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Original Article

Enhanced recovery principles applied to revision hip and knee arthroplasty reduces length of stay and blood transfusion

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ABSTRACT

Introduction: This is the first study reporting the application of Enhanced Recovery Principles (ERP) to revision arthroplasty.
Method: Retrospective series of 132 revision hip and knee replacements treated with ERP.
Results: Infiltration was associated with reduced LOS in knees (6 vs 8.5 days), lower PCA usage and incidence of transfusion in knees (2 vs 3 days) and hips (1 vs 6 days). Revisions for infection had a longer LOS (5.4 vs 11.5 days p = 0.001), a greater use of PCA and a higher incidence of transfusion (5 vs 0) in both knees and hips.
Discussion: The application of ERPs to revision arthroplasty is safe. Infiltration appears to be an important factor in improving outcome measures.

1. Introduction

Studies have demonstrated a steady increase in the number of primary and revision hip and knee replacements performed worldwide, with a predicted 6-fold increase in the need for revision total knee replacement in the US by 2030.[1] Revision surgery can be complex, lengthy and costly, particularly in the presence of bone or soft tissue loss, infection and patient co-morbidities. It is crucial, therefore, to ensure that every measure is taken to minimize the burden to the patient and the health service of revision surgery.[2–5] This can be achieved by educating and optimizing the patient preoperatively, reducing the perioperative physiological insult, minimizing the need for blood transfusion, and ensuring that pain is minimised to enable early mobilisation and rehabilitation.[6–9]

Following their success in colorectal surgery, the application of Enhanced Recovery Principles (ERP) to primary arthroplasty has become commonplace.[9–12] Different modes of ERP have been described but these all hinge around 5 principles of: departmental ethos, patient education, effective pain control, blood management and early physiotherapy.[13–17]

ERPs are well documented to reduce postoperative pain, enhance patient satisfaction and reduce hospital stay, without compromising the quality of care.[18–20] Infiltration of the surgical field with LA has been shown to be of high importance in ERPs, reducing length of stay, postoperative pain, vomiting and opioid consumption.[22,23] Additionally, older patients may have the most to gain from an ERP, which is perhaps more relevant in revision surgery.[21] However, there is a paucity of information relating to the application of ERP to revision arthroplasty cases, where perhaps there is a greater need to ensure the physiological, personal and financial burden is kept to a minimum for the patient and the healthcare provider alike.[1,9,12]

An ERP has been in place in our institution for revision arthroplasty patients since 2010. As the treatment evolved, there were changes particularly in the constituents of the infiltrate, which in 2012 was changed to include high volume, low concentration local anaesthetic 100 150 mls 0.2% Naropin (LA), Ketorolac, adrenaline and tranexamic acid (TA). Latterly a cohort of revision knee patients also received staged postoperative administration of LA via a temporary intra-articular catheter.

The aims of this study are to present the outcomes of the application of ERP to revision arthroplasty, in particular length of stay (LOS), incidence of blood transfusion, drop in haemoglobin and the rate of patient controlled analgesia (PCA) use.

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Table 1
Indications for revision and procedure performed.

	Hip		Knee
Infection	11	Malrotation	26
Periprosthetic fracture	4	Infection	19
Lysis/Loosening	24	PFJ Problem	6
Instability	5	Instability	6
Metal on Metal	11	Loosening/Lysis	6
Other	10	Stiffness	3
		Uni – Total	1
All Components	34	All Components (TC3/RHK)	39
Acetabular Component	22	Patella	6
Femoral Component	3	DAIR/Liner change	7
Fracture Fixation	1	1st Stage Insertion of Spacer	4
DAIR/Head Liner Exchange	2	2nd Stage All Components	10
1st Stage Spacer Insertion	3		

2. Patients and methods

All patients undergoing revision hip or knee replacement between 2010 and 2014, with the senior author (PY) as the primary surgeon were identified. The reason for and nature of the revision was recorded. All patients had undergone a preoperative education programme, were admitted on the day of surgery, and were mobilised with a physiotherapist on the day of, or the day after surgery. All patients received prophylactic antibiotics, were given oral TA one hour preoperatively and were administered appropriate prophylaxis for venous thromboembolism. Spinal anaesthetic (fentanyl or morphine and heavy Marcaine) was used in the majority of cases (113/132), with a fentanyl PCA, regular Paracetamol and slow and long release oral opiate preparations. All knee revisions except one were carried out under tourniquet. All patients were allowed to fully weight bear post operatively.

