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Cruciate-Retaining Versus Posterior-Stabilized Primary Total Arthroplasty. Clinical Outcome Comparison with a Minimum Follow-Up of 10 Years

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**CRUCIATE-RETAINING VERSUS POSTERIOR-STABILIZED PRIMARY  
TOTAL ARTHROPLASTY. CLINICAL OUTCOME COMPARISON WITH A  
MINIMUM FOLLOW-UP OF 10 YEARS.**

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1 **CRUCIATE-RETAINING VERSUS POSTERIOR-STABILIZED PRIMARY**  
2 **TOTAL ARTHROPLASTY. CLINICAL OUTCOME COMPARISON WITH A**  
3 **MINIMUM FOLLOW-UP OF 10 YEARS.**

4

5 **ABSTRACT**

6 **Background:** Controversy continues regarding whether the posterior cruciate ligament  
7 should be retained or removed during total knee arthroplasty (TKA) procedure. The  
8 objective was to compare the clinical outcomes with a minimum follow-up of 10 years  
9 between patients who received contemporary cruciate retaining (CR) or posterior  
10 stabilized (PS) primary TKA.

11 **Methods:** Case-control study of 268 patients underwent CR TKA versus 211 to PS  
12 design, with the same arthroplasty system, and a minimum follow-up of 10 years.  
13 Clinical assessment was performed by Knee Society scores, Western Ontario and  
14 MacMasters Universities and Short-Form 12 questionnaires, range of motion, and  
15 patient satisfaction.

16 **Results:** Successful outcomes were found for both designs. No significant differences in  
17 functional scores, range of motion, patient-related scores or patient satisfaction.  
18 Between the 5-year and last postoperative follow-up, there were a significant decrease  
19 of all clinical scores in both groups. In addition, complication rate and implant survival  
20 were similar between groups.

21 **Conclusion:** The superiority of one design over the other was not found. Both designs  
22 can be used expecting long-term successful outcomes and high survival. The choice of  
23 the design depended on the status of the posterior cruciate ligament and surgeon  
24 preference.

25 **Keywords:** Total knee arthroplasty; Cruciate-retaining; Posterior stabilized; Functional  
26 outcome; Patient satisfaction.

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29 **INTRODUCTION**

30 Total knee arthroplasty (TKA) has provided high rate of successful outcomes in patients  
31 with end-stage knee osteoarthritis [1]. Several designs have been developed to improve  
32 the durability and function of this procedure. However, the most widely used designs  
33 for primary arthroplasty have been, and continue to be today, cruciate-retaining (CR)  
34 and posterior-stabilized (PS) [2]. Currently, controversy still continues regarding  
35 whether the posterior cruciate ligament (PCL) should be retained or removed during the  
36 procedure [3]. Advantages and disadvantages for both CR and PS designs have been  
37 reported in numerous biomechanical and kinematic studies [4-7]. However, the impact  
38 of the kinematic differences on the clinical outcomes has been controversial, and the  
39 superiority of one design over the other has not been unequivocally demonstrated in  
40 vivo [8].

41 There were a large number of publications examining the clinical differences between  
42 CR and CS designs, but most of them had small size and a follow-up as short as 5 years  
43 and the findings on clinical outcomes were controversial [9-12]. As far as we know,  
44 only 3 studies have reported comparative clinical outcomes with a minimum follow-up  
45 of 10 years [13-15]. One of these [13] was a randomized study of 62 patients at 2 years  
46 and then reviewed at 10 years where the authors reported similar ROM and functional  
47 outcomes. The 2 other were retrospective comparative studies with follow-up of 10  
48 years, one of which reported better ROM and function in the PS group [14], and the  
49 other better ROM in PS group but similar functional scores [15]. Thus, evidences on  
50 long-term functional outcomes are limited and controversial. Several systematic reviews  
51 comparing both designs have reported no significant clinical differences with the  
52 available evidences [3,8], and the authors suggested that longer follow-up investigations  
53 were needed.

54 The main purpose of this study was to compare the clinical outcomes with a minimum  
55 follow-up of 10 years between patients who received contemporary CR or PS primary  
56 total knee arthroplasty. We hypothesized that long-term outcomes are similar.

57

## 58 **PATIENTS AND METHODS**

59 This long-term retrospective case-control study was approved by our institutional  
60 review board and informed consent was required to perform a new patient evaluation.

