An evidence-based review of enhanced recovery interventions in knee replacement surgery

MS Ibrahim¹, S Alazzawi², I Nizam¹, FS Haddad¹

¹University College London Hospitals NHS Foundation Trust, UK

²Basildon and Thurrock University Hospitals NHS Foundation Trust, UK

ABSTRACT

INTRODUCTION Total knee replacement (TKR) is a very common surgical procedure. Improved pain management techniques, surgical practices and the introduction of novel interventions have enhanced the patient's postoperative experience after TKR. Safe, efficient pathways are needed to address the increasing need for knee arthroplasty in the UK. Enhanced recovery programmes can help to reduce hospital stays following knee replacements while maintaining patient safety and satisfaction. This review outlines common evidence-based pre, intra and postoperative interventions in use in enhanced recovery protocols following TKR.

METHODS A thorough literature search of the electronic healthcare databases (MEDLINE®, Embase™ and the Cochrane Library) was conducted to identify articles and studies concerned with enhanced recovery and fast track pathways for TKR.

RESULTS A literature review revealed several non-operative and operative interventions that are effective in enhanced recovery following TKR including preoperative patient education, pre-emptive and local infiltration analgesia, preoperative nutrition, neuromuscular electrical stimulation, pulsed electromagnetic fields, perioperative rehabilitation, modern wound dressings, different standard surgical techniques, minimally invasive surgery and computer assisted surgery.

CONCLUSIONS Enhanced recovery programmes require a multidisciplinary team of dedicated professionals, principally involving preoperative education, multimodal pain control and accelerated rehabilitation; this will be boosted if combined with minimally invasive surgery. The current economic climate and restricted healthcare budget further necessitate brief hospitalisation while minimising costs. These non-operative interventions are the way forward to achieve such requirements.

KEYWORDS

Arthroplasty – Replacement – Knee – Recovery of function – Rehabilitation – Patient discharge

Accepted 03 March 2013

CORRESPONDENCE TO

Mazin Ibrahim, University College Hospital, 235 Euston Road, London NW1 2BU, UK
E: dibrm80@yahoo.com

Total knee replacement (TKR) is a pain relieving procedure for knee arthrosis. The number of TKRs went up from 59,000 to 79,000 in England and Wales between 2005 and 2011.¹

Enhanced recovery is a growing concept, aiming to shorten hospitalisation and boost patient function following arthroplasty procedures. A recent study comparing patients with an enhanced recovery programme (ERP) with those just prior to launching them revealed that these non-operative interventions were safe and effective in reducing median length of hospital stay (LOS) from six to four days with significant reduction in blood transfusion and urinary catheterisation.² The vast majority (95%) of these patients were mobilised within the first 24 hours postoperatively. Other studies reported similar results.^{3,4}

The current economic climate requires interventions to reduce LOS and cut overall cost without jeopardising patient care. ERP after TKR is one way to achieve this. However, cost effective studies need to be conducted. This review

outlines specific evidence-based non-operative and operative interventions currently in use with multimodal ERPs with TKR.

Methods

A thorough literature search on the subject of enhanced recovery in TKR was undertaken in the main electronic healthcare databases including MEDLINE®, Embase™ and the Cochrane Library. The keywords searched were 'enhanced recovery', 'fast track', 'total knee replacement', 'knee arthroplasty', 'preoperative education', 'local infiltration analgesia', 'preemptive analgesia', 'rehabilitation', 'pulsed electromagnetic fields', 'preoperative nutrition', 'neuromuscular electrical stimulation', 'modern wound dressings', 'minimally invasive surgery' and 'computer assisted surgery'. There was no limitation for the time or type of the publication but only English language articles were included. The different inter-

ventions available as part of ERPs during the pre, intra and postoperative period are reviewed.