Latterly, as our ERP regimen evolved, based on evidence from their application in primary arthroplasty, where possible all patients received infiltration of the surgical field, with the volume depending on the patient's weight and LA use elsewhere. In hips, infiltrate was distributed into the deep and superficial tissues after implantation. In knees, infiltrate was distributed into the posterior capsule, collaterals, synovium and superficial tissues.

The following data were collected: the anaesthetic administered, LOS (days), drop in Hb level (g/dl), incidence of blood transfusion, use of surgical field infiltration, use of an intrarticular catheter, PCA usage (ml/kg/h) and complications, readmissions and reoperations. Patient co-morbidities were quantified using the Charlson Index.[27]

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) v20. Mean values for normally distributed continuous data were compared using two-tailed student *t*-tests. Median values for non-normally distributed continuous data were compared using Mann Whitney U Tests, Chi Square tests were used to analyse nominal variables. A *p*-value of <0.05 was considered significant.

3. Results

One hundred and thirty-two revisions were identified, in 112 patients, (67 revision knees, 65 revision hips). Mean patient age was 64.5 years for hips and 66.4 years for knees. 113 procedures were carried out under spinal anaesthetic. 51 patients received infiltration, and 19 knee patients received additional LA via a catheter. 12 patients (8 knees, 4 hips) received a preoperative adductor canal or femoral nerve blocks. Table 1 shows that the most common indication for hip revision was loosening/lysis (36%) and the majority of revisions involved all components (52%). The most common indication for knee revision was malrotation (38%) with an all component revision accounting for 73% of procedures. 5 patients underwent two-stage procedures for infection, accounting for 10 admissions. All patients with the exception of 4 were discharged home (one died in hospital and 3 were transferred to other facilities for ongoing rehabilitation).

The average Charlson Index was 0.55 (0.66 for hips, 0.44 for knees), with a range of 0–4 and a mode of 0, indicating that overall the patients had no or very minimal co-morbidities.

3.1. Infiltration

Infiltration of the surgical field was undertaken in 15 hips (23%) and 36 knees (53%). Table 2 shows that these patients had a smaller drop in haemoglobin and a lower incidence of transfusion (especially in hip revisions) than patients without infiltration. Infiltrated knees had a lower LoS. PCA usage was similar in each group.

3.2. Infiltration in the absence of infection

Tables 2 and 3 show that drop in haemoglobin, and the incidence of transfusion were lower in patients that received infiltration, but this was not significant. LoS was lower in infiltrated knees, PCA usage was similar in both groups, the number of transfusions was lower in infiltrated hips ($p > 0.05$). Table 5 shows none of the 36 aseptic knees required a transfusion and the drop in haemoglobin, length of stay and PCA usage were all lower in the infiltration cohort but this was not significant ($p > 0.05$).

3.3. Infection

Tables 4 and 5 show that differences between infected and non-infected cases were more apparent in revision knees, with a

Table 2
Comparison of outcomes with and without surgical field infiltration.

	Hip		*p-value*[*]	Knee		*p-value*[*]
	Infiltration	No Infiltration		Infiltration	No Infiltration	
Number of patients	15	50		36	31	
Age (mean)	67	64		68	68	
Gender						
Male	5	20		13	17	
Female	10	30		23	14	
Haemoglobin difference (g/L)	24.5	26.0	0.809	23.9	26.6	0.580
Number of patients receiving transfusion	1	6	0.559[+]	2	3	0.522[+]
Length of stay (days)	5.7	5.2	0.702	6	8.5	0.113
PCA use (mL/kg/h)	0.020	0.018	0.975	0.015	0.017	0.399

[*] p-value calculated with Mann-Whitney *U* test unless stated.
[+] p-value calculated with Chi-Square test.

Table 3
Comparison of outcomes with and without surgical field infiltration in all component aseptic knee revisions.