61 A search to identify patients underwent CR and PS primary TKA between 2001 and  
62 2006 was performed on the departmental arthroplasty database using diagnostic and  
63 surgical codes. The inclusion criterion was primary TKA. The exclusion criteria were  
64 diagnosis of posttraumatic or inflammatory arthritis, if bone grafting was required,  
65 varus/valgus deformity greater than 15°, or prior knee osteotomy.

66 Six hundred and ten patients meeting the criteria were identified. Of them, 82 (13.4%)  
67 patients were excluded for death within 10 postoperative years unrelated to the TKA (38  
68 CR and 44 PS), 31 could not be contacted or they were unable to return for re-  
69 evaluation (17 CR and 14 PS), and 18 refused to participate in a new evaluation (12 CR  
70 and 6 PS). Among the remaining 479 patients, 268 received CR and 211 PS  
71 arthroplasty. In that time, the indication of one or the other TKA design depended on  
72 intraoperative PCL status, and the first years also on preference of the surgeon. Baseline  
73 characteristics at the time of the TKA in both groups are shown in Table 1. There were  
74 no significant differences in preoperative data between groups.

75

### 76 **Operative protocol**

77 The operations were performed by several experienced surgeons, according to the  
78 standardized practice in our center. All procedures were performed in operating room

79 with laminar flow, under spinal anaesthesia. A standard anterior midline skin incision  
80 and medial parapatellar arthrotomy was used in all patients. Standard operative  
81 techniques were used for all patients with the respective instrument systems.

82 The same modular TKA systems were used in all patients (Trekking, Samo, Italy). The  
83 two designs (CR and PS) were identical except for the cam-post mechanism. CR design  
84 had hybrid fixation (cementless femoral component) and PS design cemented fixation  
85 of both components. Tibial preparation was performed first, and intramedullary  
86 alignments were used for femur and tibia in all patients. Care was taken during bone  
87 resections to balance flexion and extension gaps. All patellae were routinely resurfaced  
88 with an all-polyethylene cemented design. After intraoperative assessment, all patients  
89 with sufficient PCL received CR TKA. Among patients receiving PS TKA, 26 had  
90 sufficient PCL and the remaining 185 had insufficient PCL.

91 According to the standard protocol, all patients received antibiotic prophylaxis with first  
92 generation cephalosporin for 24 hours (started 1 hour prior to skin incision) and  
93 thromboembolic prophylaxis with low-molecular-weight heparin for 30 days.  
94 Standardized at our centre, continuous passive knee motion started on the first  
95 postoperative day and from the third day active motion under the supervision of the  
96 therapist and full weight-bearing were allowed.

97

## 98 **Evaluations**

99 At our institution, the arthroplasty register prospectively collects clinical and  
100 radiographic data on all patients treated with arthroplasty with a minimum follow-up of  
101 5 years. Standardized assessment was performed preoperatively and postoperatively at  
102 1, 3, 6 months, and then yearly until at least 5 years. For this study, those patients with a  
103 follow-up less than 10 years were invited to return for a new clinical and radiological

104 evaluation. For clinical evaluations, the Knee Society scores (KSS) [16], reduced  
105 Western Ontario and MacMasters Universities (WOMAC) [17] and Short-Form 12  
106 (SF12) [18] questionnaires were used. The range of motion (ROM) of the knee joint  
107 was assessed with a standard goniometer. Flexion and extension lag items were also  
108 analyzed separately from KSS. The WOMAC was transformed to a 0-100 scale, so a  
109 higher value implies a better outcome. In addition, patient satisfaction was evaluated at  
110 final follow-up by a 0-10 visual analogue scale (VAS).

111 Radiological evaluation was performed using standard standing anterior-posterior,  
112 lateral and skyline views. The latest radiographs were analyzed by two independent  
113 surgeons who did not know the clinical evaluations of the patients. The Knee Society  
114 radiographic evaluation system [19] was used for position of components and zones of  
115 radiolucency or osteolysis. Loosening of the arthroplasty was defined by continuous or  
116 progressive radiolucent lines or by migration of any component.

