Enhanced recovery programmes can reduce length of stay after total knee replacement without sacrificing functional outcome at one year

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ABSTRACT

INTRODUCTION Enhanced recovery programmes (ERPs) are being widely adopted in total knee replacement (TKR) procedures but studies confirming that they have no adverse effects on functional outcomes are lacking. The aim of this study was to compare length of stay, postoperative functional outcome and range of motion at one year postoperatively between patients undergoing TKR with an ERP and those with traditional rehabilitation.

METHODS A total of 165 consecutive patients undergoing primary unilateral TKR were included in the study. Overall, 84 patients undergoing TKR with an ERP were compared with a series of 81 patients undergoing primary unilateral TKR with traditional rehabilitation, immediately before the introduction of the ERP.

RESULTS The median postoperative length of stay was 3 days in the ERP cohort and 4 in the traditionally rehabilitated cohort ($p<0.001$). There were no significant differences in the preintervention characteristics of the groups and there was no significant difference in operative time, transfusion or rates of manipulation under anaesthesia. There was no difference in magnitude of improvement in American Knee Society score ($p=0.12$) or range of motion ($p=0.81$) between the groups.

CONCLUSIONS ERP can reduce length of stay after TKR while offering improvements in knee function equivalent to those experienced by patients undergoing TKR with traditional rehabilitation. Furthermore, ERP can be implemented successfully in the setting of a district general hospital.

KEYWORDS

Enhanced recovery – Fast track – Total knee replacement

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Enhanced recovery programmes (ERPs) have been in use for many years in elective general surgery^{1–4} and they have become increasingly prominent in orthopaedic surgery in recent years.^{5–15} They aim to standardise routine perioperative care, reduce length of hospital stay and promote rapid recovery.

Total knee replacement (TKR) is an effective treatment for end-stage arthritis of the knee, and offers patients the prospect of prolonged, effective pain relief,¹⁴ improved joint function and quality of life.¹⁵ In 2011 over 618,000 TKRs were performed in the US¹⁶ while over 85,000 were performed in the UK.^{17,18} Obesity and increasing age are major risk factors for development of osteoarthritis, the most common indication for TKR.^{19,20} With an ageing population demographic and an obesity epidemic in the developed world, demand for TKR is expected to continue rising steadily.²⁰

Different ERPs have been described for lower limb arthroplasty^{5–7,10–15} and yet the principles underlying most are similar. An initial emphasis on minimally invasive surgery has shifted with the main focus now on early postoperative mobilisation, adequate multimodal and pre-emptive

pain control, preoperative education and setting of patient expectations for early discharge.

A small number of studies demonstrate that length of stay on the surgical ward after TKR can be reduced with the implementation of such protocols.^{5,7,9–12,21} This is important at a time when demand for TKR is increasing rapidly along with concurrent economic pressures dictating a need for improved efficiency and reduction in healthcare costs. ERPs are being widely adopted by hospitals as a result of these findings but there has been no published research into functional outcomes of patients treated in this manner beyond six weeks after surgery. It is essential that surgeons understand the expected longer-term functional outcomes of enhanced recovery TKR if they are to adopt its use in their routine practice and counsel patients preoperatively. Comparison with the current gold standard (traditional rehabilitation TKR) is important to determine whether ERPs meet their aims without sacrificing functional outcome.

The aim of this study was to compare length of stay, improvement in functional outcome and range of motion (ROM) at one year after surgery in patients undergoing

TKR with an ERP with patients undergoing TKR with traditional perioperative management. It was hypothesised that implementation of an ERP results in a reduction in length of stay without adversely affecting the improvement in function and ROM experienced by patients at one year postoperatively.

Methods

Patients were reviewed prior to and one year following surgery in a specifically designated arthroplasty clinic run by a consistent team of four arthroplasty nurse practitioners and data were collected in a prospectively maintained database. American Knee Society knee (AKSK) and functional (AKSF) scores²² were recorded at each visit. The AKSK score is a clinically assessed score of the knee joint in isolation, ranging between 0 and 100, based on measurements of pain (0–50), ROM (0–25), stability (0–25) and alignment (computed as a deduction of up to 20). Flexion contracture and extensor lag are attributed negative scores of up to 15 points each. The AKSF is a global functional score ranging between 0 and 100, based on a patient's manageable walking distance (0–50), ability to climb stairs (0–50) and use of walking aids (computed as a deduction of up to 20).

