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Revision Arthroplasty

Aseptic Revision Knee Arthroplasty With Total Stabilizer Prostheses Achieves Similar Functional Outcomes to Primary Total Knee Arthroplasty at 2 Years: A Longitudinal Cohort Study

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ABSTRACT

Background: Patient function is poorly characterized following revision total knee arthroplasty (TKA), although is generally accepted to be inferior to that following primary procedures.

Methods: Fifty-three consecutive aseptic revisions to total stabilizer devices were prospectively evaluated, preoperatively and at 6, 26, 52, and 104 weeks postoperatively, using the Oxford Knee Score (OKS), range of motion, pain rating scale, and timed functional performance battery. Data were assessed longitudinally and in comparison to primary TKA data with identical outcome assessments at equivalent time points.

Results: Mean outcome changes were: 13 point increase in the OKS (from 17.5 [standard deviation—SD 7.4]-32.4 [SD 7.9] points); 21 degree improvement in the knee flexion (80.6 [SD 20.5]-101.5 [SD 13.2] degrees); 60% reduction in the pain report (7.7 [SD 2.3]-1.3 [SD 0.4] points); and 15 second improvement in the timed performance assessment (47.2 [SD 19.1]-32.0 [SD 7.0] seconds; $P < .001$). No difference was seen between primary and revision cohorts in OKS or pain scores (analysis of variance, $P = .2$ and .19). Knee flexion and timed performance assessment were different between primary and revision groups (analysis of variance, $P = .03$ and $P = .02$); however, this was due to differing preoperative values. The revision cohort achieved the same postoperative scores as the primary cohort at all postoperative time points.

Conclusion: Patients undergoing revision TKA for aseptic failure with total stabilizer implants made substantial improvements in the initial 2 years following surgery in both patient-reported and directly assessed function, comparable with that achieved following primary knee arthroplasty.

Rates of revision total knee arthroplasty (TKA) are rising through an increase in the volume of primary procedures performed, increased population longevity and that younger patients are being offered joint arthroplasty than was previously the case [1]. This increase in revision rate is expected to continue, with growth of 600% predicted in revision TKA between 2005 and 2030 [2].

The cost of revision surgery is substantially greater and uses greater hospital resources than primary procedures. In addition to lower survival rates and greater complication rates, it is generally accepted that outcomes following revision arthroplasty are inferior to those following the primary procedure [3]. Around 20% of revision cases address infection of the primary implant. These cases are typically more difficult to address, often requiring multiple operations and adjunct therapies. Conversely, approximately 80% of revision cases are aseptic and more readily addressable in a single surgical episode. In this later situation, modern semiconstrained implant designs are suggested to offer high levels of function, but with the ability to accommodate significant bone loss.

Unfortunately, there is a general lack of good quality data available with which to assess the functional outcomes of revision knee arthroplasty; data that are available tend to focus on survival