117

### 118 **Statistical analysis**

119 Statistical analyses were performed with SPSS software v. 15.0 (SPSS Inc., Chicago,  
120 USA). Normal distribution was determined by the Kolmogorov-Smirnov test.  
121 Comparisons between categorical variables were made with chi-square test or non-  
122 parametric Fisher exact test or Mantel-Haenszel test, and for continuous variables with  
123 Student t-test or Mann-Whitney U-test. Comparisons between preoperative and last  
124 follow-up data were made by paired t-test or Wilcoxon signed-rank test. Multivariate  
125 analyses by logistic regression models were used to analyze independent factors  
126 affecting final ROM and KSS scores. These data were presented as Odds ratio (OR)  
127 with 95% confidence interval (CI). Kaplan-Meier test was used for TKA survival  
128 analysis with revision for any reason as end-point, and comparison between groups was

129 made by the Mantel-Haenszel log-rank test. Significance was considered for p values  
130 less than 0.05 in all tests.

131

## 132 **RESULTS**

133 Mean final follow-up from index TKA to the last assessment was 13.4 (range, 10-15)  
134 years in the CR group, and 12.7 (range, 10-15) years in the PS group. All clinical scores  
135 significantly improved from preoperative to last follow-up in both groups (p= 0.001).

136 Over the time, there were no significant differences (all, p<0.05) in any functional  
137 outcome between 3 and 5 postoperative years in both groups. Between 5 and 8  
138 postoperative years, there were significant decreases in KSS-knee (p= 0.044) in both  
139 groups and extension lag (p= 0.032) in only CR group, and no significant differences in  
140 KSS-function (p= 0.395) or knee flexion (p= 0.128) in both groups. Between 5  
141 postoperative years and final follow-up (Table 2), there were significant decreases in  
142 both groups for all functional scores except extension lag in the PS group. However, all  
143 these differences in numbers were small.

144 At the final follow-up, there were no significant differences in any KSS score or ROM  
145 between groups at either 5 postoperative years or final follow-up (Table 2). Multivariate  
146 analysis showed that only preoperative ROM had significant influence on last ROM  
147 (OR: 1.7; 95% IC: 1.1-2.3; p= 0.026), and TKA design had not influence (OR: 0.9;  
148 95%IC: 0.3-3.7; p= 0.394). Likewise, TKA design had not significant influence on last  
149 KSS-knee score (OR: 0.3; 95%IC: 0.02-2.8; p= 0.514) or KSS-function score (OR: 1.1;  
150 95%IC: 0.07-2.7; p= 0.613).

151 Regarding to the patient-reported outcomes, there were no significant differences over  
152 the time between 3, 5 and 8 postoperative years in both groups (all, p < 0.05). However,  
153 significant differences in both groups were found between 5 postoperative years and the

154 final follow-up (Table 3) in SF-12 scores (all,  $p= 0.001$ ). There was no significant  
155 change in WOMAC score between 5-year follow-up and final in either group. At final  
156 follow-up, there were no significant differences between groups in any patient-reported  
157 scores.

158 The 86 % of patients in the CR group and 84% in the PS group were satisfied with the  
159 functional outcome of their knees after 10 postoperative years ( $p= 0.565$ ). At final  
160 follow-up, there was no significant difference between groups in the level of VAS-  
161 satisfaction ( $p= 0.151$ ). There were no significant differences in patient rate with  
162 residual pain knee between groups (8% in CR group versus 6% in PS group,  $p= 0.547$ ).  
163 A higher patient rate in the PS group reported a greater frequency of swelling or  
164 tightness of their replaced knee than patients in CR group (12% versus 7%), but this  
165 difference was not significant ( $p= 0.109$ ).

166 In the CR group, 7 unrevised knees had nonprogressive, incomplete radiolucent line less  
167 than 1 mm in at least 1 zone around the tibial component (zones 1, 3, 4), while in the PS  
168 group this was in 5 unrevised knees (zones 1 and 4). No radiolucent lines around the  
169 femoral or patellar component were found in either group.

170 Overall, there were 21 (5.5%) revisions, 9 (4.2%) in the CR group and 12 (7.2%) in the  
171 PS group ( $p= 0.259$ ). There were no revisions of CR due to PCL deficiency.  
172 Complications with subsequent revisions included 3 early wound deep infections (1 CR  
173 and 2 PS) that were treated with 2-stage revisions, 9 aseptic tibial loosening (4 CR and 5  
174 PS) with a time revision ranged from 4 to 9 years, 5 polyethylene insert wear (2 CR and  
175 3 PS) with a time revision ranged from 4 to 8 years of which 2 were treated with only  
176 insert exchanges and the 3 other with tibial revision, and 4 periprosthetic femoral  
177 fracture (2 CR and 2 PS) at 4-9 years of which 3 were treated with retrograde  
178 intramedullar nail and the another with arthroplasty revision. The cumulative survival of

179 the TKA at 14-year for any reason (Fig. 1) was 95.7 % (95% CI, 93.0–98.5 %) in the  
180 CR group and 92.7 % (95% CI, 88.8–96.7 %) in the PS group, and this difference was  
181 not significant (log rank,  $p= 0.209$ ).

