A leading cause of joint pain and disability with a growing incidence worldwide, knee osteoarthritis represents a therapeutic dilemma. Total knee replacement (TKR) is the treatment of choice in severe cases that are refrac-
tory to conservative measures, as it is expected to provide pain relief and a proper postoperative range of motion (ROM) for the knee joint. Most activities of normal function necessitate around 110° of flexion; thus, many endoprosthesis designs have been modified to achieve high flexion. As the understanding of knee joint kinematics improved, the existence of multiple instantaneous centers of knee flexion/extension was challenged by some researchers who suggested a single flexion/extension axis of the normal knee. Consequently, in addition to the traditional endoprosthesis designs with multiple radii (MR) of rotation, a series of new, single-radius (SR) designs were developed. The theoretical advantages of a single radius of rotation are a better recovery of the extensor mechanism, a decrease in patellar load, and better ligament stability. Although some studies suggest superiority of the SR design, the majority report on functional outcomes, often without comparing SR with MR.

The present study aimed to compare clinical, radiological, and survivorship results of 2 posterior-stabilized knee endoprosthesis designs: an SR implant—the Scorpio® NRG Knee System (Stryker®, Mahwah, NJ, USA) and an MR implant—the NexGen® Legacy® (LPS) fixed TKR system (Zimmer®, Warsaw, IN, USA). Based on the hypothesis that the SR design would render superior results, our study evaluated whether the outcomes of TKR are influenced by the type of implant.

Patients and methods

This retrospective observational study included a consecutive series of patients undergoing primary TKR in our institution between October 2004 and December 2010. All operations were performed by one surgeon—the senior author—using 2 cemented posterior-stabilized TKR implant designs: the Scorpio® system (SR femoral design) and the NexGen® system (MR femoral design). Patients with neurosensory and/or neuromuscular deficiencies interfering with postoperative assessment, patients with hip disorders/reconstruction, and patients that could not complete the rehabilitation protocol were excluded.

Final assessment was conducted on 164 knees (139 patients), of which 25 patients underwent staged bilateral TKR. A total of 64 patients (70 knees) received the MR design (Group I) and 75 patients (94 knees) received the SR design endoprosthesis (Group II). All patients gave written informed consent to participate in the study, which was approved by our hospital’s ethics committee.

Full-length weight-bearing radiographs were obtained preoperatively, showing the hip, knee and ankle joints. Both the angle of the femoral and tibial cuts and the desired position of the entry holes were planned preoperatively.

All operations were performed under spinal and epidural anesthesia with a tourniquet. In cases of normal alignment or varus/valgus deviation of <10°, a medial parapatellar approach was used; however, in cases of valgum >10°, a lateral parapatellar approach was performed, according to the technique described by Keblish and associated with a Hoffa’s fat pad plasty.

The distal femoral and proximal tibial cuts were made perpendicular to the mechanical axis in the frontal and sagittal planes using intramedullary guides. In valgus deformity, the tibial cut was performed in a mirror-image fashion using the contralateral cutting guide. Soft tissue balancing was accomplished by sequential release of the tight medial or lateral structures in order to obtain a symmetric rectangular extension gap. Stability and alignment in extension were controlled after each release phase.

The correct rotation of the femoral component was determined using the gap technique, in which the cut surface of the proximal tibia is used as a reference line and the posterior femoral cut must be parallel to the proximal tibial cut. Femoral component size was determined using anterior referencing instruments. All components were cemented.

Peripatellar synovectomy was performed in all cases, followed by osteophyte removal and electrocautery of the patellar rim for partial denervation. In the case of patella resurfacing, a cemented all-polyethylene component was inserted and fixed.

The lateral approach offers the advantages of better exposure of the capsule-ligamentous structures that require release, while the soft tissue deficit on the anterolateral portion of the wound can be resolved by the Hoffa plasty. The Hoffa pad is prepared, taking care to maintain a postero-inferior pedicle with an intact vascular supply, and is later used to cover the soft tissues defect created by alignment on the inferolateral side.

