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ORIGINAL ARTICLE

A Multimodal Clinical Pathway Can Reduce Length of Stay After Total Knee Arthroplasty

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Abstract Clinical pathways reduce length of stay which is critical for hospitals to remain financially sound. We sought to determine if a multimodal pathway focusing on pre-op discharge planning and pre-emptive pain and nausea management lead to reduced length of stay, better pain management, and more rapid functional gains without an increase in post-op complications. A multimodal pathway incorporating pre-op discharge planning and pre-emptive pain and nausea management was initiated in August of 2007. Physical therapy began the day of surgery. Two hundred eleven patients treated over a 3-month period with the new pathway were compared to 192 patients treated in the last 3 months of an older pathway. Length of stay, VAS scores for pain, and the incidence of nausea were compared. Length of time to achieve functional milestones while in hospital and the incidence of complications out to 6 months were compared. Average length of stay was reduced by 0.26 days. VAS scores for pain were lower. Several functional milestones were achieved earlier and complications were not increased. Efforts to control nausea were not successful and severe nausea was experienced in 40% of patients in both groups. This enhanced pathway can lead to an important reduction in length of stay. Although this reduction seems small, it can significantly increase patient throughput and increase hospital capacity. Post-op nausea continues to be an impediment in patient care after TKR.

Keywords clinical pathways · pre-emptive pain management · total knee replacement

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Each author certifies that his or her institution has approved the reporting of these cases, that all investigations were conducted in conformity with ethical principles of research, and that the requirement for informed consent for participating in the study was waived.

Level of Evidence: Level III: therapeutic study. See the guidelines online for a complete description of level of evidence.

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Introduction

In the USA, demand for total joint arthroplasty has risen steadily over the past decade. By 2030, TKR demand is expected to increase by 673%, equivalent to 3.48 million procedures [11]. This projected increase in demand will challenge hospital facilities and their financial resources. Efforts to reduce length of stay while improving patient comfort are essential. Most hospitals in the USA have fixed bed capacity and fixed overhead costs yet are receiving decreasing rates of reimbursement for surgical procedures. Economic health of hospitals therefore depends on an increase in patient throughput by decreasing length of stay.

Standardized total joint arthroplasty clinical pathways employing accelerated perioperative care and rehabilitation have demonstrated mixed results in decreasing LOS [5, 6, 10, 14–16, 18, 19] while others suggest improved patient evaluation of results as measured by improved quality of life measures [12, 13]. Pre-emptive pain management programs using NSAIDS or COX-2 medications and dexamethasone can shorten hospital stay and decrease the likelihood of discharge to a skilled nursing facility but not all studies confirm these findings [2, 3, 5, 6, 9, 17]. Several reports have reached conflicting conclusions regarding the efficacy of earlier physical therapy on discharge [7, 8, 10, 12–14, 16]. Similarly, pre-operative patient education programs have demonstrated a varying contribution to decreased LOS [12–15, 18, 19].

Most previous studies have assessed interventions individually rather than addressing multiple interventions simultaneously. Although this approach allows for validation of any

given intervention, this limited scope may underestimate the true impact of multicomponent clinical pathways. It was our belief that a more comprehensive, multimodal pathway that combines multiple features would yield a lower length of stay. In addition, most of the prior studies combine total knee and total hip arthroplasty data which may be inappropriate, as the two procedures can be markedly different in recovery, rehabilitation, and pain management requirements.

Epidural analgesia for pain management can lead to a high incidence of post-op nausea and orthostasis that limits patient mobilization during the first 48 post-op hours [3, 4, 6, 17]. At our institution a clinical pathway which incorporated a pre-operative patient education classroom and treated post-operative pain with epidural analgesia combined with femoral nerve block had been in place since 1996. Length of stay ranged between 4.5 and 5 days (Fig. 1). It was our observation that patient mobilization during the first two post-op days was often hampered by nausea, dizziness, and orthostasis which we attributed to the epidural analgesia. In this study, we sought to decrease these side effects of epidural analgesia with by employing a pre-emptive pain management program allowing us to lower the drug concentration and shorten the duration of the epidural hoping to diminish the incidence of post-op nausea and orthostasis, permitting more aggressive mobilization of the patients immediately after surgery.

In August 2007, a modified total knee arthroplasty (TKA) clinical pathway was initiated. The new focus included pre-operative patient education and discharge planning, pre-emptive pain management and nausea prevention, shortened duration of epidural analgesia, and earlier patient mobilization. The primary purpose of this study was to assess whether these interventions, taken together, can decrease length of stay measured in days to a level below that achieved from our prior pathway. Additionally, we aimed to document that pre-emptive management of pain and nausea can decrease patient VAS scores for pain and documented episodes of nausea. Thirdly, we hoped to document that these interventions do not increase rates of early complications and finally, that the resulting decrease in length of stay leads to valuable increase in patient throughput as measured by a calculation of increased bed utilization.