The American Knee Society clinical rating system recognises that patients' global functional status may be affected for reasons unrelated to the knee joint in question. Consequently, patients are further categorised to account for their overall status independently to the knee joint under review. Patients in category A are those with unilateral knee disease or bilateral knee disease with a previous successful knee replacement on the contralateral side, those in category B have disease affecting the knee in question and a symptomatic contralateral knee, and category C represents patients with polyarthrititis or general frailty/clinical disease.

The database was examined over a three-year period (January 2010 – April 2013) and all patients who underwent prosthetic knee replacement under the care of the senior author were selected. This time period bridges an abrupt change from traditional perioperative rehabilitation to ERP, which occurred in January 2012.

Unicompartmental knee replacements, patellofemoral replacements and revision TKRs were excluded to ensure comparable pathology in both groups. There were 169 potentially eligible primary TKR patients during this time period. There were no simultaneous bilateral TKR cases. Two patients undergoing complex primary TKR with augments or metaphyseal sleeves were excluded as well as one patient with a contralateral below-knee amputation and another with a significant psychiatric disorder. One hundred and sixty-five consecutive standard primary unilateral TKR patients were therefore included for analysis.

Each patient received a PFC[®] Sigma[®] primary cemented TKR (DePuy Leeds, UK). Intravenous antibiotics were given at induction of anaesthesia in the form of ceftriaxone 1g. A tourniquet was inflated immediately prior to the procedure in both groups and deflated at the end. Intermittent calf

compression was in place on the non-operated limb for the duration of the operation and following surgery, venous thromboembolic prophylaxis was addressed with rivaroxaban unless the patient was on warfarin preoperatively. The senior author performed or directly supervised all procedures. Data were collected on operation length, length of stay, blood transfusion and urinary catheterisation.

Statistical analysis

Statistical analysis was performed using SPSS[®] version 20 (IBM, New York, US). Shapiro–Wilk testing was used to determine whether data were normally distributed. Two-tailed Student t-tests were used to compare means for normally distributed data. Mann–Whitney U tests were used to compare non-normally distributed data. Paired data were compared using a paired t-test when normally distributed or a related-samples Wilcoxon signed-rank test when non-normally distributed. Chi-squared tests were used to analyse nominal datasets, except where the expected count in any cell was <5, when Fisher's exact test was used. A *p*-value of <0.05 was considered statistically significant.

Enhanced recovery programme

A multidisciplinary ERP was introduced for patients undergoing TKR in January 2012. Team members include the surgeon, anaesthetist, nursing staff, occupational therapists and physiotherapists. Changes were made to preoperative, perioperative and postoperative care, as detailed below.

Patients were reviewed by an orthopaedic physiotherapist on a one-to-one basis at the preoperative assessment clinic and the normal course of postoperative events was explained. Expectations were set for mobilisation on the day of surgery and early discharge. The patients were given a leaflet with advice regarding exercises, wound care and answers to frequently asked questions. All patients (except the first patient on the operating list) were admitted on the day of surgery. Intraoperative periarticular injection was undertaken with 4mg of morphine, 20ml of 0.5% bupivacaine with adrenaline (1:200,000) and 30mg of ketorolac made up to 50ml volume using normal saline. Patients in both groups (non-ERP and ERP) received spinal anaesthesia unless failed or contraindicated, and were given 500mg of tranexamic acid during wound closure and a further 500mg three hours following surgery unless contraindicated.

Postoperatively, patients were mobilised on the day of surgery providing no excess wound soakage occurred, except for the last patient on the operating list, who was mobilised the following morning. Mobilisation was using a Zimmer frame initially but progressed to two sticks as soon as possible. Analgesia was provided with regular paracetamol and OxyContin[®] (controlled release oxycodone; Napp, Cambridge, UK) and OxyNorm[®] (oxycodone; Napp), as required. Patient controlled analgesia was not used in patients in the ERP, whereas it had been routinely used prior to this. Postoperative exercises remained unchanged and consisted of active toe, ankle and quadriceps exercises, straight leg raise, static quadriceps exercises and active knee flexion on a sliding heel board. Patients were discharged when they could climb stairs independently and the wound was dry.