Preoperative interventions

Preoperative education

Preoperative education is essential for most fast track clinical pathways adopted to enhance early functional recovery and hospital discharge.^{3,5} The Norwich ERP was successful in reducing LOS following total knee and total hip replacement, and included preoperative physiotherapy education sessions for rehabilitation.⁶ Preoperative education reduced LOS after either total knee or total hip arthroplasty by one day using one-to-one individualised preoperative teaching, either by phone or in person.⁵ However, this programme would certainly be time consuming and expensive to achieve in the current economic era. It will therefore be necessary to conduct a cost effective study to justify the use of such programmes. We must explore and understand patient expectations in order to achieve the best patient reported outcome⁷ while avoiding dissatisfaction from unmet expectations.⁸

Preoperative physiotherapy

Optimising preoperative physical activity has a vital role in reducing LOS following TKR as shown in a study concerned with identifying patients at risk prior to fast track TKR implementing nurse-led screening clinics and preoperative education.⁹

Preoperative nutrition

The state of nourishment plays an important role in the perioperative period. This may affect functional recovery and LOS. Malnutrition can lead to wound infection, delayed healing, sepsis, prolonged hospitalisation and increased mortality.^{4,10}

Albumin and transferrin are both biochemical markers of nutrition; low levels have been found to be predictors of longer recovery times and longer hospital stays.^{4,11} Triceps skinfold is an anthropometric parameter of nutrition that has an inversely proportional relationship with postoperative infection risk after TKR.¹²

Low body mass index in the elderly was found to increase LOS following TKR.¹³ Obesity, on the other hand, can affect results perioperatively. Increased body mass index has been found to increase operation time.^{14,15}

A patient's haemoglobin level can affect hospital stay. A low preoperative level has been associated with increased LOS following TKR while the first postoperative haemoglobin level has also been found to affect hospitalisation time following TKR.¹⁵

Pre-emptive analgesia

Pre-emptive analgesia is a pharmacological intervention prior to surgery. It aims to prevent central sensitisation of pain through completely blocking painful stimuli and afferent signals from the operative site.¹⁶ Various modalities can be used individually or in combination including oral analgesia/regional/peripheral nerve block. Oral pre-emptive

analgesia includes opioids, non-steroidal anti-inflammatory drugs (NSAIDs), acetaminophen, clonidine and ketamine.¹⁷

In a retrospective study, 200 patients underwent hip or knee arthroplasty.¹⁸ Comparisons were made between those who had a pre-emptive multimodal analgesic regime emphasising peripheral nerve block with those who had conventional intravenous followed by oral analgesia. The first group was found to have significantly improved perioperative outcomes and fewer adverse events.

Buvanendran *et al* conducted a randomised, placebo controlled, double blinded trial of 70 patients who underwent total knee arthroplasty (TKA).¹⁹ Patients were randomly assigned to receive 50mg of oral rofecoxib at 24 hours as well as at 1–2 hours before TKA and continue for 15 days postoperatively or a matching placebo at the same times. The rofecoxib group had less epidural analgesic need and in-hospital opioid consumption, a lower median pain score, less postoperative vomiting and a decrease in sleep disturbance than the placebo group. The first group also required a shorter time in physical therapy to achieve effective joint range of motion than the placebo group.

Mallory *et al* found that regimes using cyclooxygenase-2 inhibitors administered for two weeks preoperatively and continued for ten days postoperatively resulted in significantly shorter hospital stays.²⁰

Neuromuscular electrical stimulation

Quadriceps function is an integral part of successful TKR. Preoperative quadriceps muscle stimulation failure and atrophy can affect functional recovery following TKR in osteoarthritic patients. This will be combined with further weakness in this muscle postoperatively.²¹

Neuromuscular electrical stimulation (NMES) is an adjunct for both prehabilitation and rehabilitation non-operative interventions in TKR to strengthen quadriceps function. This modality involves applying transcutaneous current to neuromuscular junctions to stimulate muscle contraction.^{21,22}

NMES was compared with standard preoperative physiotherapy in patients undergoing TKR in a randomised study.²¹ The study demonstrated significant preoperative gains in walk, stair climb and chair rise time in the NMES group, and similar objective functional recovery from 6 to 12 weeks postoperatively. There was no difference in LOS between the groups. This was based on eight weeks of unsupervised, preoperative and home-based NMES training of the affected knee, which can be an effective way to tackle the extra cost from applying this modality on TKR total cost.

Nevertheless, a systematic review published in 2010 examining the effectiveness of NMES in the context of muscle strengthening failed to draw any conclusions.²² This may be related to the quality of studies included in that review.

