International Orthopaedics (SICOT) (2011) 35:1777–1782
DOI 10.1007/s00264-011-1226-6

ORIGINAL PAPER

# Scorpio single radius total knee arthroplasty. A minimal five-year follow-up multicentric study

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Received: 30 November 2010 / Accepted: 1 February 2011 / Published online: 2 March 2011


**Abstract**
*Purpose* Our goal was to evaluate the five-year follow-up results of the Scorpio single radius total knee arthroplasty.
*Method* We performed a retrospective study based upon a multicentre database to evaluate the minimum five-year follow-up clinical and radiological results of 747 patients (831 knees) who underwent primary Scorpio single radius total knee arthroplasty.
*Results* The mean age of the patients was 71.9 years. At a minimal five-year follow-up, 141 patients were lost to follow-up, 83 patients had died, eight patients had undergone revision of a component, and the remaining 589 patients (602 knees) had a complete clinical and radiological evaluation after a median of six years (range, 5–8). The mean clinical component of the knee score was 92.2 points, and the mean functional component of the knee score was 76.9 points. At last follow-up, 530 of the 602 knees were rated as excellent or good. Only four knees developed patellar complications requiring revision. The survival rate at six years was 95.2%±1.9% and 98.3%±0.6 with revision for any reason and revision for mechanical failure as the end point, respectively.
*Conclusion* This medium-term study indicates favourable clinical and radiological results for this single flexion-extension radius design arthroplasty, with a low complication rate on the patellar side.

## Introduction

Long-term clinical success of various designs of total knee arthroplasty have been widely published in the literature [1–5]. However, some concerns remain in relation to femoro-patellar symptoms, anterior knee pain, patellar clunk, and backside wear [6–8]. Recently, an original design, based upon a single femoral radius has been introduced to improve the extensor mechanism function [9–11]. The aim of this

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retrospective study was to evaluate the minimal five-year follow-up clinical and radiological outcomes of the Scorpio (Stryker Orthopaedics, Mahwah, NJ) single radius total knee arthroplasty (TKA).

## Patients and methods

### Patients

Between November 1997 and December 2000, 831 consecutive Scorpio TKAs (Fig. 1) were implanted in 747 patients at one of the authors' institutions. All patients had given informed consent for participation in the study. There were 506 females with a mean age of 72.3 years (range, 41–89 years) and 241 males with a mean age of 71.6 years (range, 42–86 years). The right knee was replaced in 363 patients, the left in 310 patients, and 74 patients had bilateral implantation. The initial diagnosis was primary osteoarthritis in 723 knees, medial condyle osteonecrosis in 21 knees, post valgus osteotomy in 56 knees, post-traumatic arthritis in ten knees, and rheumatoid arthritis in 21 knees. The mean BMI was 29.4 kg/m² for women and 28.6 kg/m² for men. Of the 747 patients, only 135 (18.4%) had a normal BMI (18–25); thus, 612 patients were overweight to severely obese.

**Fig. 1** Scorpio posterior-stabilized (PS) cemented fixed bearing total knee arthroplasty (TKA)

Using the Charnley classification [12], 485 of the 747 patients (65%) were Class A, 224 (30%) Class B, and the remaining 38 (5%) Class C. Preoperative deformity, as measured on long leg standing views, was considered as absent (± 3°) in 128 of the 831 knees (15.4%), whereas 550 knees (66.3%) were in varus, and the remaining 153 knees (18.3%) were in valgus. Coronal deformity greater than 10° was present in 215 of the 831 knees (25.9%), including 169 varus and 46 valgus knees.

### Implants

In all 831 cases a single radius Scorpio TKA (Stryker Orthopaedics, Mahwah, NJ) was used, including 665 (80%) of the posterior-stabilized (PS) design and 166 (20%) of the cruciate-retaining (CR) design. The indication for PS or CR design was left to the surgeon's discretion. Among the six participating surgeons, four systematically used a PS design, whereas the remaining two used a CR design in knees with a functional posterior cruciate ligament in the absence of a major coronal deformity. Hence, of the 215 knees with a deformity greater than 10°, a PS system was used in 159 of the 169 varus knees (94.1%) and in 45 of the 46 valgus knees (97.8%). Whereas, in the 616 knees with minor or no frontal deformity, a PS system was used in 436 knees (70.7%).

