	1	EU	IV
Churchill <sup>50</sup>	2002-2004	5.6	20	50	75	Y	Y	1	U.S.	IV
Clement <sup>39</sup>	1991-1999	10	39	21	55	N	N	1	EU	IV
Collin <sup>24</sup>	1995	10	56	NA	67	Y	Y	4	U.S.	II
Edwards <sup>36</sup>	2004-2005	2.2	53	53	69	Y	Y	1	U.S.	I
Fevang <sup>32</sup>	1994-2005	10	69	32	68	N	N	54	EU	IV
Foruria <sup>53</sup>	1980-2000	5.5	50	32	82	Y	Y	1	U.S.	IV
Fox <sup>8</sup>	1984-2004	15	1542	50	64	Y	Y	1	U.S.	IV
Fucetese <sup>35</sup>	2000-2007	4.2	22	14	69	Y	Y	1	EU	IV
Groh <sup>33</sup>	2005-2007	2.8	83	56	67	NA	NA	1	U.S.	IV
Kasten <sup>38</sup>	1997-2003	9	96	27	70	N	N	1	EU	IV
Khan <sup>20</sup>	1996-1998	10	25	NA	79	N	N	1	EU	IV
Rahme <sup>40</sup>	2001-2004	2	26	36	64	N	N	1	EU	I
Raiss <sup>34</sup>	1998-2002	7	21	NA	55	N	N	1	EU	IV
Rice <sup>54</sup>	1995-1999	5	12	93	66	Y	Y	1	U.S.	IV
Sperling <sup>55</sup>	1976-1991	20	187	29	57	Y	Y	1	U.S.	IV
Tammachote <sup>56</sup>	1985-1991	15	100	65	68	Y	Y	1	U.S.	IV
Taunton <sup>21</sup>	1989-1994	10	83	60	68	Y	Y	1	U.S.	IV
Throckmorton <sup>22</sup>	1991-2005	4.3	100	NA	69	Y	Y	1	U.S.	III
Walch <sup>25</sup>	1996-2003	10	333	32	69	Y	N	4	EU	IV
Walch <sup>9</sup>	1996-2003	8.6	518	NA	68	Y	N	10	EU	III
Wirth <sup>18</sup>	2002-2004	3	44	56	66	Y	Y	2	U.S.	IV
Young <sup>23</sup>	1991-2003	15	226	19	67	Y	N	9	EU	IV
Zilber <sup>57</sup>	1982-1993	11	20	10	60	N	N	1	EU	IV

Study	Design (%)			Diagnosis (%)					University	Private Practice
	Keeled	Pegged	Metal	DJD	Trauma OA	RA	ON	Misc.		
Arnold 2011 <sup>51</sup>	0	100	0	100	0	0	0	0	Y	N
Bartelt 2011 <sup>26</sup>	9	NA	NA	100	0	0	0	0	Y	N
Betts 2009 <sup>52</sup>	0	0	100	0	0	100	0	0	N	Y
Castagna 2010 <sup>37</sup>	100	0	100	77	14	9	0	0	N	Y
Churchill 2010 <sup>50</sup>	0	100	0	100	0	0	0	0	N	Y
Clement 2010 <sup>39</sup>	0	0	100	0	0	100	0	0	Y	N
Collin 2011 <sup>24</sup>	82	0	0	100	0	0	0	0	Y	Y
Edwards 2010 <sup>36</sup>	49	51	0	100	0	0	0	0	N	Y
Fevang 2009 <sup>32</sup>	NA	NA	NA	57	19	17	1	7	Y	Y
Foruria 2010 <sup>53</sup>	60	0	40	100	0	0	0	0	Y	N
Fox 2009 <sup>8</sup>	NA	NA	NA	64	11	16	4	6	Y	N
Fucntese 2010 <sup>35</sup>	0	100	0	45	36	9	9	0	Y	N
Groh 2010 <sup>33</sup>	0	100	0	92	5	0	2	1	N	Y
Kasten 2010 <sup>38</sup>	100	0	0	79	9	2	7	2	Y	N
Khan 2009 <sup>20</sup>	100	0	0	48	0	52	0	0	Y	N
Rahme 2009 <sup>40</sup>	46	54	0	81	7	0	11	0	Y	N
Raiss 2008 <sup>34</sup>	100	0	0	100	0	0	0	0	Y	N
Rice 2008 <sup>54</sup>	100	0	0	100	0	0	0	NA	Y	N
Sperling 2007 <sup>55</sup>	NA	NA	NA	0	0	100	0	0	Y	N
Tammachote 2009 <sup>56</sup>	0	0	100	100	0	0	0	0	Y	N
Taunton 2008 <sup>21</sup>	0	0	100	89	6	0	5	1	Y	N
Throckmorton 2010 <sup>22</sup>	50	50	0	100	0	0	0	0	Y	N
Walch 2011 <sup>25</sup>	100	0	0	100	0	0	0	0	Y	N
Walch 2012 <sup>9</sup>	100	0	0	100	0	0	0	0	Y	Y
Wirth 2012 <sup>18</sup>	0	100	0	100	0	0	0	0	Yes	No
Young 2011 <sup>23</sup>	100	0	0	100	0	0	0	0	Yes	Yes
Zilber 2008 <sup>57</sup>	NA	NA	NA	45	10	35	10	0	No	Yes