Materials and methods

We designed a retrospective case-control study to evaluate the efficacy of the newly modified Total Knee Arthroplasty Clinical Pathway at our hospital initiated on August 20, 2007. After approval from the Institutional Review Board, selected patients undergoing primary, unilateral TKA during two 3-month periods were identified from our total joint replacement registry. The control group (CG) was composed of patients who underwent surgery between May 1 and August 19, 2007 which was during the year prior to initiation of the enhanced pathway. The study group (SG) was composed of those patients enrolled in the Clinical Pathway between May 1 and August 19 of 2008. The sampling period was felt to be appropriate to allow the participating surgeons and ancillary staff to become accustomed to employing the pathway protocols. Similarly, an end date of August 19th coincided with the last day before the pathway was initiated. During this time period 884 unilateral TKR patients were admitted to the hospital. Patient selection was largely dictated by surgeon willingness to participate with the enhanced pathway as well as data availability from the hospital total joint registry. The CG patients were enrolled in CERT, an institutional database which tracks objective and subjective patient data. These patients were operated upon by a variety of participating surgeons. To be included in the study patients also had to be represented in another institutional database which tracks physical therapy and rehabilitation milestones achieved after surgery. This process identified 192 patients as the control group. The study group was similarly selected, resulting in 211 patients. The patient demographics, arthritic diagnoses, and profile of medical comorbidities as assessed by American Society of Anesthesia scores were similar between the groups.

The new clinical pathway employed changes to the prior clinical pathway used for the management of the TKA patient. The new pathway modifications focused on improved discharge planning and pre-emptive pain and

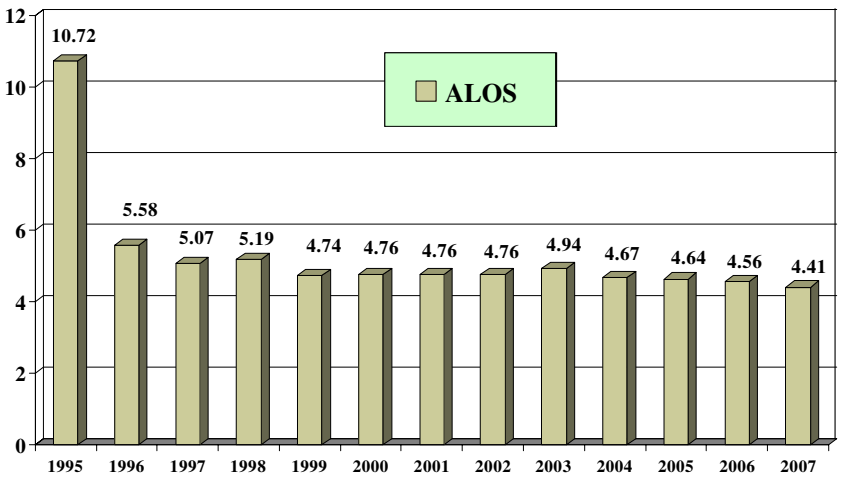

Fig. 1. This graph displays the average length of stay from 1995 through 2007 which was the year prior to initiation of the new pathway. The older pathway was initiated in 1996

nausea management with earlier discontinuation of the epidural analgesia (Table 1). Under the old pathway the pre-operative education class did not specifically address discharge planning and case management was not initiated in the pre-hospital phase. Furthermore, under the old pathway the epidural analgesia was continued for 48 h and the strength or concentration of the epidural infusion was not standardized but ordered by the acute pain service team during their daily rounds. Under new pathway guidelines, patients attended a comprehensive interdisciplinary pre-operative TKA education class 1 week before surgery which also addressed expectations for expected length of stay. A discharge coordinator from the hospital "Quality of Care" committee was added to the education class to help develop a discharge plan for each patient pre-operatively. Additionally, prior to admission, patients were called by telephone to further coordinate their individual discharge plan. The pre-emptive pain and nausea intervention consisted of oral administration of meloxicam (7.5 or 15 mg) and dexamethasone (6 mg) 1 h prior to surgery. Patients received 15 mg of meloxicam unless they were older than 75 years or had a serum creatnine greater than 1.5 in which case 7.5 mg was given. Also, intravenous ondansetron 4 mg was administered in the operating room as an additional pre-emptive measure to control post-operative nausea. Post-operatively, patients pain was controlled by epidural patient controlled analgesia using a solution of 0.6% bupivicaine and 10 μg hydromorphone per cubic centimeters at 4 cc per hour with additional demand dosing up to 20 cc per hour. On the morning of POD #1 this was converted from a continuous infusion to on-demand only and was to be discontinued completely by noon of post-operative day 2 with transition to oral pain medication. The previous pathway allowed the pain team to choose a variety of patient controlled epidural analgesia (PCEA) concentrations and no strict stop time was defined. The final modifications attempted faster mobilization of the patients via early physical therapy and ambulation. This began the day of surgery with initiation of range of motion and standing with a Jordan splint. The patient then progressed each day to achievement of physical therapy milestones including transfer, walking with and without an assistive device, and ascending and descending stairs.