182

### 183 **DISCUSSION**

184 Currently, controversy regarding to the advantages and disadvantages of CR and PS  
185 designs continue, and the clinical superiority of one design over the other has still not  
186 been demonstrated [3]. The main objective of the present study was to compare long-  
187 term clinical outcomes between both designs. The main findings were successful  
188 outcomes for both CR and PS arthroplasties, with no significant differences at a  
189 minimum postoperative follow-up of 10 years in functional scores, ROM, patient-  
190 related scores or patient satisfaction. Between the 5-year and final postoperative follow-  
191 up, there were a significant decrease of all clinical scores in both groups, although the  
192 differences in numbers were small. In addition, complication rate and implant survival  
193 were similar between groups.

194 Potential advantages of CR designs include more normal knee kinematics, especially  
195 increased femoral rollback on the tibia during flexion, intact PCL preventing anterior  
196 translation of the femur on the tibia, greater inherent stability of the prosthesis,  
197 increased proprioception, greater passive knee range of motion (ROM), enhanced  
198 quadriceps muscle power, preservation of bone, and less blood loss [20,21]. On the  
199 other hand, with PS designs have been reported advantages such as greater ease of  
200 balancing of soft tissues, more congruent articulations, increased rollback with reduced  
201 posterior tibial subluxation and greater range of flexion, and superior patellofemoral  
202 kinematics [6,22,23].

203 There were a large number of studies comparing clinical differences between CR and  
204 CS designs, but few of them had a follow-up of 10 years. Scott et al [12], in a  
205 randomized study compared 55 patients who received a CR design and 56 PS design  
206 with mean follow-up of 4 years, reported similar clinical and radiographic outcomes  
207 between both, although the PS patients received significantly more transfusions than CS  
208 patients. However, other studies have reported no difference in blood loss between CR  
209 and PS designs [24] or higher blood loss with the design [25]. In other randomized  
210 study of 98 patients, Chaudhary et al [9] reported similar pain, ROM, function, quality  
211 of life scores and complication rates between CR and PS groups after a follow-up of 2  
212 years. Clark et al [26], in other randomized study of 143 patients with a minimum 2-  
213 year follow-up reported no significant differences between groups regarding to  
214 functional scores or ROM. On the contrary, other randomized studies found significant  
215 clinical differences.

216 Maruyama et al [27], in a randomized comparison of 20 patients whom were bilaterally  
217 operated with both CR and PS designs reported similar knee scores but higher range of  
218 motion in the PS knees after a mean follow-up of 2 years. Harato et al [10], in a  
219 multicenter randomized study of 99 CR patients and 99 PS patients with a minimum  
220 follow-up of 5 years, found no significant differences between both groups in functional  
221 outcomes, satisfaction or complication rate, but improvement in range of motion was  
222 better in the PS group. Ozturk et al [11], comparing randomly 33 CR patients and 28 PS  
223 patients with a deformity greater than 10° and follow-up of 7 years, reported that both  
224 types of prosthesis produced similarly successful functional outcomes but flexion arc  
225 was larger in PS knees. Overall, a recent meta-analysis of randomized controlled trials  
226 [2] found similar clinical outcomes with regard to knee function, pain, ROM and  
227 complications between CR and PS designs.

228 To our knowledge, only 3 studies have reported on the comparative clinical outcomes  
229 with follow-up over 10 years [13-15] and with controversial findings. In agreement with  
230 us, Mayne et al [15] found similar functional scores, ROM and revision rate between  
231 both designs. Likewise, Beaupre et al [13] found no differences in functional outcomes  
232 or revisions, although ROM data were not reported. On the contrary, other long-term  
233 study de 414 patients [14] reported significantly better functional outcomes and ROM  
234 with the PS design, although excellent 10-year survival was also reported for both  
235 designs. However, although clinical score differences were significant, to our  
236 understanding those differences in numbers were small. On the other hand, other large  
237 retrospective study [28], showed a significant difference in TKA survival at 15-year  
238 between CR and PS designs (90% versus 77%), although unfortunately they did not  
239 report functional results.