	All component aseptic TKR		*p-value*[*]
	Infiltration	No Infiltration	
Number of patients	23	13	
Age (mean)	66	68	
Gender			
Male	9	9	
Female	14	4	
Haemoglobin difference (g/L)	25.6	31.5	0.070
Number of patients receiving transfusion	0	0	–
Length of stay (days)	5.5	6.2	0.415
PCA use (mL/kg/h)	0.014	0.017	0.871

[*] p-value calculated with Mann-Whitney *U* test unless stated.

significantly lower average length of stay (11 days vs. 5 days, $p < 0.05$), and transfusion requirements (5 vs. 0, $p < 0.05$), in aseptic knees, whereas PCA usage was similar in each group ($p > 0.05$).

3.4. Catheter in knees

Table 6 shows that the incidence of transfusion, PCA usage and length of stay were all higher in the catheter group (n = 19), but this did not reach statistical significance.

3.5. Transfusions

Twelve patients (9%) received a postoperative blood transfusion, the trigger for which was a haemoglobin concentration of <8 g/dl with symptoms of anaemia. All knee patients receiving a transfusion (5 patients) had undergone all component revisions for infection. Seven hip revision patients received a transfusion (one ankylosed hip, one periprosthetic fracture, 2 second stage revision for infection and 3 requiring major femoral and acetabular impaction bone grafting procedures).

Overall, the use of infiltrate was associated with a lower incidence of blood transfusion, although this was not significant. All component knee revisions for infection were more likely to receive a transfusion than aseptic revisions (p = 0). Infiltration in aseptic hip revisions was associated with a lower transfusion incidence (1 vs. 4, $p > 0.05$)

3.6. Complications, readmissions and reoperations

Twenty-two patients (19%) incurred a complication (12 knee patients and 10 hip patients). Only one patient was readmitted within the first 6 weeks after discharge. This patient developed a superficial haematoma following a revision hip replacement, which was managed non-operatively. Ten patients (8%) were readmitted, all greater than 6 weeks after their initial admission (see Table 7). Eleven (9%) underwent further surgical intervention, (one patient incurred a intraoperative periprosthetic fracture which was revised during the same hospital stay). Infection accounted for the greatest proportion of unplanned readmissions and reoperations (4 patients). There was only one dislocation, which happened in a patient undergoing revision for metal related pathology, who also incurred a deep infection requiring a 2-stage

Table 4
Comparison of outcomes in the presence and absence of infection.

	Hip		*p-value*[*]	Knee		*p-value*[*]
	Infection	Not Infection		Infection	Not Infection	
Number of patients	11	54		19	48	
Age (mean)	59	66		72	67	
Gender						
Male	7	18		7	21	
Female	4	36		12	27	
Haemoglobin difference (g/L)	21.8	26.4	0.8	26.4	24.6	0.889
Number of patients receiving transfusion	2	5	0.384[+]	5	0	**0.000**[+]
Length of stay (days)	4.4	5.6	0.076	11.6	5.4	**0.001**
PCA use (mL/kg/h)	0.016	0.019	0.772	0.018	0.015	0.728

[*] p-value calculated with Mann-Whitney *U* test unless stated.
[+] p-value calculated with Chi-Square test.

Table 5
Comparison of outcomes in aseptic cases treated with and without infiltration.

	Aseptic Hip		*p-value*[*]	Aseptic Knee		*p-value*[*]
	Infiltration	No Infiltration		Infiltration	No Infiltration	
Number of patients	13	41		30	18	
Age (mean)	69	65		67	67	
Gender						
Male	4	14		11	10	
Female	9	27		19	8	
Haemoglobin difference (g/L)	24.4	27.1	0.701	23.6	26.4	0.449
Number of patients receiving transfusion	1	4	0.825[+]	0	0	–
Length of stay (days)	6	5.4	0.583	5.2	5.8	0.349
PCA use (mL/kg/h)	0.021	0.019	0.984	0.014	0.018	0.306

[*] p-value calculated with Mann-Whitney *U* test unless stated.
[+] p-value calculated with Chi-Square test.

Table 6
Comparison of outcomes with knees treated with indwelling catheter and infiltration alone.