Pulsed electromagnetic fields

Decreased mobility following TKR results from local joint swelling, inflammation and pain.^{23,24} Pulsed electromagnetic fields (PEMFs) is a safe and non-invasive modality to reduce joint swelling and inflammation, the need for NSAIDs and the time to functional recovery through its effect on the

A_{2A} receptors of inflammatory cells.^{24,25} Many studies have demonstrated the effect of PEMFs following knee surgery. A study showed that PEMFs reduced the use of NSAIDs, improved functional recovery and were well accepted by patients who had undergone knee arthroscopy.²⁵ Similar findings were reported for patients who had undergone arthroscopic anterior cruciate ligament repair.²⁶

Intraoperative interventions

Local infiltration anaesthesia

Local infiltration anaesthesia (LIA) is an 'enabling' process involving intraoperative infiltration of anaesthetic agents into the knee joint. This may be followed by small boluses of this mixture administered postoperatively using an intra-articular catheter for pain management and early mobilisation.

Kerr and Kohan coined the term in Sydney when it was developed in the late 1990s²⁷ as a part of the multimodal pain management and early mobilisation protocol after joint replacements. They reported good postoperative pain control and less postoperative narcotic side effects after hip and knee joint replacements, allowing mobilisation within hours of surgery. This enabled early discharge after a single overnight stay.

Reports have emerged of improved mobilisation with reduced LOS and narcotic consumption using LIA²⁸ as well as faster postoperative mobilisation with reduced pain and analgesic requirements after LIA.²⁹ Although LIA was effective, Specht *et al* reported that adding further LIA mixture via a catheter in the postoperative period (after LIA infiltration intraoperatively) had no influence on postoperative pain or tiredness but had some influence on nausea and vomiting, and LOS.³⁰ Despite this, LIA is still regarded as a simple, practical, safe and effective analgesic method for use following knee replacements.²⁷

Minimally invasive surgery

Cosmesis and reduced length of scar to <14cm in TKR is a crucial part of minimally invasive surgery (MIS). With MIS, there may be potential benefits in reducing soft tissue trauma, blood loss and operating time, less pain postoperatively with faster rehabilitation and early discharge.³¹ However, in a study comparing conventional TKR, MIS and computer assisted minimally invasive knee arthroplasty, there was no significant difference in the postoperative Western Ontario and McMaster Universities Arthritis Index score, Knee Society score or the frequency of early complications.³² In that study, restoration of the mechanical leg axis and component positioning were significantly more accurate with use of the computer assisted technique, with no difference in that between conventional TKR and MIS.

It is logical to hypothesise that LIA would be ideal with MIS of the knee to enhance postoperative recovery and early discharge in a fast track setting. However, there are no studies that have looked into this specifically.

Computer assisted total knee arthroplasty

A computer assisted navigation system can be used to improve implant alignment, especially in the coronal plane.

Most of the available studies comparing this technique with the conventional approach failed to show any significant improvement in the functional outcome or quality of life during short-term and medium-term follow-up periods.³³ Computer assisted TKA with or without MIS in combination with LIA in the peri and postoperative period can be a focus for future studies to determine their effect on enhanced postoperative recovery and early discharge following TKR.

Postoperative interventions

Physiotherapy

Physiotherapy and rehabilitation is an essential part of fast track pathways for TKR. Physiotherapy starts mostly on postoperative day 0.^{6,34} A randomised controlled study comparing two different rehabilitation programmes (mobilising patients on day 0 or on day 1) has shown that the mobilisation of patients on day 0 in addition to other fast track modalities reduces LOS significantly.³⁴ Early postoperative mobilisation was found to be a significant risk factor affecting LOS following TKR in patients over 75 years.¹³ In a Canadian comparative study, it was shown that patients on the fast track protocol, who had been mobilised on day 0, were discharged 69 hours earlier than those not on the pathway and mobilised on the first postoperative day (47 vs 116 hours).⁵ The patients were mobilised once or twice on day 0 with emphasis on bed transfer, movement from sitting to standing, then progressing to ambulation 5–10m with the assistance of staff and a walking aid. The Norwich ERP showed that mobilisation on day 0 significantly reduces LOS and produces better pain scores.⁶

Wound care

Wound infection can affect recovery following knee arthroplasty and can prolong hospitalisation. Wound oozing and haematoma can both increase the risk of infection following knee replacement.³⁵ Wound oozing cessation was found to be significantly reduced with shorter tourniquet time, periarticular local anaesthesia and the subvastus approach, which, in turn, reduced hospital stay and enhanced recovery.³⁶