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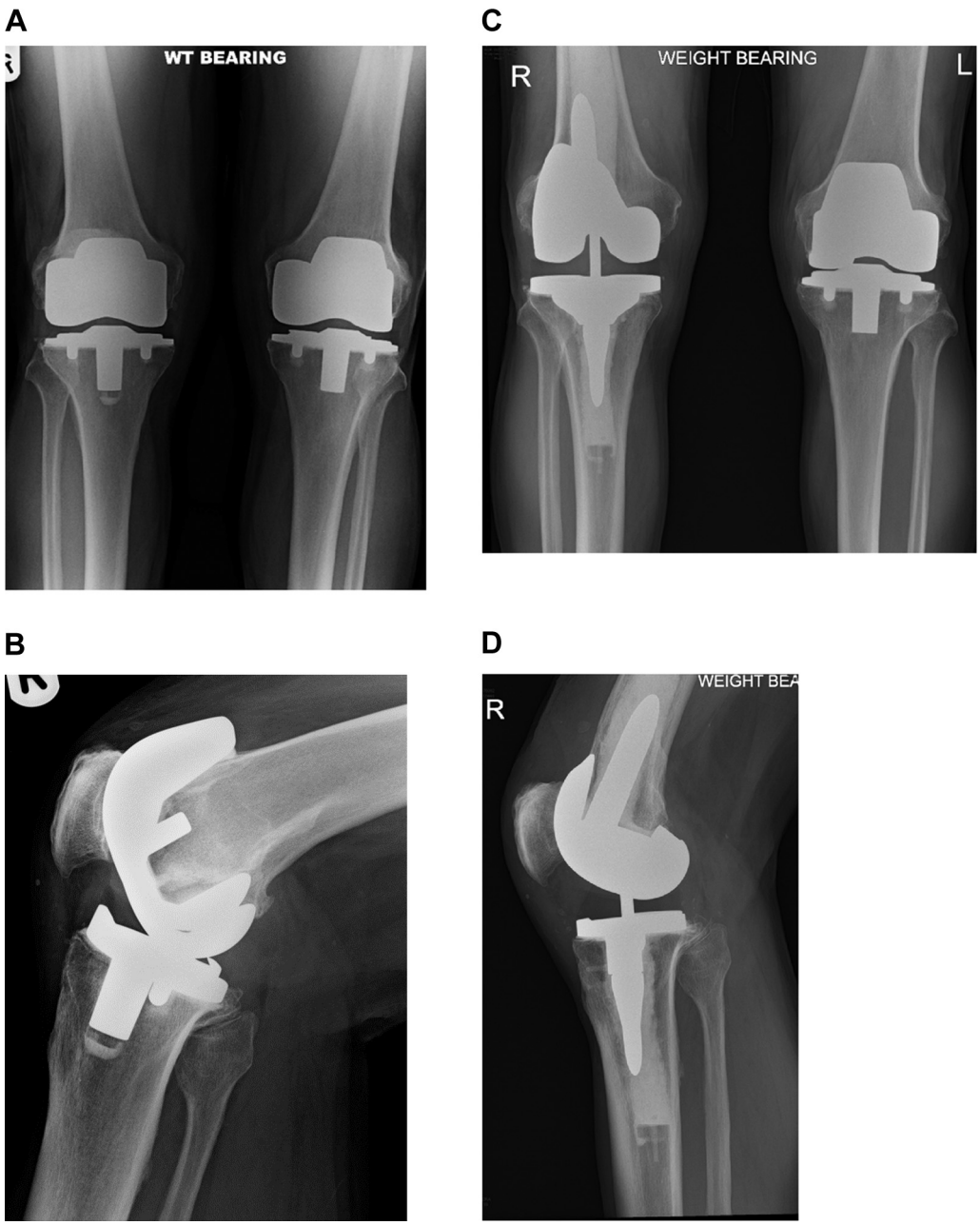

Fig. 1. Illustrative radiograph of TS revision for aseptic failure. Panel A—preoperative anteroposterior (AP). Panel B—preoperative lateral. Panel C—postoperative AP. Panel D—postoperative lateral.

and surgical complications or come from studies conducting registry reviews of patient-reported outcomes metrics [4]. Specifically, direct linked longitudinal assessment of physical function in patients undergoing revision knee arthroplasty is lacking in the orthopedic literature.

The primary aim of this study was to chart patient-reported and functional outcomes in the initial 2 years following aseptic revision TKA using semiconstrained total stabilizer implants. A secondary aim was to contextualize these data by comparing with existing (published) data for primary TKA.

Patients and Methods

Following local ethical approval, we prospectively assessed consecutive aseptic revision total knee arthroplasties using total stabilizer implants (Triathlon TS, Stryker) performed at a single UK orthopedic teaching hospital over a 2-year period between 2010 and 2012. The study center is the only hospital receiving adult referrals for a predominantly urban population of approximately 850,000 people.

Patients were identified from the planned operation lists of 4 consultant orthopedic surgeons. All procedures were revision of a primary implant to a total stabilizer device. Surgery was conducted using standardized instrumentation and a uniform surgical technique focusing on joint line restoration and posterior condylar offset. All components were cemented. Local standards of care and postoperative protocols were used.