Patients received 3 doses of prophylactic antibiotics on the day of surgery. Anticoagulation with low-molecular weight heparin was started 24 hours before surgery and lasted for 25–30 days. A drain was used for 24 hours, and compression stockings were worn for 2 weeks. Quadriceps-strengthening and continuous passive movement (CPM) exercises were started immediately postoperatively. Weight-bearing was allowed from the second postoperative day, using a walking frame as
needed. Weight-bearing high-flexion activities such as squatting and kneeling were allowed as tolerated.

Detailed physical examinations were performed preoperatively, at 3 and 12 months postoperatively, and annually thereafter. Clinical parameters were recorded during each assessment, including both total and functional Knee Society score (KSS), knee ROM, postoperative anterior knee pain, and possible complications. Statistical analyses were made using data obtained preoperatively and at final follow-up.

Radiological evaluation was based on weight-bearing posterior-anterior, lateral, and Merchant view radiographs, obtained preoperatively and at follow-ups. The images were assessed for limb alignment, component positioning, and the presence and location of radiolucent lines at the bone-cement interface. Femoral and tibial angles ($\alpha$ and $\beta$) were measured on the posterior-anterior view, and the femoral and tibial flexion angles ($\gamma$ and $\sigma$) on the lateral view, as described by Sarmah et al. and Kim et al.\[9,10\] (Figure 1). Radiolucent line width was measured according to the Knee Society Roentgenographic Evaluation System,\[11\] A total score was obtained from the sum of the widths of radiolucent lines and used to determine apparent mechanical failure or impeding failure as described by Kumar et al.\[12\] These data were used for survivorship analysis. Heterotopic ossifications were evaluated based on Figgie and Goldberg's classification, as reported by Atamaz et al.\[13\]

All statistical calculations were performed using GraphPad software (GraphPad Software, Inc., La Jolla, California, USA). The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to determine variable distribution. Data were characterized as mean and standard deviation for variables with normal distribution or as median and 25th–75th percentiles for variables with abnormal distribution, respectively. Adequate statistical tests were chosen according to data distribution. Differences between mean values were determined by Student’s $t$-test and for nonparametric data by Mann-Whitney $U$ test (median and range). A chi-square test and a Fisher’s exact test were used to analyze frequency distribution of the data. The end point for endoprosthesis survival was defined as revision for any reason or the necessity of revision (apparent/impeding mechanical failure). Kaplan-Meier survival data were used to construct survival probabilities of implants at 7 years, and log-rank test was used to compare those probabilities. All tests were interpreted relative to the significance threshold $p=0.05$.

**Results**

Of the 164 cases (139 patients) included in the study, 42.7% received an MR implant and 57.3% an SR implant. Left to right knee ratio was similar for the 2 implants (1.06:1 for the MR implant and 1.19:1 for the SR implant). The 2 patient groups were similar in demo-

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**Table 1.** Diagnosis in the 2 groups.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Group I</th>
<th>Group II</th>
<th>Total number of cases (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chondrocalcinosis</td>
<td>2</td>
<td>0</td>
<td>2 (1.2)</td>
</tr>
<tr>
<td>Osteonecrosis</td>
<td>3</td>
<td>1</td>
<td>4 (2.4)</td>
</tr>
<tr>
<td>Primary osteoarthritis</td>
<td>61</td>
<td>85</td>
<td>146 (89.0)</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>2</td>
<td>0</td>
<td>2 (1.2)</td>
</tr>
<tr>
<td>Posttraumatic arthritis</td>
<td>2</td>
<td>8</td>
<td>10 (6.1)</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>94</td>
<td>164 (100)</td>
</tr>
</tbody>
</table>
graphics, diagnosis, and disease characteristics, with no statistically significant differences in follow-up (Tables 1 and 2).

No statistically significant difference was found in total postoperative blood loss between the 2 study groups.

However, there was a significant difference in tourniquet time, and thus operative time (Table 2).