### Surgical data

All procedures were performed by one of the authors using an antero-medial parapatellar approach in 793 of the 831 knees (95.4%) and a lateral approach in 38 knees (4.6%). A tibial tubercle osteotomy was performed in 25 knees (3%). Moderate soft tissues release was done in 322 knees, whereas major release was necessary in 49 knees. Lateral patellar retinaculum section was performed in 184 of the 831 knees (23.9%), including 21 knees with valgus deformity greater than 10°, 41 knees with varus deformity greater than 10°, and 122 knees with no or minor deformity. An intra-medullary guide was used systematically on the femoral side and in 90% of the knees on the tibial side. The femoral component was cemented in 482 knees (58%) and the tibial component in 747 knees (89%). Patellae were resurfaced using an all-polyethylene implant in 819 of the 831 knees (98.6%). The surgical details according to the operating surgeon are summarised in Table 1. Thickness of the tibial insert measured 8 mm in 364 knees (43.9%), 10 mm in 266 knees (32%), 12 mm in 120 knees (14.5%), 15 mm in 36 knees (4.3%), and 18 mm in the remaining 45 knees (0.5%). Intraoperatively, full extension was obtained in 814 knees (98%), and absence of posterior laxity was noted in 829 knees (99.7%). Residual minor coronal laxity was present in 49 knees (5.9%), including 25 knees with

**Table 1** Surgical details according to the operating surgeon

| Surgeon | Type of implant | Fixation | Distal femoral cut angle | Tibial slope |
|---|---|---|---|---|
| 1 | PS | Femur uncemented Tibia cemented | 7° | 0° |
| 2 | PS | All cemented | 5° in males 7° in females | 6° |
| 3 | PS | All cemented | According to HKS angle | 0° |
| 4 | PS | All cemented | According to HKS angle | 0° |
| 5 | CR if functional PCL and coronal deviation < 10° | Femur uncemented Tibia cemented | According to HKS angle | 5° |
| 6 | CR if functional PCL and coronal deviation < 10° | All cemented | 7° | 0° |

*PS* posterior-stabilized, *CR* cruciate-retaining, *PCL* posterior cruciate ligament

preoperative deformity greater than 10° (11 valgus and 14 varus knees). Patella tracking was considered as optimal in 794 of the 831 knees (95.5%), whereas a tendency to lateral instability was noted in the remaining 37 knees (4.5%), including 13 knees with preoperative deformity greater than 10° (seven varus and 11 valgus knees).

### Postoperative regimen

Postoperatively, patients received systemic antibiotics for 48 hours and venous thromboembolism prevention therapy for five weeks. Weight bearing was allowed as tolerated immediately after operation. All patients had early mobilisation, physiotherapy and continuous passive motion.

### Clinical and radiological follow-up evaluation

All preoperative and postoperative data were recorded by the operative surgeon. The Knee Society rating system was used for clinical evaluation including pain, range of motion (ROM), stability and function [13]. The range of motion of the knee joint was determined with a standard goniometer. The patients were asked to extend and bend their knees as much as they could while lying in the supine position. The knee score then was classified as excellent (170–200 points), good (140–169 points), fair (110–139 points), or poor (< 110 points). Radiographic evaluation was based upon an anteroposterior view of knee with the patient standing, a lateral view at 30° of flexion, a merchant view, and a long leg standing view. Postoperative implant alignment and radiolucent lines according to the Knee Society scoring system [14] were measured manually using a ruler and goniometer.

### Statistical analysis

A paired Student's *t* test was used to compare pre- and postoperative scores. Statistical analysis of the relationship between various preoperative factors and the clinical and radiological results was performed using nonparametric tests. Significance was determined with SPSS statistical software (SPSS Inc., Chicago, IL). A survivorship analysis according to the actuarial method was conducted using revision for any reason, and revision for mechanical reason at the time of follow-up as the end-points. The survival curve was derived from the cumulative survival rate over time, as calculated from the actuarial life table. The standard error, given as a percentage, and the 95% confidence intervals were calculated from the data in the life table [15].

## Results

At the minimum five-year follow-up evaluation, of the 747 patients, 505 patients were still alive and had not required any revision surgery after a mean follow-up of 5.5 years (median, 6 years; range, 5–8). Eighteen patients had undergone revision of either or both components. Eighty-three patients had died of an unrelated cause, and 141 patients had been lost to follow-up. Thus the status of 690 (83%) of the original 831 knees was known at the last follow-up evaluation. All the patients who were still alive and had not had a revision were evaluated both clinically and using the radiographs previously described made at a minimum of five years after the index arthroplasty.

### Complications and revisions

Complications included delayed wound healing in 14 knees (1.7%) and a deep haematoma in 13 knees (1.6%). Periprosthetic fracture on the tibial side occurred in three knees. These were treated with plate fixation and healed with no further complication. Early postoperative stiffness (knee flexion less than 90°) required manipulation under general anaesthesia in 11 knees (1.3%), and open debridement combined with synovectomy in one knee.