Patients were recruited with informed consent and assessed preoperatively, then at outpatient clinical review at 6 weeks, 6 months, 1 year, and 2 years postoperatively in a clinical testing facility attached to the hospital outpatients department.

Table 1
Revision Cohort Longitudinal Outcomes (Mean, SD).

	Preop	6 wk	26 wk	52 wk	104 wk
OKS	17.55 (8.82)	25.23 (10.89)	29.50 (11.84)	30.18 (11.55)	32.39 (10.39)
Pain scale	7.67 (2.29)	4.54 (2.25)	2.76 (2.63)	2.23 (2.72)	1.33 (2.08)
Range of motion (°)	80.60 (20.54)	93.85 (18.43)	102.62 (15.61)	101.78 (18.09)	101.52 (13.15)
Functional tasks, s	47.22 (19.08)	30.91 (7.87)	32.96 (7.24)	32.35 (8.74)	32.00 (6.97)

OKS, Oxford Knee Score; SD, standard deviation.

Outcomes were contrasted with those of a previously reported study of 212 TKAs performed by the same surgeon group [5]. This comparator cohort consisted of patients undergoing primary TKA for a diagnosis of osteoarthritis. Cemented, cruciate-retaining, fixed-bearing implants were used in all cases as per the surgeon's routine practice. This study was chosen as the comparator group prospectively evaluated the functional outcomes of a cohort of primary TKAs using identical outcome assessments at equivalent time points [5], allowing direct comparison. The consistency in both surgeons and surgical philosophy reduces the influence of potential confounding variables. All source data from the primary TKA study were available to the authors for comparative statistical analysis.

Outcome Assessments

A comprehensive protocol comprising patient-reported questionnaires and objective functional assessments was used to evaluate patient outcome. The Oxford Knee Score (OKS), a frequently used and a well validated 12-item response questionnaire designed to assess the patient's perceived pain and functional ability [6,7]. Scores range from 0-48, with higher values representing better function. Global knee pain severity was assessed using an 11-point (0-10) numerical rating scale, where 0 represents no pain and 10 the worst possible pain [8]. Patient satisfaction was assessed using a 4-point Likert response scale; options were very satisfied, satisfied, unsure, or dissatisfied, responses were dichotomized to positive response (satisfied or very satisfied) or not.

Active measures of knee flexion were determined using universal goniometry [9]. The ability to perform daily functional tasks was assessed with the aggregated locomotor function score. This score is a composite timed measure of observed locomotor function using tests of walking, stair ascent/decent, and chair transfers; previously demonstrated to be valid, reliable, and responsive [10]. Specifically, patients were asked to walk over a flat 8-meter course, ascend then descend a platform consisting of 7 fixed steps, and perform a chair transfer task. Time was recorded using a handheld stopwatch (Zeon, UK). Data were collected at all time points.

Outcome data were collected at all assessments except for patient satisfaction, which was evaluated at a single time point (year 2 assessment).

Statistical Analysis

Data for parametric variables are reported by means with SDs as a measure of dispersion. Satisfaction data are reported as percentages, and were dichotomized to positive or negative values to compare with wider literature [11].

Primary Analysis

Change in outcome parameters over time was assessed with repeated measures analysis of variance (ANOVA; general liner