At final follow-up, there was a significant improvement in postoperative values of KSS (both total and functional scores) in all cases, as compared to the preop-

### Table 2. Characteristics of the 2 patient groups.

<table>
<thead>
<tr>
<th></th>
<th>Group I</th>
<th>Group II</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age in years (range)</td>
<td>68.0 (47–79)</td>
<td>66.7 (52–86)</td>
<td>0.19*</td>
</tr>
<tr>
<td>Female/male (%)</td>
<td>78.5/21.5</td>
<td>69.1/30.9</td>
<td>0.24*</td>
</tr>
<tr>
<td>Median follow-up time (months)</td>
<td>32.0 (13–75)</td>
<td>35.0 (12–112)</td>
<td>0.09**</td>
</tr>
<tr>
<td>Normal/Valgus/Varus alignment (%)</td>
<td>4.6/10.8/84.6</td>
<td>14.9/9.6/75.5</td>
<td>0.11*</td>
</tr>
<tr>
<td>Ahlbäck stage IV/V (%)</td>
<td>8.9/91.9</td>
<td>11.7/88.3</td>
<td>0.76*</td>
</tr>
<tr>
<td>Tourniquet time (minutes)</td>
<td>90.0 (60–115)</td>
<td>82 (58–115)</td>
<td>0.0001**</td>
</tr>
<tr>
<td>Total postoperative blood loss (ml)</td>
<td>900 (250–2050)</td>
<td>950 (150–2900)</td>
<td>0.35**</td>
</tr>
</tbody>
</table>

*: Student’s t-test; **: Mann-Whitney test; #: Chi-square test.

### Table 3. Results of the clinical assessment in the 2 groups.

<table>
<thead>
<tr>
<th></th>
<th>Group I</th>
<th>Group II</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Knee Society Score preoperatively</td>
<td>44.0±10.2</td>
<td>44.9±12.8</td>
<td></td>
</tr>
<tr>
<td>Mean Knee Society Score at final follow-up</td>
<td>87.2±7.5</td>
<td>86.8±11.3</td>
<td></td>
</tr>
<tr>
<td>p value</td>
<td>0.0001*</td>
<td>0.0001*</td>
<td></td>
</tr>
<tr>
<td>Mean functional Knee Society Score preoperatively</td>
<td>48.4±10.5</td>
<td>50.5±10.7</td>
<td></td>
</tr>
<tr>
<td>Mean functional Knee Society Score at final follow-up</td>
<td>86.2±7.1</td>
<td>81.5±13.7</td>
<td></td>
</tr>
<tr>
<td>p value</td>
<td>0.0001*</td>
<td>0.0001*</td>
<td></td>
</tr>
</tbody>
</table>

*: Student’s t-test.

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Fig. 2. Statistical comparison of mean KSS values (total and functional) obtained pre- and postoperatively for the 2 implant designs: KSS preop=total Knee Society Score preoperatively; KSS po=total Knee Society Score postoperatively at final follow-up; KSS(F) preop=functional Knee Society Score preoperatively; KSS(F) po=functional Knee Society Score postoperatively final follow-up; MR=multi-radius; SR=single-radius. [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]
erative values (Table 3). However, there were no statistically significant differences between the 2 patient groups (Figure 2).

There were no significant differences between the 2 implant designs in terms of component positioning, except for tibial flexion angle ($p=0.002$) (Table 4). Heterotopic ossifications were found in a total of 8 cases: 3 cases of grade 1 ossification in the SR group, 3 cases of grade 1 in the MR group, and 2 cases of grade 2 in the MR group ($p=0.67$).

Because of the numerical difference between resurfaced and unresurfaced patellae in the 2 implant groups (63 versus 7 for MR, 91 versus 3 for SR), it was not possible to perform a comparison of radiologic measurements based on the presence/absence of a patellar component between the 2 patient groups.

None of the patients underwent revision arthroplasty during the follow-up period. Nonetheless, there were a total of 3 cases (1.8%) that required revision: 2 with an SR implant (1 apparent and 1 impending mechanical failure) and 1 with an MR implant (impending failure). The Kaplan-Meier survival curve showed 95.8% (95% CI: 91.8–99.8%) survivorship for the MR endoprosthesis design at 60 months and 92.7% (95% CI: 87.7–97.7%) survivorship for the SR design at 84 months. Hence, we found no statistically significant difference between the 2 endoprosthesis designs in terms of implant survival ($p=0.31$) (Figure 3).

Infectious complications were identified in 3 patients from the SR group (1.8%): in 2 cases the endoprostheses were explanted at 7 months and 21 months after TKR, respectively, while in the third case, polyethylene component revision was performed at 5 months after the initial surgery. There were 8 cases of postoperative hematoma (4.8%), 4 cases of wound dehiscence (2.4%), 5 cases of skin necrosis (3.0%), and 6 cases of thrombosis (3.6%). Skin and wound complications were resolved surgically, while hematomas and thrombosis were treated medically. The 5 observed cases of peroneal nerve palsy (3.0%) showed full recovery at 6 months.