There is a growing interest in the use of modern wound dressings (eg Aquacel® Surgical; ConvaTec, Uxbridge, UK) in the context of enhanced recovery. However, a prospective audit comparing two types of wound dressings (traditional vs modern) as part of an enhanced recovery non-operative intervention in a district hospital failed to find any significant difference in LOS between these groups, with a significantly shorter wear time and more dressing changes in the traditional form (Mepore®; Mölnlycke, Dunstable, UK) as well as significantly less blistering in the modern type (Aquacel® Surgical).³⁷

Conclusions

The incidence of TKR is on the rise, with an increase both in cost and resources on healthcare professionals. The current economic climate requires a reduction in hospitalisation and enhanced patient recovery following TKR, which ultimately reduces cost. Adopting fast track pathways with

the different modalities mentioned in this article will help to achieve these targets. We recommend combining non-operative measures of enhanced recovery perioperatively with MIS to maximise a patient's recovery following TKR. We also suggest cost effectiveness studies to evaluate the benefit of these modalities.

References

1. National Joint Registry for England and Wales. *9th Annual Report*. Hemel Hempstead: NJR; 2012.
2. 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.
3. 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.
4. Berend KR, Lombardi AV, Mallory TH. Rapid recovery protocol for peri-operative care of total hip and total knee arthroplasty patients. *Surg Technol Int* 2004; **13**: 239–247.
5. Yoon RS, Nellans KW, Geller JA *et al*. Patient education before hip or knee arthroplasty lowers length of stay. *J Arthroplasty* 2010; **25**: 547–551.
6. 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.
7. Scott CE, Bugler KE, Clement ND *et al*. Patient expectations of arthroplasty of the hip and knee. *J Bone Joint Surg Br* 2012; **94**: 974–981.
8. Jourdan C, Poiraudou S, Descamps S *et al*. Comparison of patient and surgeon expectations of total hip arthroplasty. *PLoS One* 2012; **7**: e30195.
9. Hansen TB, Bredtoft HK, Larsen K. Preoperative physical optimization in fast-track hip and knee arthroplasty. *Dan Med J* 2012; **59**: A4381.
10. Parker MJ, Gurusamy K, Stoker M. Surgery in elderly patients. *Curr Orthop* 2004; **18**: 333–344.
11. Del Savio GC, Zelico SB, Wexler LM *et al*. Preoperative nutritional status and outcome of elective total hip replacement. *Clin Orthop Relat Res* 1996; **326**: 153–161.
12. Font-Vizcarra L, Lozano L, Rios J *et al*. Preoperative nutritional status and post-operative infection in total knee replacements: a prospective study of 213 patients. *Int J Artif Organs* 2011; **34**: 876–881.
13. Raut S, Mertes SC, Muniz-Terrera G, Khanda V. Factors associated with prolonged length of stay following a total knee replacement in patients aged over 75. *Int Orthop* 2012; **36**: 1,601–1,608.
14. Hallert O, Li Y, Brismar H, Lindgren U. The direct anterior approach: initial experience of a minimally invasive technique for total hip arthroplasty. *J Orthop Surg Res* 2012; **7**: 17.
15. Jibodh SR, Gurkan I, Wenz JF. In-hospital outcome and resource use in hip arthroplasty: influence of body mass. *Orthopedics* 2004; **27**: 594–601.
16. Dahl JB, Kehlet H. Preventive analgesia. *Curr Opin Anaesthesiol* 2011; **24**: 331–338.
17. Dalury DF, Lieberman JR, Macdonald SJ. Current and innovative pain management techniques in total knee arthroplasty. *Instr Course Lect* 2012; **61**: 383–388.
18. Hebl JR, Dilger JA, Byer DE *et al*. A pre-emptive multimodal pathway featuring peripheral nerve block improves perioperative outcomes after major orthopedic surgery. *Reg Anesth Pain Med* 2008; **33**: 510–517.