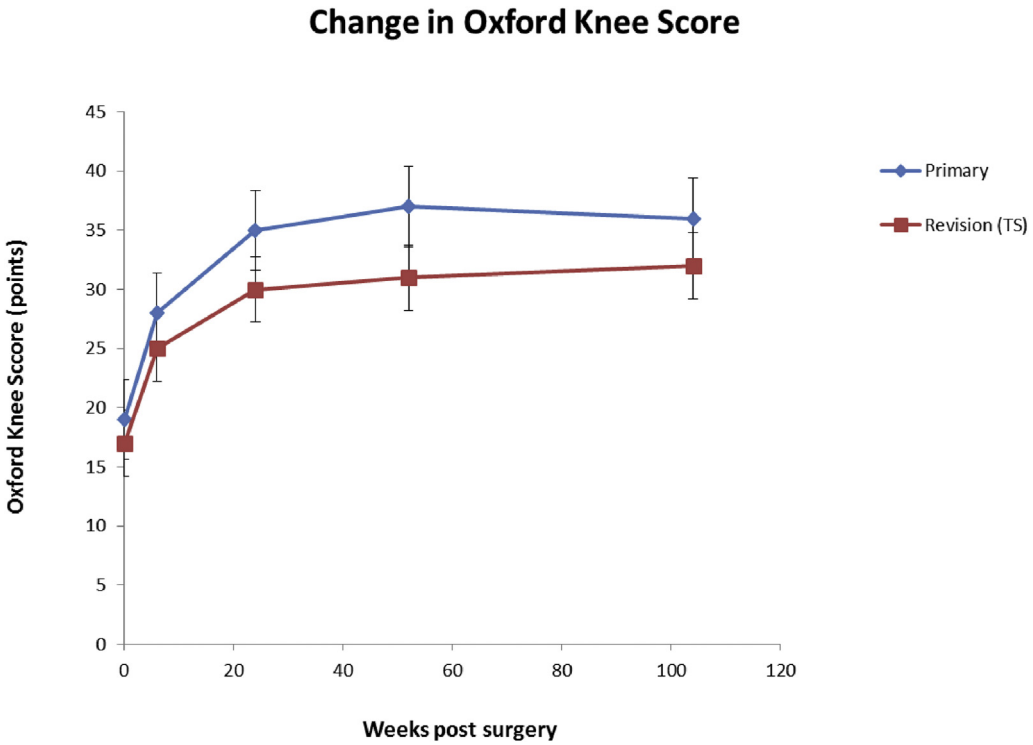

Fig. 2. Oxford Knee Score (OKS; comparators with 95% confidence intervals [CIs]).

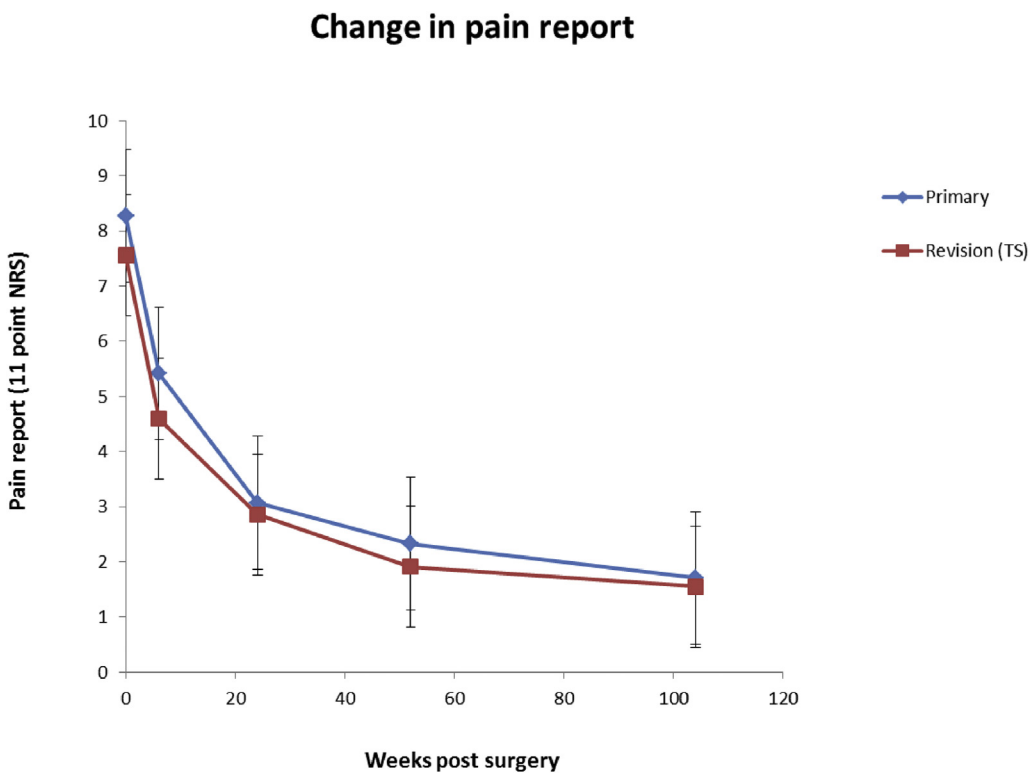

Fig. 3. Pain scores (comparators with 95% CIs). NRS, numerical rating scale.

models) for longitudinal data with Tukey honest significant difference 95% simultaneous confidence intervals (CIs) as post-hoc pairwise comparison.