Four knees developed isolated patellar complications, including one patellar fracture that was successfully managed non-operatively, one patellar implant loosening that required revision, one extensor mechanism rupture, and

one patellar instability. In the latter knee, instability was related to a technical error and required revision that led to an infection.

Eighteen knees required revision of the prosthetic components, including ten knees (1.2%) for infection, and eight knees (1%) for mechanical failure. Septic complications were related to delayed wound healing or deep haematoma in four knees, septic haematological dissemination in five knees, and revision for patellar instability in one knee. All infected knees were treated by two-stage revision.

Mechanical failure requiring implant revision included isolated tibial component loosening in two knees, isolated patellar component loosening in one knee, both femoral and tibial components in three knees, pain related to an oversized tibial component in one knee, and painful stiffness in one knee.

## Clinical results

The clinical results were assessed for the 589 patients (602 knees) who were still alive with a complete evaluation and had not had a revision at the time of the minimum five-year evaluation. The mean clinical component of the Knee Society score significantly improved from 30.1 points preoperatively to 92.2 points at the time of the last follow-up (Wilcoxon rank test, $p<0.001$). The mean functional component of the Knee Society score significantly improved from 40.8 points preoperatively to 76.9 points at last follow-up (Wilcoxon rank test, $p<.001$). Knee function score s at the last follow-up according to the preoperative Charnley classification were 82.5 points, 75.2 points, and 54.5 points in classes A, B and C patients, respectively. Three hundred and thirty knees (55%) were rated as excellent; 212 knees were rated as good (35%); 50 knees were rated as fair (8%); and ten knees were rated as poor (2%). Pain was reported as "none" or "mild during stairs climbing only" in 557 knees (92.5%), whereas preoperatively it was reported as "moderate continual" to "severe" in 528 knees (87.7%). The mean active flexion significantly (Wilcoxon rank test, $p<0.05$) increased from 107° (range, 45–140) preoperatively to 114° (range, 70–140) at last follow-up. Of the 602 knees, an extension lag greater than 10° was present for 78 knees (13%), whereas complete extension was obtained in 524 knees (87%) at the last follow-up. Among the various preoperative parameters evaluated, the age of the patient at the time of the index arthroplasty was significantly negatively correlated with the gain in KS function score (Spearman rank correlation coefficient, $p<0.002$). The increase in global and clinical KS scores was significantly greater in male patients compared to females, and in patients with coronal deformity greater than 10° ($p<0.05$). Last follow-up knee flexion was correlated with preoperative flexion (Wilcoxon rank test, $p<0.05$); however, highest gain in knee flexion was observed in patients with the lowest preoperative range of motion (Table 2). The use of PS versus CR implants did not significantly influence last follow-up flexion, but PS implants provided significantly better results in terms of pain ($p<0.001$). Knee flexion at the last follow-up was not significantly different (Mann Whitney test, $p=0.1$) whether a posterior slope was used during tibial preparation (115.3°) or the tibial cut was orthogonal in the sagittal plane (113.5°). However, it should be noted that knees with a posterior slope had a better KS function score ($p<0.001$), and the knees with the highest flexion were observed in cases of a posterior slope ($p<0.005$).

## Radiological results

The correction of coronal deformity was efficient, independent of the type of preoperative deformity: mean preoperative varus was −9.7° versus −5.6° postoperatively, and mean preoperative valgus was 10° versus 4.6° postoperatively. In the case of frontal deformity greater than 10°, preoperative varus ($n=125$) was −14.8° versus −0.9° postoperatively, and preoperative valgus ($n=26$) was −15.5° versus −0.7° postoperatively. On the tibial side, no significant difference (test, $p>0.5$) was observed when comparing intra- (beta angle 89°) versus extramedullary guide (beta angle 88°). The presence of postoperative radiolucent lines was not correlated with the postoperative alignment, or with the mode of fixation ($p>0.5$). However, there was a significant correlation between the number of radiolucent lines on the anteroposterior view of the tibia and a BMI greater than 25 ($p<0.05$), and with PS implants ($p<0.05$). Similarly, the number of radiolucent lines was correlated with a low postoperative flexion and in cases of postoperative pain (test, $p<0.05$).

## Survival analysis

With revision of either component for any reason as the end point, the cumulative survival rate at six years was 95.2%±1.9% (95% confidence interval, 93.2–100%). With revision for mechanical failure as the end point, the survival rate at six years was 98.3%±0.6 (95% confidence interval, 96–100%).