Results

Data regarding the index admission were available for all 165 patients. One hundred and fifty-five patients (94%) were reviewed in the arthroplasty clinic at one year, one patient (traditional rehabilitation) was dead (metastatic bowel adenocarcinoma), and one was terminally ill and therefore not reviewed. Five patients were alive but only received 5–8 months of follow-up review and were excluded from one-year analysis while three were lost to follow-up.

Overall, 81 patients (44 female) underwent TKR with traditional rehabilitation (non-ERP group) while the remaining 84 patients (42 female) underwent TKR with an ERP ($p=0.58$). The mean patient age was not significantly different in the non-ERP (70.1 years, standard deviation [SD]: 10.5 years) and ERP (69.8 years, SD: 8.9 years) groups ($p=0.87$). The median body mass index was 31.8 kg/m² (range: 20.5–41.9 kg/m²) in the non-ERP and 32.4 kg/m² (range: 22.6–46.6 kg/m²) in the ERP cohorts ($p=0.62$).

The mean preoperative haemoglobin concentration was 13.5 g/dl (SD: 1.4 g/dl) in the non-ERP group and 13.5 g/dl (SD: 1.6 g/dl) in the ERP group ($p=0.95$). There was no significant difference in the distribution of patients across ASA (American Society of Anesthesiologists) grades ($p=0.57$), American Knee Society category ($p=0.52$) or anaesthesia type ($p=0.52$; Table 1). The preoperative median ROM (93° [range: 45–125°] vs 94° [range: 16–135°], $p=0.47$), mean AKSK score (34.2 [SD: 14.1] vs 34.9 [SD: 14.1], $p=0.75$) and median AKSF score (both 65 [range: 20–100], $p=0.61$) were not significantly different between the groups.

The median operative time was 1 hour 10 minutes (range: 50 minutes – 2 hours 8 minutes) in the non-ERP patients and 1 hour 9 minutes (range: 49 minutes – 1 hour 35 minutes) in the ERP patients ($p=0.10$). The mean change in haemoglobin between the preoperative measurement and that on the first postoperative day was slightly lower ($p=0.007$) in the non-ERP cohort (−1.8 g/dl, SD: 0.7 g/dl) than in the ERP cohort (−2.2 g/dl, SD: 0.8 g/dl). There were four blood transfusions in each group ($p=1.0$). Thirteen patients in the non-ERP group and six ERP patients underwent urinary catheterisation ($p=0.07$).

All patients were discharged directly to their place of residence. Length of stay data were not normally distributed. The median postoperative length of stay was 4 days

Figure 1 Cumulative discharge rates for traditional rehabilitation and enhanced recovery programme (ERP) groups for each postoperative day

(range: 2–16 days) in the non-ERP group and 3 days (range: 2–14 days) for ERP patients ($p<0.001$) (Fig 1).

In the non-ERP group, 1% of patients were discharged by day 2, 20% by day 3, 62% by day 4 and 69% by day 5. In the ERP cohort, 7% of patients were discharged by day 2, 51% by day 3, 76% by day 4 and 86% by day 5.

Full AKSK scoring including ROM measurements were taken for 161 patients preoperatively (78 non-ERP, and 83 ERP) and 148 patients at one year (75 non-ERP, 73 ERP). Both groups demonstrated significant improvement ($p<0.001$) in AKSK from preoperative measurement to measurement at one year following surgery and there was no significant difference in the magnitude of change (median increase of 57 [range: −25.4–+85.0] in the non-ERP cohort and 52.8 [range: −3.0–+86.6] in the ERP cohort, $p=0.12$). Both groups showed significant improvement ($p<0.001$) in the pain score component of the AKSK (median: +40 [range: −20–+50] for non-ERP patients and +40 [range: 0–50] for ERP patients) and there was no significant difference in the magnitude of change between the groups ($p=0.55$).

Both groups experienced a modest increase in the mean ROM, averaging 6.5° (SD: 19.5°) in the non-ERP cohort ($p=0.006$) and 5.8° (SD: 19.2°) in the ERP cohort ($p=0.012$). There was no significant difference in the magnitude of this change between the groups ($p=0.81$).