Secondary Analysis

The outcomes achieved in this revision cohort were compared against results achieved in a cohort of patients undergoing primary TKA with equivalent assessments using repeated measures ANOVA general linear models, with post-hoc comparisons *via* Tukey honest significant difference 95% CIs. Analyses were carried out in SPSS version 20. Significance was accepted at $P = .05$.

Results

Descriptive Analysis

Fifty-three patients were recruited to this study in the recruitment period. Three patients were lost to follow-up during the study. One patient died in the year after surgery (cardiac condition), and 2 stopped attending review clinics and/or returning correspondence; of these, 1 was lost to follow-up after 6-week review, and the other after 1-year review. All data were included in the analysis. The prospective nature of this study allowed for tightly controlled follow-up; as such all assessments are within 8 weeks of planned follow-up, based on the time of surgery. Final review assessment was at 24 ± 2 months.

Mean age of the cohort was 73.23 years (SD 10.41), 57% were men. Mean time since index surgery was 9.03 years (SD 5.6, data range 1-23 years). Mode of failure was dichotomized to diagnoses of aseptic component loosening in 39 cases (74%) and primary component instability in 14 cases (26%). These represent early and late aseptic failures. Primary implant survival differed between these diagnostic criteria, with a mean time since index surgery of 11.4 years (SD 4.6, data range 7-23 years) in the loosening group and 2.5 years (SD 1.2, data range 1-5 years) in the instability group.

The caseload we describe here reflects the range of aseptic revisions that often require significant bony reconstruction; 90% of these cases required distal and posterior femoral augmentation (frequently using 10 mm blocks) and corresponding use of femoral stems. Our surgical technique favors the use of short cemented stems. “Freshen-up” cuts were often sufficient to address tibial bone loss with only 50% of case requiring augments; however, stems were required in every patient. An illustrative example of one of the included cases is provided as preoperative and postoperative radiographs (Fig. 1). The specific usage of stems and augments in this cohort is available as Supplementary Table 1.

Clinical Outcomes

None of these cases were revised within the 2-year follow-up period. There were no readmissions to hospital with complications. Postoperative complications included one clinically diagnosed deep vein thrombosis, where the patient was treated with warfarin, and one transient motor deficit in the common peroneal nerve, which resolved spontaneously, with no further symptoms noted beyond 6 months postoperation.

Primary Analysis (Triathlon TS Revision Cohort Longitudinal Outcomes)

Mean changes in outcomes measures (between preop and 2 years postop) were: 15 point increase in the OKS (from 17.6 [SD 7.4]-32.4 [SD 7.9] points); 21 degree improvement in the knee flexion (80.6 [SD 20.5]-101.5 [SD 13.2] degrees); 60% reduction in the pain report (7.7 [SD 2.3]-1.3 [SD 0.4] points); and 15 second improvement in the timed performance assessment (47.2 [SD 19.1]-32.0 [SD 7.0] seconds) (Table 1).