**Table 2** Flexion gain according to the preoperative flexion

| Flexion gain | < 90 | 90 to < 100 | 100 to < 110 | 100 to < 120 | > 120 |
|---|---|---|---|---|---|
| Degrees (°) | 26 | 19 | 11 | 4 | −3 |
| Percent (%) | 38 | 21 | 11 | 4 | −2 |

## Discussion

The Scorpio single radius total knee prosthesis was introduced in 1996 in an attempt to reduce concerns associated with other types of designs including patellar symptoms [9–11]. To the best of the authors' knowledge this is the first study on a consecutive series of patients evaluated after a minimal five-year follow-up following this particular single radius TKA including such a high number of patients. Moreover, as indicated in Table 1, each operating surgeon used his usual technique in terms of modes of fixation and PCL preservation, all representative of the current standards in Europe. This latter aspect also represents a limitation as it might have introduced some lack of homogeneity. Another limitation of the study is the percentage of patients lost to follow-up (17%), which is frequently associated with this type of multicentre retrospective study of a large number of patients.

The clinical results were favourable, as the gain in KS global score was greater than 100%, and 542 of the 602 knees (90%) with complete clinical and radiological data after a minimum five-year follow-up were rated as excellent or good. These results are comparable with other types of implants [3]. We are aware of two series evaluating the Scorpio TKA at similar follow-up. Kolisek and Barnes [16] reported on a consecutives series of 103 primary PS Scorpio TKA, and obtained good to excellent results in 96% of the knees after a mean four-year follow-up. Similarly, Abbas and Gunn [17] indicated good to excellent results in 116 of 125 (92.8%) PS Scorpio TKA after a minimum five-year follow-up study. The mean postoperative flexion (114°) of our series was comparable to the mean postoperative flexion reported in various designs of TKAs ranging from 107° in the series of Buechel et al. [19] to 115° in the series of Kelly et al. [20]. Using the Scorpio PS TKA, Kolisek and Barnes [16], and Abbas and Gunn [17] reported a mean postoperative flexion of 124.5° and 106°, respectively. The authors of this study acknowledge that the gain in flexion obtained (mean 10°) was limited. This observation might be related to a relative high number of overweight patients (over 80% with a BMI>25), and to a mean preoperative flexion of 106°. Indeed, it has been demonstrated in previous studies that postoperative flexion was highly dependent upon preoperative flexion [18]. We also found that the gain in postoperative flexion was significantly associated with a posterior tibial slope (from 5° to 6°), as indicated in previous studies [21, 22].The septic complication rate observed in our study is comparable to other studies specifically evaluating infection following TKA in France [23]. The mechanical failure rate that should be considered as directly related to implant design was very low in this series with only five of the 602 knees (0.8%) over a minimal five-year follow-up. Moreover, patellar complications, including one case of fracture, one case of loosening, one case of extensor mechanism rupture and one case of instability, occurred in only four of the 602 knees (0.7%). These results on the patellar side are in accordance with the results of Kolisek and Barnes [16] who reported only one patellar fracture in 103 TKAs. Also these authors more specifically evaluated anterior knee pain and patellar clunk syndrome following PS Scorpio TKA. Among the 100 knees with a minimal four-year follow-up, the incidence of anterior knee pain was 5%, whereas the incidence of patellar clunk was 1%. These observations tend to validate the single radius design of the Scorpio TKA that increases the extensor mechanism moment arm, thus improving extensor mechanism function and reducing femoro-patellar joint reaction force. The question of whether the specific design of the Scorpio knee arthroplasty does not require resurfacing of the patella being "patella-friendly" is unclear from the literature [24, 25]. The implant modes of fixation and the type of implants (PS versus CR) did not significantly influence the overall clinical or radiological results. The survival of the Scorpio TKA in our study at six years was 95.2% using revision for any reason as the end point, and 98.3% using revision for mechanical failure as the end point. Abbas and Gunn [17] reported a survival of 99.3% at eight years (95% confidence interval, 98–100%) for the Scorpio PS TKA. Based upon the Mayo implant registry including 11,606 TKAs, Rand et al. [26] reported a significantly lower ($p<0.0001$) survival for CR (76%) versus PS implants (91%) at ten years. In terms of alignment, coronal alignment of the tibial components was achieved in only 60% of the knees which fits with the meta-analysis reported by Novak et al. [27]. This emphasises the need to use both extra and intra-medullary alignment, or navigation (at extra cost) to reduce the number of outliers [27]. Also, in order to optimise flexion [28], a modified tibial insert that incorporates a relaxed posterior slope has been introduced with promising short-terms results.

This multicentre study based upon 831 Scorpio single radius TKAs performed at a mean of 5.5 years shows very good results with only 0.8% mechanical failure and 0.7% patellar-related complications. This cohort is still being followed up for longer-term clinical and radiological results.

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