When analysing change in AKSF, only patients who remained in the same American Knee Society category at one year were compared (55 in the non-ERP group and 45 in the ERP group). Both cohorts demonstrated improvements in AKSF score and there was no statistically significant difference in the magnitude of mean improvement

Table 1 Anaesthesia type in both patient groups

	Non-ERP group (n=81)	ERP group (n=84)
Spinal anaesthesia	73	80
General anaesthesia	6	3
Epidural anaesthesia	1	1
Combined general + spinal anaesthesia	1	0
ERP = enhanced recovery programme		

between the groups (+6.9 [SD: 18.2] for non-ERP patients and +5.9 [SD: 21.6] for ERP patients, $p=0.80$).

One patient in the non-ERP cohort and five in the ERP group underwent manipulation under anaesthesia (MUA) in the first year ($p=0.21$). Two patients developed a postoperative cardiac arrhythmia during admission and one deep vein thrombosis was diagnosed within six months in the non-ERP group. These complications were not observed in the ERP cohort. Two non-ERP patients and one patient in the ERP developed acute confusional state following surgery. Postoperative lower respiratory tract infection and superficial wound infection were treated in one patient from each group. No deep infections or revisions were recorded within one year.

Discussion

The focus of previous studies on TKR ERPs has been almost exclusively on length of stay,^{8–10,21} with few commenting on general quality of life outcomes (SF-36[®] and EQ-5D[™]), either at early timepoints⁷ or without a comparator group rehabilitated in the traditional method.²³ While reducing length of stay is a key objective in any ERP, the effect on joint function in the longer term must also be understood before any such programmes can be recommended to patients over traditional rehabilitation programmes. Despite a lack of evidence demonstrating equivalence of functional outcome to that in traditional rehabilitation methods, ERPs have been widely implemented throughout the UK and other countries. Two studies report on early postoperative functional scores at six weeks^{5,11} but no data are available regarding longer-term functional outcomes.

Even with an absence of studies demonstrating equivalence of functional outcomes in the medium term, ERPs are becoming increasingly popular. One randomised study whose title suggests comparison of traditional with fast track TKR¹² was not felt to be a suitable comparator as the protocol differed in many ways from ERPs in wider use. The authors reported a significantly longer length of stay than that described in the published literature, followed by routine 18-day admission to a rehabilitation ward. They reported at 12 weeks following surgery on a combined score calculated as the sum of the AKSK and AKSF scores. This calculation has been advised against,²⁴ and ignores the design of the AKSK to overcome the negative effects of pathology in other joints and general frailty^{22,24} when assessing the replaced knee joint.

Our study design allowed direct comparison of changes in knee specific and general functional scores between patients undergoing TKR with an ERP and the current accepted gold standard traditional rehabilitation. To our knowledge, it is the first study to report knee specific functional outcomes and ROM at one year following surgery in the context of an ERP. There were no significant differences in the preoperative characteristics of both groups (age, sex, body mass index, preoperative haemoglobin levels, ASA grade, anaesthesia type, American Knee Society category, AKSK and AKSF scores, and ROM).

Length of stay was reduced significantly in the ERP group and similar to that described in other ERPs.^{5,8,21} Our study shows a 25% reduction in median postoperative length of stay, which could potentially improve efficiency and throughput on the orthopaedic elective unit. These are both important factors in the current economic climate, where health services face constant pressures and the need to meet strict waiting time targets.

Operative technique was modified by the addition of periarticular injection. We perform injection in two stages, the first (posterior infiltration on medial and lateral aspects of knee) while the cement is being mixed and the second (quadriceps muscle infiltration and peritibial infiltration) while the cement is curing with the leg in extension. Despite this additional step, we have shown that periarticular injection can be undertaken without prolonging surgical time. We believe that injections facilitate pain free mobilisation in the hours after surgery, which in turn increases patients' confidence in their ability to mobilise, even after the effects of the injected drugs have worn off.^{5,6} However, a systematic review in 2013 concluded that injection alone did not reduce length of stay.²⁵

Reporting AKSK gives a clear indication of objective joint specific function. In keeping with previously reported outcomes after routine TKR, both groups (traditional rehabilitation and ERP) experienced significant improvement in pain and AKSK scores¹⁴ as well as modest improvement in ROM,²⁶ which can be attributed to TKR, and there was no detectable difference in the magnitude of these changes attributable to the method of rehabilitation. We suggest that improvement in knee specific functional scores at one year after TKR with an ERP is equivalent to that observed with traditional TKR.