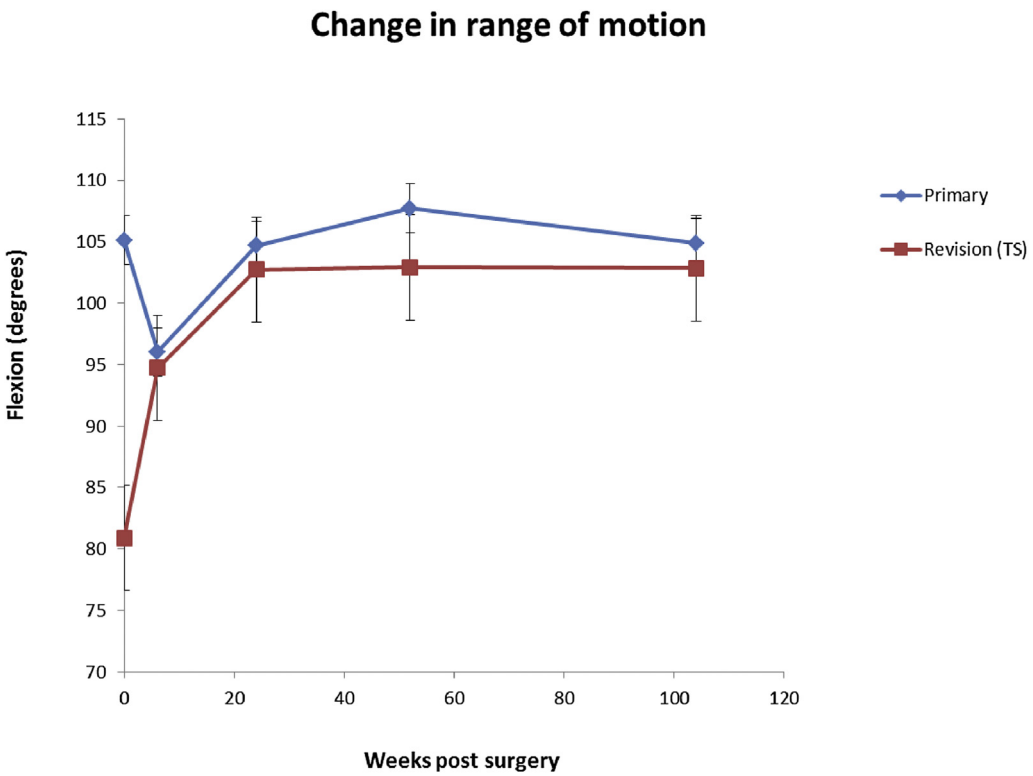

Fig. 4. Range of motion (comparators with 95% CIs).

Longitudinal changes in all 4 outcome measures were statistically significant at $P < .001$ (repeated measures ANOVA), highlighting the positive effect of revision arthroplasty on the patient's pain and physical function (Figs. 2-5). Post-hoc analysis demonstrated statistically significant differences between early assessment points (preop, 6 weeks, and 26 weeks postop) across all 4 outcome parameters, further changes over time were not statistically different to the 6-month time point.