	Knee		*p-value*[*]
	Catheter	No catheter	
Number of patients	19	17	
Age (mean)	68	68	
Gender			
Male	6	8	
Female	13	9	
Haemoglobin difference (g/L)	22.2	25.8	0.129
Number of patients receiving transfusion	2	0	0.169[+]
Length of stay (days)	6.3	5.7	0.379
PCA use (mL/kg/h)	0.016	0.014	0.452

[*] p-value calculated with Mann-Whitney *U* test unless stated.
[+] p-value calculated with Chi-Square test.

revision with a constrained implant. One patient died in hospital, 3 days after surgery from a pulmonary embolus. Four aseptic knee revision patients underwent reoperation (one had a 2 stage revision for infection and one was revised for ligamentous instability, 2 underwent manipulation under anaesthetic for stiffness).

3.7. Periprosthetic fractures

Four patients underwent surgery for periprosthetic fractures (2 as the primary reason for admission, and 2 following revision surgery). The average length of stay in hospital for these patients was 5.7 days, which was comparable with aseptic hip revision (5.5 days). The 2 patients whose initial diagnosis was a periprosthetic fracture were transferred to other facilities for ongoing rehabilitation. None of these patients were readmitted following fracture treatment.

4. Discussion

ERPs are well reported to result in improved health related quality of life compared with traditional rehabilitation.[2–5] They are well established in primary arthroplasty with the key aim of safely reducing LoS, whilst improving pain control, patient satisfaction and outcome, and avoiding readmission and complications by a balance of education, continuity and focused rehabilitation.[6–12,20,22–25]

Revision surgery shares some of these goals. However, the length, complexity and costs are much greater and their effect on patients with more challenging surgical problems and comorbidities, mean that the key objectives of ERP in revision surgery are different. Specifically there is a greater need to optimise blood management (by reducing intraoperative blood loss) and postoperative pain.[2–4] It is therefore not possible to directly compare these patient groups. Similarly early and accelerated mobilisation in revision knee is perhaps more important than in the primary setting, particularly if the reason for revision is stiffness.

This observational study is the first to specifically describe the outcomes of applying ERPs to both revision hip and knee replacements and to report our experience with these protocols as the treatment has evolved. Whilst our outcome measures are all multifactorial, we have shown that infiltration of the surgical field appears to be associated with a significantly reduced length of stay (2.5 days) and a lowering of the rate of blood transfusion, especially following revision knee replacement. We have also shown that the readmission rate was very low, with only one patient (0.8%) being readmitted within 6 weeks of their initial admission. This 'failed discharge' rate is lower than several published series of enhanced recovery primary joint replacements.[3,6–8,10,17,19,20] Similarly, our overall complication rate (8% readmission, 9% reoperation, mainly for infection) is lower than published series for aseptic revision knee surgery (9.9% readmission, 3.5% reoperation) and revision hip replacement (18.5% readmission, 6.1% reoperation).[4,5]

The use of a temporary catheter in revision knee replacement did not appear to offer any improvement in PCA usage, blood transfusion or length of stay. This finding did not correlate with published data[17] although the numbers are very small and the patients were not randomised. It is also possible that infection patients within this cohort with longer than average LoS (for other reasons) have skewed this result. The numbers of aseptic revision patients that received an indwelling catheter were too small for meaningful analysis. As such future analysis of aseptic, all component knee revisions may provide a more accurate portrayal of the effect of an indwelling catheter.

One of the largest series of aseptic revision knee outcomes from the Danish Joint Registry suggest a mean LoS of 4 days, a 90 day readmission rate of 9.9%, a reoperation rate of 3.5% and mortality of 0.2%.[4] In their series age and complexity of surgery were risk factors for readmission and reoperation, and they suggested that outcomes in aseptic revisions were comparable with primary procedures. Husted et al., 2011 assessed the feasibility of applying ERP to revision knee replacement, concluding it to be safe, with similar outcomes to primary knee arthroplasty.[2] They studied 30 aseptic revisions in 29 patients, with an average LoS of 2 days. They report a 10% readmission/reoperation rate in this group and 8 patients required a blood transfusion.

None of our 36 aseptic all component knee revisions required a transfusion. Only 2 (5%) underwent further surgery (one for a further revision for ligament instability, one for infection). Our average LoS was longer in this group (5.7 days). Theirs was a feasibility study and was early on in the evolution of ERP

Table 7
Intra/post operative complications and unplanned readmissions and reoperations. (Misc – Abductor failure, MCL insufficiency).