\*ASES = American Shoulder and Elbow Surgeons member, LOE = level of evidence, EU = European Union, NA = not available, DJD = degenerative joint disease, Trauma OA = posttraumatic osteoarthritis, RA = rheumatoid arthritis, and ON = osteonecrosis.

**TABLE E-2 Univariate Meta-Regression of the Outcomes on Risk Factors**

Factor*	Asymptomatic Radiolucent Lines		Symptomatic Loosening		Revision	
	Rate Slope (95% CI)	P Value	Rate Slope (95% CI)	P Value	Rate Slope (95% CI)	P Value
Mid-range of study years, per 10 yr	0.8 (−2.6, 4.3)	0.6	−0.4 (−1.4, 0.7)	0.5	−0.8 (−1.6, 0.0)	0.06
Duration, per 5 yr	−2.0 (−4.7, 0.7)†	0.21†	0.1 (−0.8, 1.0)	0.8	0.3 (−0.3, 1.0)	0.3
Crude rate, Y vs. N	3.8 (−1.1, 8.6)	0.13	−0.4 (−1.6, 0.8)	0.5	−0.5 (−1.3, 0.4)	0.3
Keeled vs. pegged vs. metal		0.6		0.9		0.14
Keeled	Reference		Reference		Reference	
Pegged, per 100%	2.0 (−4.3, 8.3)	0.5	0.3 (−1.6, 2.2)	0.8	−0.3 (−1.3, 0.7)	0.6
Metal-backed, per 100%	−2.4 (−9.4, 4.5)	0.5	0.5 (−1.9, 3.0)	0.7	1.0 (−0.03, 2.0)	0.06
Cemented, Y vs. N	2.8 (−2.6, 8.3)	0.3	−0.8 (−3.3, 1.6)	0.5	−0.8 (−1.8, 0.1)	0.08
DJD, per 100%	1.9 (−4.4, 8.2)	0.6	−1.1 (−2.9, 0.7)	0.2	−1.1 (−2.6, 0.5)	0.2
Posttraumatic arthritis, per 10%	0.3 (−2.5, 3.0)	0.9	0.4 (−0.3, 1.2)	0.3	0.4 (−0.3, 1.0)	0.3
Rheumatoid arthritis, per 20%	−0.6 (−1.9, 0.7)	0.4	0.2 (−0.2, 0.5)	0.4	0.2 (−0.1, 0.5)	0.2
Osteonecrosis, per 5%	1.5 (−1.6, 4.6)‡	0.3‡	0.5 (−0.5, 1.4)	0.3	−0.2 (−0.8, 0.5)	0.6
Misc. diagnoses, per 5%	−4.1 (−11.5, 3.4)	0.3	0.5 (−0.8, 1.9)	0.4	1.0 (0.0, 1.9)	0.04
Male sex, per 50%	−1.6 (−7.4, 4.1)	0.6	−1.6 (−3.1, −0.1)	0.04	−0.6 (−1.9, 0.8)	0.4
Mean age, per 10 yr						
Multiple surgeons, Y vs. N	−1.2 (−6.0, 3.6)	0.6	0.6 (−0.5, 1.7)	0.3	0.6 (−0.3, 1.5)	0.2
Fellowship training, Y vs. N	−0.1 (−4.9, 4.7)	1	−0.4 (−1.6, 0.9)	0.5	0.1 (−0.8, 1.1)	0.8
ASES membership, Y vs. N	1.1 (−3.5, 5.7)	0.6	−0.0 (−1.3, 1.2)	1	0.3 (−0.7, 1.2)	0.6