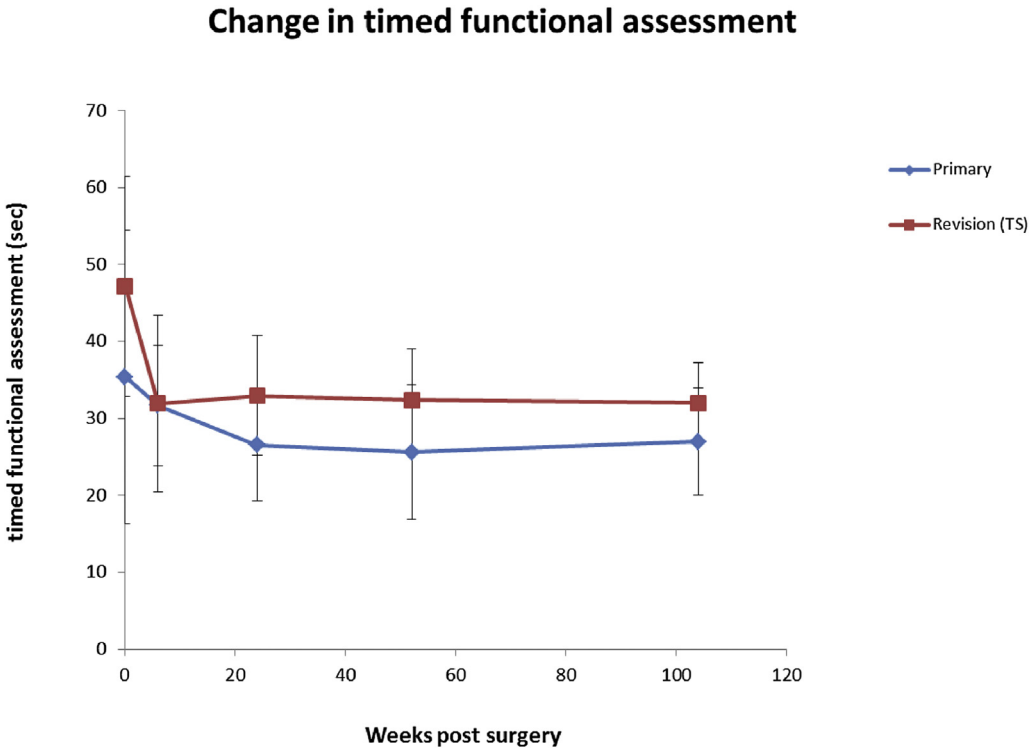

Fig. 5. Timed functional performance (comparators with 95% CIs).

Table 2
Patient-Reported Satisfaction at 2 y Postsurgery (n = 50).

	Very Satisfied	Satisfied	Unsure	Dissatisfied	Very Dissatisfied
Cases (%)	19 (38)	23 (46)	5 (10)	3 (6)	0 (0)

Patient-reported postoperative satisfaction with revision knee arthroplasty at 2 years was 84% (Table 2). Of the 3 patients that reported dissatisfaction with outcome, 2 highlighted continuing pain and 1 highlighted postoperative complications as reasons for their response.

Secondary Analysis (Comparison to Primary TKA Outcomes)

Outcome data for this revision cohort were contrasted with that of a previously reported cohort of 212 primary TKA patients performed by the same surgeons with identical outcome assessments at equivalent time points [5] (Table 3).

Secondary analysis compared the revision cohort with the primary knee arthroplasty data. The revision cohort was 5 years older (primary cohort 68.3 years [9.0], paired *t* test, $P = .01$), with a higher proportion of men (primary cohort 32% men, chi square, $P = .037$).

No difference was observed between primary and revision groups in the OKS (repeated measures ANOVA, $P = .2$). Post-hoc assessment demonstrated a similar trajectory of change with overlapping CIs at individual assessment time points (Fig. 2). Similarly, no between group difference was observed in pain scores (repeated measures ANOVA, $P = .19$; Fig. 3).

Range of motion was significantly different between groups over the 2-year assessment period (repeated measures ANOVA, $P = .03$); however, this was due to the notably poorer preoperative flexion scores in the revision cohort. Post-hoc analysis showed that there was no difference between groups in flexion at any postoperative time point (Fig. 4), and that the revision cohort achieved the same flexion parameters as the primary group. Similarly, although there were statistically significant between group differences in the timed performance test across the assessment period (repeated measures ANOVA, $P = .02$), this was driven by the preoperative value being notably worse in the revision group. Postoperatively, there was no difference in the functional performance time (Fig. 5).

Discussion

This study highlights high levels of functional performance in a consecutive cohort of aseptic revision TKA patients in the initial 2 years after surgery. Postoperative outcomes were seen equivalent to those following primary knee arthroplasty in terms of range of motion, pain report, patient-reported outcome score, and timed functional performance.

Revision knee arthroplasty is, generally, a costly and complex intervention that requires considerably more resources than the index surgery [12]. Although improvements are reported in patient health and function, outcomes of revision knee arthroplasty are accepted as being worse than those of primary procedures [3,13]. The outcomes of revision knee arthroplasty are particularly difficult to quantify, as the "level" of revision procedure is not always clear, and results differ according to the mode of failure, with outcomes following septic revision notably worse [3,14]. From an implant perspective, revision knee arthroplasty ranges from fairly minor procedures such as secondary patella resurfacing or liner exchange, to constrained linked and megaprostheses, and patient outcomes will likely reflect the indications for surgery. There is a distinct lack of functional outcome data available in the wider literature with which to evaluate patient recovery following revision knee arthroplasty beyond implant survival statistics, rates of surgical complications, and registry data [4]. In possibly, the most comprehensive article to date, Baker et al [3] report an analysis using data from the UK National Joint Registry and demonstrate revision cases to perform worse than primaries as assessed with patient-reported data (the OKS and satisfaction score) at 12 months. Lesser satisfaction is a typical report following revision surgery; Baier et al [15] reported a 28% complication rate and 26% reoperation rate in a series of 78 revision knees. Notably, these authors reported that 28% of patients would not have chosen revision surgery if they could "go back in time and decide again".