Complications – Number of patients, (Number of readmissions/reoperations)			
Superficial Infection	5 (0)	DVT/PE	3
Deep Infection	4 Readmissions 4		2 Readmissions 2
DAIR 2 Stage	Reoperations 4 (2) (2)	Knee Stiffness Requiring MUA	Reoperations 2
Periprosthetic Fracture	5 Readmissions 1 Reoperations 2	Death	1
Haematoma	4 Readmissions 1	Misc	2 Readmissions 2 Reoperations 2

(2008–10), and before the widespread use of TA, which may account for our lower transfusion and reoperation rate.

4.1. Pain management

Until recently there has been a paucity of level-one evidence supporting the use of high volume LA infiltration of the surgical field in hip and knee arthroplasty.[29] There is no doubt that infiltration offers localised postoperative analgesia, and has advantages over contemporary peripheral nerve blockade. Indeed, a recent level-one study has shown that patients receiving infiltration had a shorter LoS compared with peripheral nerve blockade.[30]

Our study has shown a benefit of surgical field infiltration, and an association with a shorter length of stay and incidence of transfusion in revision knees, but has not demonstrated a difference in PCA usage. However, this outcome measure is not as sensitive as a validated pain score, which would not be possible to record retrospectively, and only gives an overall rate of usage. Similarly, analysis of use of peripheral nerve block in these cohorts was not possible due to small numbers.

4.2. Blood management

Overall 12 patients received a transfusion (9%), with revisions for infection accounting for more than half of the transfused cases (5 knees, 2 hips). Septic revisions can be complex and prolonged involving significant debridement compared with aseptic cases. Patients are also often anaemic preoperatively and can have significant comorbidities, increasing the effect of blood loss.[26]

In the absence of infection, 5 revision hip patients received transfusions, with infiltration not appearing to offer an advantage in reducing the likelihood of a transfusion. Two of these patients presented with periprosthetic fractures and 2 underwent major femoral and acetabular revisions, with impaction bone grafting. Exposure, comorbidities and pre and intraoperative blood loss are greater in these situations, making the likelihood of transfusion greater.

Careful management of coagulation and the use of TA have been well documented to reduce the need for transfusion however, in more complex and prolonged surgery the likelihood remains.[31–35] It is perhaps our pre-optimisation of patients and use of TA that has resulted in our low transfusion rate.

Periprosthetic fracture surgery is, on the whole, acute and undertaken on patients that have greater co-morbidities, loose or failing implants and poor bone stock, making outcome less predictable than in planned revision surgery where there is opportunity for preoperative optimisation. In this series there were only 2 patients presenting with periprosthetic fractures. Both had low Charlston scores and did not require a transfusion. Two further periprosthetic fractures occurred during or after their initial revision. One was revised during the same admission, less than 2 weeks following initial surgery. Both required transfusions but probably as a result of having 2 major surgeries in a short space of time.

Our series had very low Charlson indexes (average 0.5), indicating that they were fit patients. The LoS and patient discharge destination for our series of revisions was comparable with other series of primary joints, with similar Charlson indexes.[28]

We acknowledge that there are limitations to this study. It is a retrospective observational study of small heterogenous cohorts, without a control group for comparison, and as such the impact of our statistical analysis is limited. Additionally within the knee infection group one patient was treated as an inpatient for several weeks, which may have skewed the results.

The measurement of PCA usage (mls/kg/h) is perhaps an inaccurate way of portraying pain, as it only provides an average usage and lacks the sensitivity to assess variations over time, and the relative effect of other analgesic modalities. Prospective analysis of PCA demand, range of movement, distance walked and using validated pain and joint specific functional scores would be more useful.

Patients' LoS, blood management and postoperative pain control are entwined in a complex relationship, influenced by a number of multifactorial processes. This retrospective case series suggests that LA infiltration appears to have a beneficial impact on each of these parameters, but due to the nature of this study the conclusions drawn relating to the impact of LA infiltration are not robust, but larger randomised trials with well-defined cohorts are likely to support our findings, especially with the strength of evidence in the primary setting.

This original study assesses the outcomes of ERP revision arthroplasty and shows that this practice is safe, with improved outcome measures and a 0.8% readmission rate at six weeks following discharge. We have shown that infiltration of the surgical field is a crucial factor, and is associated with a reduction in length of stay of 2.5 days and a lower rate of blood transfusion, especially following revision knee replacement.

Conflict of interest

The authors have none to declare.

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