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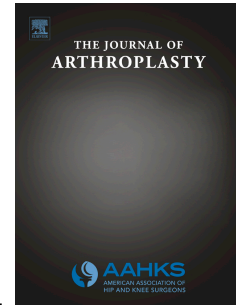
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**CRUCIATE-RETAINING VERSUS POSTERIOR-STABILIZED PRIMARY
TOTAL ARTHROPLASTY. CLINICAL OUTCOME COMPARISON WITH A
MINIMUM FOLLOW-UP OF 10 YEARS.**

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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

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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
KSS-knee			
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	
KSS-function			
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	
ROM			
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	
Flexion			
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	
Extension lag			
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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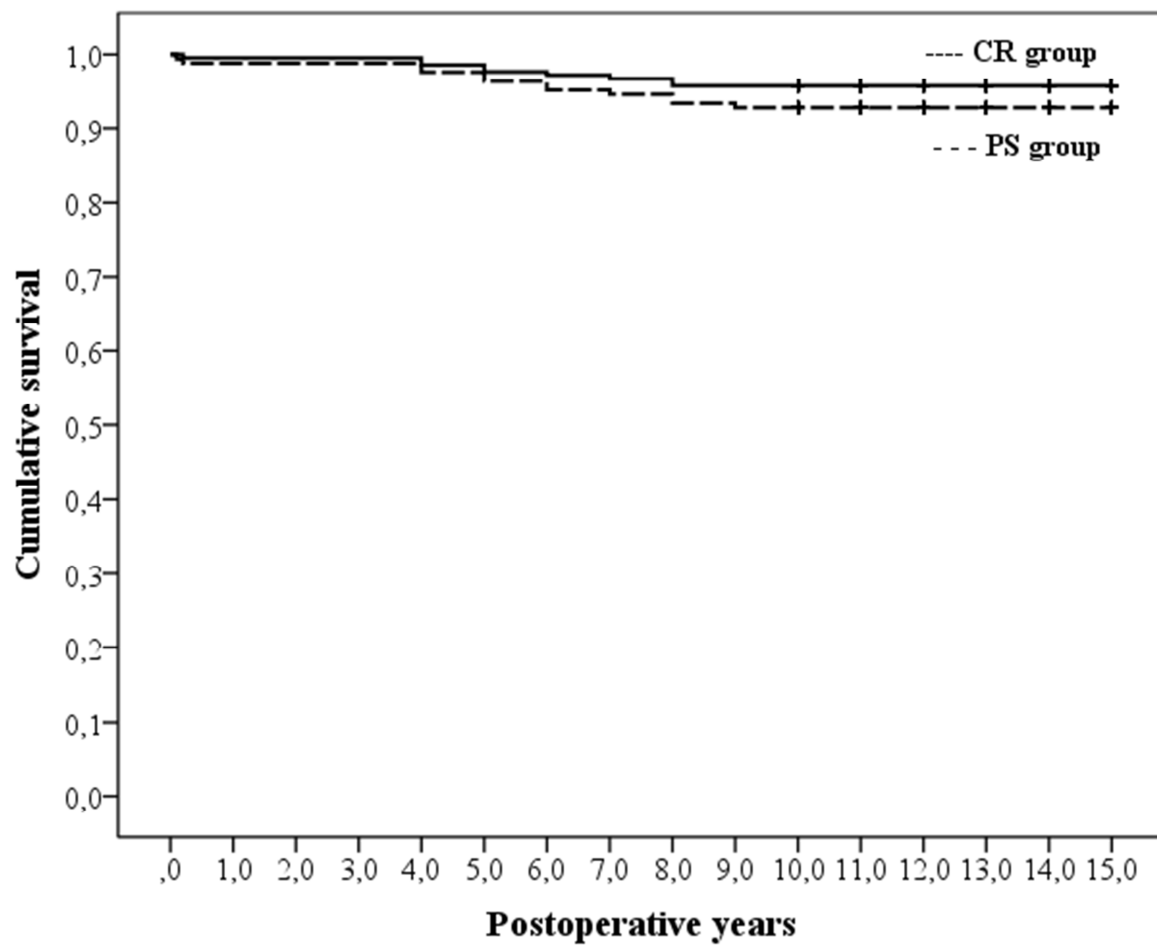
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Fig. 1. Kaplan-Meier cumulative survival curves ($p= 0.209$)

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