Unlike the AKSK score, the AKSF score is a global measure of patient function and may be affected by pathology in other joints, co-morbidities or general frailty. Changes in AKSF score are therefore not necessarily representative of function in the surgically replaced knee joint. The designers of this scoring system categorised patients to account for factors unrelated to the joint in question but that might affect overall AKSF score.^{22,24} Only patients who remained in the same category prior to and following surgery were compared, indicating no significant change in symptoms arising from other joints or general frailty. Again, both groups demonstrated comparable improvements in AKSF score by one year.

TKR aims primarily to relieve pain while maintaining a functional ROM and both groups demonstrated this trend. Postoperative ROM is determined by a number of factors, the most important being preoperative ROM.^{26–28} Maurerhan *et al* raised concerns of significantly increased requirements for MUA for joint stiffness with reducing length of stay.²⁹ We did not experience this phenomenon. MUA has been shown to provide most benefit when performed in the early postoperative period^{27,30} and is seldom performed beyond one year after surgery, hence our decision to report on MUA at this timepoint. Patients in both groups demonstrated a small but significant improvement in mean ROM

at one year after TKR and the magnitude of improvement was comparable between the groups, indicating that an ERP had no adverse effects on joint ROM at one year.

Data regarding incidence of postoperative complications were collected specifically at discharge from hospital and at one year following surgery. Although not a primary outcome measure in this study, we have reported on incidence of complications encountered. There did not appear to be any notable differences in complication rates between the groups.

It is acknowledged that this was a non-randomised study. Furthermore, prospectively collected data were reviewed retrospectively and this leaves potential for bias. However, it has been demonstrated that there were no significant differences between the preintervention populations. As a single surgeon series, potential bias introduced with multiple operating surgeons (and associated variations in surgical technique and standards) is avoided. The individual effects of each measure implemented in this ERP were not studied. Further randomised controlled prospective studies should be undertaken to confirm these findings at five and ten years following surgery, and to identify the individual contributions of each component of a successful ERP.

Conclusions

The results of this study support our initial hypothesis that an ERP in elective TKR can reduce length of stay without compromising expected improvements in knee function at one year following surgery. Results were equivalent to those experienced by patients undergoing TKR with traditional rehabilitation. An ERP may facilitate improved patient throughput in elective orthopaedic units without lengthening operating time or compromising longer-term joint function and it can be implemented successfully in the setting of a district general hospital.