19. Buvanendran A, Kroin JS, Tuman KJ *et al*. Effects of perioperative administration of a selective cyclooxygenase 2 inhibitor on pain management and recovery of function after knee replacement: a randomized controlled trial. *JAMA* 2003; **290**: 2,411–2,418.
20. Mallory TH, Lombardi AV, Fada RA *et al*. Pain management for joint arthroplasty: preemptive analgesia. *J Arthroplasty* 2002; **17**(4 Suppl 1): 129–133.
21. Walls RJ, McHugh G, O'Gorman DJ *et al*. Effects of preoperative neuromuscular electrical stimulation on quadriceps strength and functional recovery in total knee arthroplasty. A pilot study. *BMC Musculoskelet Disord* 2010; **11**: 119.
22. Monaghan B, Caulfield B, O'Mathúna DP. Surface neuromuscular electrical stimulation for quadriceps strengthening pre and post total knee replacement. *Cochrane Database Syst Rev* 2010; **1**: CD007177.
23. Moretti B, Notarnicola A, Moretti L *et al*. I-ONE therapy in patients undergoing total knee arthroplasty: a prospective, randomized and controlled study. *BMC Musculoskelet Disord* 2012; **13**: 88.
24. Dallari D, Fini M, Giavaresi G *et al*. Effects of pulsed electromagnetic stimulation on patients undergoing hip revision prostheses: a randomized prospective double-blind study. *Bioelectromagnetics* 2009; **30**: 423–430.
25. Zorzi C, Dall'Oca C, Cadossi R, Setti S. Effects of pulsed electromagnetic fields on patients' recovery after arthroscopic surgery: prospective, randomized and double-blind study. *Knee Surg Sports Traumatol Arthrosc* 2007; **15**: 830–834.
26. Benazzo F, Zanon G, Pederzini L *et al*. Effects of biophysical stimulation in patients undergoing arthroscopic reconstruction of anterior cruciate ligament: prospective, randomized and double blind study. *Knee Surg Sports Traumatol Arthrosc* 2008; **16**: 595–601.
27. Kerr DR, Kohan L. Local infiltration analgesia: a technique for the control of acute postoperative pain following knee and hip surgery: a case study of 325 patients. *Acta Orthop* 2008; **79**: 174–183.
28. Andersen KV, Pfeiffer-Jensen M, Haraldsted V, Søballe K. Reduced hospital stay and narcotic consumption, and improved mobilization with local and intraarticular infiltration after hip arthroplasty. *Acta Orthop* 2007; **78**: 180–186.
29. Andersen LJ, Poulsen T, Krogh B, Nielsen T. Postoperative analgesia in total hip arthroplasty: a randomized double-blinded, placebo-controlled study on peroperative and postoperative ropivacaine, ketorolac, and adrenaline wound infiltration. *Acta Orthop* 2007; **78**: 187–192.
30. Specht K, Leonhardt JS, Revald P *et al*. No evidence of a clinically important effect of adding local infusion analgesia administered through a catheter in pain treatment after total hip arthroplasty. *Acta Orthop* 2011; **82**: 315–320.
31. Lloyd JM, Wainwright T, Middleton RG. What is the role of minimally invasive surgery in a fast track hip and knee replacement pathway? *Ann R Coll Surg Engl* 2012; **94**: 148–151.
32. Lüring C, Beckmann J, Haiböck P *et al*. Minimal invasive and computer assisted total knee replacement compared with the conventional technique: a prospective, randomised trial. *Knee Surg Sports Traumatol Arthrosc* 2008; **16**: 928–934.
33. Lützner J, Günther KP, Kirschner S. Functional outcome after computer-assisted versus conventional total knee arthroplasty: a randomized controlled study. *Knee Surg Sports Traumatol Arthrosc* 2010; **18**: 1,339–1,344.
34. 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.
35. Saleh K, Olson M, Resig S *et al*. Predictors of wound infection in hip and knee joint replacement: results from a 20 year surveillance program. *J Orthop Res* 2002; **20**: 506–515.
36. Butt U, Ahmad R, Aspros D, Bannister GC. Factors affecting wound ooze in total knee replacement. *Ann R Coll Surg Engl* 2011; **93**: 54–56.
37. Hopper GP, Deakin AH, Crane EO, Clarke JV. Enhancing patient recovery following lower limb arthroplasty with a modern wound dressing: a prospective, comparative audit. *J Wound Care* 2012; **21**: 200–203.