240 Strengths of the present study were the relatively large number of patients from a single  
241 center, follow-up over 10 years, and relatively low rate of loss of follow-up. To our  
242 knowledge, this was one of the largest studies on comparative long-term outcomes  
243 published to date. However, the study was not according to usual practice because  
244 patients with severe knee deformity were excluded. Moreover, inherent to any long-  
245 term study involving elderly patients, there were 13% of patients losses to follow-up.

246 In addition, this study had other limitations. First, this study was limited by its  
247 retrospective design. Our patient cohorts were not randomized and patient selection bias  
248 may have occurred. On the other hand, our findings could be specific to the implant  
249 used and not be generalized to other arthroplasty systems. In addition, CR model was  
250 hybrid whereas the PS was cemented which could be a confounding factor on outcomes  
251 or longevity of the prosthesis.

252

253 **CONCLUSIONS**

254 The present study demonstrated successful survival for both designs with similar  
255 clinical outcomes between CR and PS designs at long-term follow-up. Thus, the  
256 superiority of one design over the other was not found. Both designs can be used  
257 expecting long-term successful outcomes and high survival. The choice of the design  
258 depended on the status of the posterior cruciate ligament and surgeon preference.  
259 Currently, we prefer the CR design whether the ligament is sufficient because it requires  
260 less bone resection.

261

262 **REFERENCES**

- 263 1. Wylde V, Dieppe P, Hewlett S, Learmonth ID. Total knee replacement: is it really an  
264 effective procedure for all? *Knee*. 2007;14:417-23.
- 265 2. Li N, Tan Y, Deng Y, Chen L. Posterior cruciate-retaining versus posterior stabilized  
266 total knee arthroplasty: a meta-analysis of randomized controlled trials. *Knee Surg*  
267 *Sports Traumatol Arthrosc*. 2014;22:556-64.
- 268 3. Verra WC, Boom LG, Jacobs WC, Schoones JW, Wymenga AB, Nelissen RG.  
269 Similar outcome after retention or sacrifice of the posterior cruciate ligament in total  
270 knee arthroplasty. *Acta Orthop*. 2015;86:195-201.
- 271 4. Murakami K, Hamai S, Okazaki K, Ikebe S, Nakahara H, Higaki H, Shimoto T,  
272 Mizu-Uchi H, Kuwashima U, Iwamoto Y. Kinematic analysis of stair climbing in  
273 rotating platform cruciate-retaining and posterior-stabilized mobile-bearing total knee  
274 arthroplasties. *Arch Orthop Trauma Surg*. 2017;137:701-11.
- 275 5. Kim SM, Jang SW, Seo JG, Lee SS, Moon YW. Comparison of cruciate retaining  
276 and PCL sacrificing TKA with respect to medial and lateral gap differences in varus  
277 knees after medial release. *J Arthroplasty*. 2015;30:26-30.

- 278 6. Becher C, Heyse TJ, Kron N, Ostermeier S, Hurschler C, Schofer MD, Fuchs-  
279 Winkelmann S, Tibesku CO. Posterior stabilized TKA reduce patellofemoral contact  
280 pressure compared with cruciate retaining TKA in vitro. *Knee Surg Sports Traumatol*  
281 *Arthrosc.* 2009;17:1159-65.
- 282 7. Matthews J, Chong A, McQueen D, O'Guinn J, Wooley P. Flexion-extension gap in  
283 cruciate-retaining versus posterior-stabilized total knee arthroplasty: a cadaveric study. *J*  
284 *Orthop Res.* 2014;32:627-32.
- 285 8. Luo SX, Zhao JM, Su W, Li XF, Dong GF. Posterior cruciate substituting versus  
286 posterior cruciate retaining total knee arthroplasty prostheses: a meta-analysis. *Knee.*  
287 2012;19:246-52.
- 288 9. Chaudhary R, Beaupré LA, Johnston DW. Knee range of motion during the first two  
289 years after use of posterior cruciate-stabilizing or posterior cruciate-retaining total knee  
290 prostheses. A randomized clinical trial. *J Bone Joint Surg Am.* 2008;90:2579-86.
- 291 10. Harato K, Bourne RB, Victor J, Snyder M, Hart J, Ries MD. Midterm comparison  
292 of posterior cruciate-retaining versus -substituting total knee arthroplasty using the  
293 Genesis II prosthesis: a multicenter prospective randomized clinical trial. *Knee.*  
294 2008;15:217-21.
- 295 11. Öztürk A, Akalın Y, Çevik N, Otuzbir A, Özkan Y, Dostabakan Y. Posterior  
296 cruciate-substituting total knee replacement recovers the flexion arc faster in the early  
297 postoperative period in knees with high varus deformity: a prospective randomized  
298 study. *Arch Orthop Trauma Surg.* 2016;136:999-1006.
- 299 12. Scott DF, Smith RR. A prospective, randomized comparison of posterior stabilized  
300 versus cruciate-substituting total knee arthroplasty: a preliminary report with minimum  
301 2-year results. *J Arthroplasty.* 2014;29(9 Suppl):179-81.