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References

1. Wilmore DW, Kehlet H. Management of patients in fast track surgery. *BMJ* 2001; **322**: 473–476.
2. Kehlet H, Wilmore DW. Multimodal strategies to improve surgical outcome. *Am J Surg* 2002; **183**: 630–641.
3. Kehlet H, Dahl JB. Anaesthesia, surgery, and challenges in postoperative recovery. *Lancet* 2003; **362**: 1,921–1,928.
4. Kehlet H, Wilmore DW. Evidence-based surgical care and the evolution of fast-track surgery. *Ann Surg* 2008; **248**: 189–198.
5. Isaac D, Falode T, Liu P *et al*. Accelerated rehabilitation after total knee replacement. *Knee* 2005; **12**: 346–350.
6. Ranawat AS, Ranawat CS. Pain management and accelerated rehabilitation for total hip and total knee arthroplasty. *J Arthroplasty* 2007; **22**(7 Suppl 3): 12–15.
7. Larsen K, Sørensen OG, Hansen TB *et al*. Accelerated perioperative care and rehabilitation intervention for hip and knee replacement is effective: a randomized clinical trial involving 87 patients with 3 months of follow-up. *Acta Orthop* 2008; **79**: 149–159.
8. Husted H, Holm G, Jacobsen S. Predictors of length of stay and patient satisfaction after hip and knee replacement surgery. *Acta Orthop* 2008; **79**: 168–173.
9. Raphael M, Jaeger M, van Vlymen J. Easily adoptable total joint arthroplasty program allows discharge home in two days. *Can J Anaesth* 2011; **58**: 902–910.
10. Smith TO, McCabe C, Lister S *et al*. Rehabilitation implications during the development of the Norwich Enhanced Recovery Programme (NERP) for patients following total knee and total hip arthroplasty. *Orthop Traumatol Surg Res* 2012; **98**: 499–505.
11. McDonald DA, Siegmeth R, Deakin AH *et al*. An enhanced recovery programme for primary total knee arthroplasty in the United Kingdom – follow up at one year. *Knee* 2012; **19**: 525–529.
12. den Hertog A, Gliesche K, Timm J *et al*. Pathway-controlled fast-track rehabilitation after total knee arthroplasty: a randomized prospective clinical study evaluating the recovery pattern, drug consumption, and length of stay. *Arch Orthop Trauma Surg* 2012; **132**: 1,153–1,163.
13. Ibrahim MS, Alazzawi S, Nizam I, Haddad FS. An evidence-based review of enhanced recovery interventions in knee replacement surgery. *Ann R Coll Surg Engl* 2013; **95**: 386–389.
14. Arthur CH, Wood AM, Keenan AC *et al*. Ten-year results of the Press Fit Condylar Sigma total knee replacement. *Bone Joint J* 2013; **95**: 177–180.
15. Räsänen P, Paavolainen P, Sintonen H *et al*. Effectiveness of hip or knee replacement surgery in terms of quality-adjusted life years and costs. *Acta Orthop* 2007; **78**: 108–115.
16. HCUPnet. Agency for Healthcare Research and Quality. <http://hcupnet.ahrq.gov/> (cited June 2015).
17. Scottish Arthroplasty Project. *Scottish Arthroplasty Project Biennial Report 2012*. Edinburgh: ISD Scotland; 2012.
18. National Joint Registry for England and Wales. *9th Annual Report*. Hemel Hempstead: NJR; 2012.
19. Arden N, Nevitt MC. Osteoarthritis: epidemiology. *Best Pract Res Clin Rheumatol* 2006; **20**: 3–25.
20. Carr AJ, Robertsson O, Graves S *et al*. Knee replacement. *Lancet* 2012; **379**: 1,331–1,340.
21. Husted H, Jensen CM, Solgaard S, Kehlet H. Reduced length of stay following hip and knee arthroplasty in Denmark 2000–2009: from research to implementation. *Arch Orthop Trauma Surg* 2012; **132**: 101–104.
22. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. *Clin Orthop Relat Res* 1989; **248**: 13–14.
23. Larsen K, Hansen TB, Søballe K, Kehlet H. Patient-reported outcome after fast-track knee arthroplasty. *Knee Surg Sports Traumatol Arthrosc* 2012; **20**: 1,128–1,135.
24. König A, Scheidler M, Rader C, Eulert J. The need for a dual rating system in total knee arthroplasty. *Clin Orthop Relat Res* 1997; **345**: 161–167.
25. Jiang J, Teng Y, Fan Z *et al*. The efficacy of periarticular multimodal drug injection for postoperative pain management in total knee or hip arthroplasty. *J Arthroplasty* 2013; **28**: 1,882–1,887.
26. Gatha NM, Clarke HD, Fuchs R *et al*. Factors affecting postoperative range of motion after total knee arthroplasty. *J Knee Surg* 2004; **17**: 196–202.
27. Maloney WJ. The stiff total knee arthroplasty: evaluation and management. *J Arthroplasty* 2002; **17**(4 Suppl 1): 71–73.
28. Ritter MA, Hartly LD, Davis KE *et al*. Predicting range of motion after total knee arthroplasty. Clustering, log-linear regression, and regression tree analysis. *J Bone Joint Surg Am* 2003; **85**: 1,278–1,285.
29. Mauerhan DR, Mokris JG, Ly A, Kiezbak GM. Relationship between length of stay and manipulation rate after total knee arthroplasty. *J Arthroplasty* 1998; **13**: 896–900.
30. Yercan HS, Sugun TS, Bussièrè C *et al*. Stiffness after total knee arthroplasty: prevalence, management and outcomes. *Knee* 2006; **13**: 111–117.