Multicenter, Y vs. N	−1.6 (−6.7, 3.6)	0.5	0.2 (−1.3, 1.6)	0.8	0.7 (−0.4, 1.8)	0.2
Europe, Y vs. N	−1.1 (−5.6, 3.3)	0.6	0.3 (−0.9, 1.5)	0.6	0.0 (−0.9, 1.0)	1
Walch grade available, Y vs. N	0.6 (−3.9, 5.0)	0.8	−0.2 (−1.4, 0.9)	0.7	−0.3 (−1.2, 0.7)	0.6
University, Y vs. N	−1.4 (−6.6, 3.8)	0.6	1.2 (−0.1, 2.5)	0.08	0.5 (−0.5, 1.5)	0.3
Private, Y vs. N	−1.1 (−5.7, 3.4)	0.6	−0.4 (−1.6, 0.9)	0.5	0.3 (−0.7, 1.2)	0.6
Conflict of interest, Y vs. N	4.7 (−0.1, 9.4)	0.06	0.2 (−1.2, 1.5)	0.8	0.2 (−0.8, 1.2)	0.7
Walch class		0.046		0.04		0.9
A1	Reference		Reference		Reference	
A2 vs. A1, per 10%	−3.0 (−5.6, −0.3)	0.03	−1.1 (−2.4, 0.2)	0.11	−0.5 (−2.4, 1.5)	0.6
B1 vs. A1, per 10%	1.4 (−1.1, 4.0)	0.3	0.3 (−0.8, 1.4)	0.6	−0.1 (−1.4, 1.3)	0.9
B2 vs. A1, per 10%	0.8 (−3.9, 5.5)	0.8	0.1 (−1.2, 1.5)	0.8	0.4 (−1.2, 1.9)	0.6
C vs. A1, per 10%	−12.5 (−26.1, 1.0)	0.07	−3.8 (−8.1, 0.4)	0.08	−2.1 (−8.0, 3.8)	0.5

\*DJD = degenerative joint disease, and ASES = American Shoulder and Elbow Surgeons. †Rahme 2009<sup>40</sup> excluded; slope = −3.4 (−6.5, −0.3), p = 0.03 when included. ‡Rahme 2009<sup>40</sup> excluded; slope = 3.9 (0.8, 7.1), p = 0.01 when included.

**TABLE E-3 Meta-Analysis of the Within-Study Association of the Asymptomatic Glenoid Loosening Rate with Keeled Compared with Pegged Glenoids**

Study	Glenoid	N	Mean Follow-up (yr)	Radiolucent Lines (%)	Annualized Rate (%/yr)	Odds Ratio (95% CI)	P Value
Edwards 2010 <sup>36</sup>			2.17				0.01
	Pegged	27		15	6.9	1.00 (ref.)	
	Keeled	26		46	21.2	4.93 (1.41, 20.29)	
Throckmorton 2010 <sup>22</sup>			4.27				0.2
	Pegged	50		26	6.1	1.00 (ref.)	
	Keeled	50		38	8.9	1.74 (0.75, 4.16)	
Rahme 2009 <sup>40</sup>			2.00				0.3
	Pegged	14		57	28.5	1.00 (ref.)	
	Keeled	12		75	37.5	2.25 (0.44, 13.63)	
Pooled in meta-analysis							0.01
	Pegged					1.00 (ref.)	
	Keeled					2.37 (1.21, 4.67)	