- 302 13. Beaupre LA, Sharifi B, Johnston DW. A randomized clinical trial comparing  
303 posterior cruciate-stabilizing vs posterior cruciate-retaining prostheses in primary total  
304 knee arthroplasty: 10-year follow-up. *J Arthroplasty*. 2017;32:818-23.
- 305 14. Sando T, McCalden RW, Bourne RB, MacDonald SJ, Somerville LE. Ten-year  
306 results comparing posterior cruciate-retaining versus posterior cruciate-substituting total  
307 knee arthroplasty. *J Arthroplasty*. 2015;30:210-5.
- 308 15. Mayne A, Harshavardhan HP, Johnston LR, Wang W, Jariwala A. Cruciate  
309 retaining compared with posterior stabilised Nexgen total knee arthroplasty: results at  
310 10 years in a matched cohort. *Ann R Coll Surg Engl*. 2017. doi:  
311 10.1308/rcsann.2017.0086.
- 312 16. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical  
313 rating system. *Clin Orthop Relat Res*. 1989;248:13-4.
- 314 17. Bellamy N, Buchanan W, Goldsmith CH, Campbell J, Stitt LW. Validation study of  
315 WOMAC: a health status instrument for measuring clinically important patient relevant  
316 outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip and the  
317 knee. *J Rheumatol*. 1988;15:1833-40.
- 318 18. Ware JE Jr, Kosinski M, Keller SD. A 12-Item Short-Form Health Survey:  
319 construction of scales and preliminary tests of reliability and validity. *Med Care*.  
320 1996;34:220-33.
- 321 19. Ewald FC. The Knee Society total knee arthroplasty roentgenographic evaluation  
322 and scoring system. *Clin Orthop Relat Res*. 1989;248:9-12.
- 323 20. Hunt NC, Ghosh KM, Blain AP, Rushton SP, Longstaff LM, Deehan DJ. No  
324 statistically significant kinematic difference found between a cruciate-retaining and  
325 posterior-stabilised Triathlon knee arthroplasty: a laboratory study involving eight  
326 cadavers examining soft-tissue laxity. *Bone Joint J*. 2015;97B:642-8.

- 327 21. Matsumoto T, Kubo S, Muratsu H, Matsushita T, Ishida K, Kawakami Y, Oka S,  
328 Matsuzaki T, Kuroda Y, Nishida K, Akisue T, Kuroda R, Kurosaka M. Different pattern  
329 in gap balancing between the cruciate-retaining and posterior-stabilized total knee  
330 arthroplasty. *Knee Surg Sports Traumatol Arthrosc.* 2013;21:2338-45.
- 331 22. Bercik MJ, Joshi A, Parvizi J. Posterior cruciate-retaining versus posterior-stabilized  
332 total knee arthroplasty: a meta-analysis. *J Arthroplasty.* 2013;28:439-44.
- 333 23. Cho KY, Kim KI, Song SJ, Bae DK. Does cruciate-retaining total knee arthroplasty  
334 show better quadriceps recovery than posterior-stabilized total knee arthroplasty?  
335 Objective measurement with a dynamometer in 102 knees. *Clin Orthop Surg.*  
336 2016;8:379-85.
- 337 24. Cankaya D, Ozkurt B, Aydin C, Tabak AY. No difference in blood loss between  
338 posterior-cruciate-ligament-retaining and posterior-cruciate-ligament-stabilized total  
339 knee arthroplasties. *Knee Surg Sports Traumatol Arthrosc.* 2014;22:1865-9.
- 340 25. Mähringer-Kunz A, Efe T, Fuchs-Winkelmann S, Schüttler KF, Paletta JR, Heyse  
341 TJ. Bleeding in TKA: posterior stabilized vs. cruciate retaining. *Arch Orthop Trauma*  
342 *Surg.* 2015;135:867-70.
- 343 26. Clark CR, Rorabeck CH, MacDonald S, MacDonald D, Swafford J, Cleland D.  
344 Posterior-stabilized and cruciate-retaining total knee replacement: a randomized study.  
345 *Clin Orthop Relat Res.* 2001;392:208-12.
- 346 27. Maruyama S, Yoshiya S, Matsui N, Kuroda R, Kurosaka M. Functional comparison  
347 of posterior cruciate-retaining versus posterior stabilized total knee arthroplasty. *J*  
348 *Arthroplasty.* 2004;19:349-53.
- 349 28. Abdel MP, Morrey ME, Jensen MR, Morrey BF. Increased long-term survival of  
350 posterior cruciate-retaining versus posterior cruciate-stabilizing total knee replacements.  
351 *J Bone Joint Surg Am.* 2011;9:2072-8.