As such, the data we report here is of interest as it both charts the patients' postoperative recovery in the 2 years following revision surgery and contextualizes this against that of primary knee arthroplasty using comparable data at equivalent time points. Interestingly, the average pain report and the OKS were equivalent between primary and revision cases preoperatively, suggesting a similar level of symptomology before surgery; however, range of motion and timed performance tasks were notably worse preoperatively among the revision group, suggesting a greater physical dysfunction. Despite this "lower" starting point, similar improvements in all parameters were observed longitudinally in the 2 years following surgery in both primary and revision groups; the overlapping CIs reflecting the statistical equivalence of the data at the postoperative assessment time points. Eighty-four percent of patients in this revision series reported being either satisfied or highly satisfied with the outcome, a figure that is also directly comparable with typical reports following primary knee arthroplasty [11,16].

The majority of improvement (across all assessed parameters) was seen in the early postoperative period. Significant improvements were recorded between preop and 6 weeks and between 6 weeks and 6 months postop, with no further relevant functional changes over time. This is somewhat in contrast to the typical clinical assertion that postoperative recovery is a slow process. Our data instead suggest that a comparatively rapid physical recovery and reduction in pain symptoms can be achieved at the earliest clinically relevant postoperative time points in this patient group.

Strengths and Limitations

To our knowledge, this is the most detailed postoperative functional analysis of a multisurgeon series of semiconstrained revision implants to date. There are many strengths to this study,

Table 3
Comparator Data for Primary TKA (Mean, SD).

	Preop	6 wk	26 wk	52 wk	104 wk
OKS	19.1 (7.41)	27.4 (8.86)	34.9 (8.25)	37.8 (7.89)	36.4 (8.17)
Pain scale	8.27 (1.46)	5.36 (2.55)	2.99 (2.70)	2.34 (2.57)	1.69 (2.16)
Range of motion (°)	104.85 (14.40)	96.31 (13.25)	104.30 (12.40)	107.36 (11.76)	104.17 (10.11)
Functional tasks, s	35.41 (14.32)	31.67 (11.50)	26.56 (7.78)	25.61 (6.60)	26.62 (5.50)

OKS, Oxford Knee Score; SD, standard deviation; TKA, total knee arthroplasty.

including the prospective repeated measures methodology, length of longitudinal follow-up, depth of the functional assessments performed, and the consistency of surgical protocol. All 4 surgeons performed high volumes of revision knee arthroplasty [16] and used the same surgical philosophy and technique. This consistency allows us to report average functional outcomes of this cohort of aseptic revision knee arthroplasties performed with total stabilizer implants; however, the results may not necessarily translate to other techniques, implants, or situations. A further limitation is the restricted postoperative time frame of 2 years, which allows us to comment on the early postoperative function achieved by patients, but not on implant survival.

Conclusions

Patients undergoing revision TKA with semiconstrained total stabilizer implants made substantial improvements in the OKS, pain scores, knee flexion, and timed functional performance in the initial 2 years after surgery. The early functional results achieved are remarkably similar to those reported for primary arthroplasty, highlighting that high levels of patient function can be achieved following revision knee arthroplasty using semiconstrained devices. This finding is important in relation to the projected high volumes of revision surgery over the next 2 decades, potentially in relatively "young" patients with higher expectations of functional ability in their older years.

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Supplementary Table 1
Augments and Stems Used (%Cases).

	Stem, mm	Cases (%)	Distal, mm	Cases (%)	Posterior, mm	Cases (%)
Femur	0	5	0	10	0	10
	50	65	5	50	5	30
	100	30	10	30	10	60
			15	10		
Tibia	0	0	0	50		
	50	75	5	15		
	100	25	10	35		