### Discussion

In this study, we compared 2 posterior-stabilized knee endoprostheses: an SR and an MR design. Beginning with the premise that the SR implant design would yield better results, pre- and postoperative clinical, functional, and radiological results were retrospectively compared. The outcomes of this series of patients did not show any significant differences between the SR and MR implant systems in terms of clinical and radiological results, and survivorship was also similar, based on Kaplan-Meier analysis. The only 2 differences observed were in tourniquet time and radiologically observed tibial flexion angle on the lateral view. There were no revision arthroplasties during the follow-up period; however, 3 cases showed radiological signs of implant failure, based on radiolucent line width measurements. Heterotopic ossification was found in a relatively small percentage of cases (4.8%), and 3 patients developed infectious complications (1.8%).

TKR implant systems with a single radius of femoral flexion/extension have been introduced as a means of improving the biomechanical and functional results of TKR. The extended quadriceps moment arm, ligament isometry, and increase in contact area in every stage of flexion/extension have been emphasized as the benefits of such a design, producing clinically and functionally superior results.\[2,3,5,6\] However, many of these studies
did not compare their results with those of similar patients with MR endoprostheses, nor did they evaluate survivorship of the 2 types of implants. Furthermore, in vitro studies such as the one reported by Stoddard et al. who showed that the biomechanics of both SR and MR designs are similar, with no significant differences in kinematics and stability.

Our clinical results showed improvements in all cases when comparing final follow-up values to those obtained preoperatively. These results are in line with those reported by Jo et al., who found no significant difference in clinical outcomes between patients treated with SR versus MR implants after a minimum follow-up of 2 years. Larsen et al. observed similar KSS scores at 1 year postoperatively in patients treated with SR and MR design implants. Other authors suggested excellent clinical and functional outcomes at a minimum of 5 years. Despite this, Gómez-Barrena et al. compared the same types of prostheses as we did and found better functional and clinical results of the SR design at 7–9 months of follow-up. In a larger analysis of 1012 TKR cases, Palmer et al. concluded that at 2 years postoperatively, pain, ROM, and KSS values are better in cases of SR design. A similarly large-scale study by Cook et al. found improvements in function, stability, and pain when using an SR design in 559 TKRs followed for an average of 3.9 years.

The longer operative time observed when using the MR design can be linked to the complexity of instruments used with this implant system. Although statistically significant, the radiological tibial angle differences did not translate into functional or mechanical problems during the follow-up period. The infection rate (1.82%) was in line with the data reported in the literature.

The rate of heterotopic ossification (4.8%) might be explained by the relative lack of predisposing factors (trauma, immobilization, previous heterotopic ossification) in our cases. In contrast, some authors report heterotopic ossification rates of up to 39%. Atamaz et al. consider pharmacological thromboprophylaxis to be responsible for the appearance of this postoperative complication; while this treatment was used in the present study, the percentage of postoperative heterotopic ossification remained low.

Although we included 2 similar groups of patients and performed statistical analysis of implant survival, our study has several limitations: the retrospective design of the study could not prevent selection bias and the relatively short follow-up period provided limited results which could change in the long-term. We were not able to perform statistical analysis of resurfaced versus unresurfaced patella measurements for the 2 implant designs due to the small number of cases in which the patella was not replaced. Currently, there is no consensus regarding the need for patella resurfacing in TKR, with many studies showing no outcome differences between the 2 therapeutic approaches.

Even though we hypothesized that the SR design would yield better results, we were unable to find any significant differences between the mid-term outcomes of using either implant type. Based on our results, we concluded that both SR and MR posterior-stabilized knee endoprostheses can offer significant clinical and functional improvement in the mid-term, with good implant survival. Future studies should focus on long-term implant survival that might validate the superiority of one implant design over the other. Furthermore, given the fact that SR designs may offer a decrease in patellar load and facilitate a better recovery of the extensor mechanism, the survivorship of patellar components and the differences between resurfaced and unresurfaced patellae should be investigated when using the 2 implant types.

Conflicts of Interest: No conflicts declared.

References