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354 **LEGEND OF FIGURE**

355 **Fig. 1.** Kaplan-Meier cumulative survival curves ( $p= 0.209$ )

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360 **Table 1. Baseline characteristics at the time of the TKA**

	CR group n= 268	PS group n= 211	p-value
Age at TKA	68.8 (7.1)	70.1 (8.3)	0.108
Gender (F/M)	196/72	144/67	0.142
BMI	31.6 (5.2)	32.5 (5.8)	0.118
Alignment pre	4.2° (4.8°) VR	4.6° (5.1°) VR	0.438
KSS-knee	35.9 (14.6)	36.4 (15.2)	0.746
KSS-function	45.3 (15.9)	47.2 (14.7)	0.229
ROM	91.6 (12.4)	90.8 (13.5)	0.553
Flexion	94.4 (10.7)	92.6 (11.3)	0.116
Extension lag	3.2 (3.4)	3.3 (3.7)	0.787
Global WOMAC	40.6 (9.2)	39.8 (8.7)	0.387
SF12-physical	21.5 (5.7)	20.8 (6.1)	0.255
SF12-mental	42.4 (9.8)	41.6 (9.6)	0.426

361 Continuous data as mean (SD). Alignment, preoperative. VR: varus femorotibial

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364 **Table 2. Functional outcomes over the time**

	CR group	PS group	p
<b>KSS-knee</b>			
At 5 years	88.3 (6.4)	87.7 (6.9)	0.382
At final follow-up	86.4 (7.1)	85.2 (7.6)	0.117
p	0.015	0.001	
<b>KSS-function</b>			
At 5 years	88.1 (8.4)	87.9 (9.3)	0.826
At final follow-up	84.4 (9.1)	85.6 (9.8)	0.223
p	0.001	0.029	
<b>ROM</b>			
At 5 years	104.3 (9.7)	102.9 (10.1)	0.174
At final follow-up	101.2 (10.4)	100.7 (10.7)	0.648
p	0.001	0.054	
<b>Flexion</b>			
At 5 years	105.2 (10.9)	103.1 (11.4)	0.069
At final follow-up	101.3 (11.1)	100.4 (9.6)	0.399
p	0.001	0.020	
<b>Extension lag</b>			
At 5 years	1.0 (1.6)	1.3 (1.4)	0.056
At final follow-up	1.4 (1.8)	1.2 (1.9)	0.299
p	0.016	0.585	

365 Data as mean (SD). KSS: Knee Society score.

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368 **Table 3. Patient-reported outcomes over the time**

	CR group	PS group	p
Global WOMAC			
At 5 years	84.4 (19.2)	86.7 (20.2)	0.262
At final follow-up	82.2 (20.1)	83.3 (19.6)	0.592
p	0.249	0.120	
SF12-physical			
At 5 years	40.6 (7.2)	41.8 (8.1)	0.134
At final follow-up	38.2 (8.1)	36.9 (8.9)	0.143
p	0.001	0.001	
SF12-mental			
At 5 years	49.4 (7.4)	48.8 (7.9)	0.446
At final follow-up	44.1 (8.2)	43.4 (9.3)	0.445
p	0.001	0.001	
VAS-satisfaction			
At final follow-up	7.9 (1.9)	7.6 (2.1)	0.151

369 Data as mean (SD). Global WOMAC: amount of pain and physical function. VAS:

370 visual analogue scale for patient satisfaction.

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**Fig. 1.** Kaplan-Meier cumulative survival curves ( $p= 0.209$ )

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