Length of stay was the primary variable of this study and was defined by the POD the patient was discharged, with POD 0 being the day of surgery and POD #1 being the first day after the surgery. The potential increase in bed capacity resulting from a shorter length of stay was calculated in the following way: (reduced LOS in days)× (total number of TKR patients treated during the study period) × (average % hospital occupancy during study period)/mean LOS in days achieved by old pathway.

Pain data from the patient's hospital chart was recorded by the acute pain service on daily rounds. Pain was reported verbally by the patient on the day of surgery through POD #4 using a visual analog scale with values 1–10, with 10 representing the worst pain they have ever experienced. The highest VAS from each POD was recorded. Nausea incidence was defined as the need to treat with anti-nausea medication in the patient's post-operative course. Drugs used included metoclopromide, ondansetron, scopolamine, and trimethobenzamide hydrochloride. Retrospective review of the hospital chart was performed by two unblinded observers (O.A. and P.C.) to retrieve the pain VAS scores and the incidence of nausea. Regarding rehabilitation data, the physical therapists recorded ROM on each POD as well as the POD on which each milestone was achieved. These included the assisted and unassisted completion of the following: transferring from bed to chair, walking, use of a cane and crutches, and navigating stairs. Discharge to home occurred when the patient was "judged medically and surgically stable by the attending physician

Table 1 Comparison of the elements of the old TKR clinical pathway and the new pathway

Features of TKR pathway	Old pathway (1996–August 2007)	New pathway (initiated August 2007) Changes
Patient education	Patient instructed in TKR Care Plan, use of PCEA, PT protocol, and use of CPM Class Q and A	All elements of old pathway Discharge planning addressed Discharge planner attends class Individual patient D/C plan formulated
Pain management	Femoral nerve block with epidural monitored daily by acute pain service Discontinued by 48 h based on patient VAS Nausea management PRN by nursing staff	Meloxicam 7.5 or 15 mg/Decadron 6 mg 1 h prior to surgery Ondansetron during surgery PCEA demand only: D/C by 36 h
Physical therapy	BID sessions beginning POD #1	Mobilized to upright position and ambulation attempted POD 0 BID sessions POD #1
Discharge planning education	Begun in post-op period	Plan initiated during pre-op education Plan reinforced by pre-hospitalization Phone call by discharge planner

and surgeon and when the physical therapist treating the patient judged the patient was safe to be discharged home or to a rehab facility". The goal was discharge patients to a rehab facility on POD #3 or to home by POD #4. Finally, all adverse events occurring in the first six post-operative months were recorded from hospital records as well as patient contact performed for 6-month follow-up included in the CERT database.

Descriptive statistics were calculated for all variables (means, medians, etc.). *t* tests were used to analyze continuous variables (e.g., length of stay) and chi-square tests were used for categorical variables (e.g., nausea, all adverse events). An ANOVA model was used to analyze post-operative pain at different time points to adjust for patient use of patient-controlled analgesia (PCA). All data analysis was performed using SAS software v9.1, SAS (Institute Inc., Cary, NC, USA). The level of significance was accepted as $p \leq 0.05$.

Results

The enhanced clinical pathway resulted in a shortened mean length of stay for the study group compared to the control group treated with the older protocol ($p=0.0073$; Table 2). Average LOS decreased from 4.03 to 3.77 days. This 0.26 day decrease in LOS resulted in an increased capacity of 43 patients. In other words, if all total knee replacements performed at the hospital during this 3-month period experienced this reduced length of stay 43 additional admissions would have been possible [(0.26)(884)(0.785)/4.2=43].

Patients reported less post-operative pain under the newer regimen (Table 3). VAS scores were lower ($p \leq 0.05$) for each post-operative day except POD #2. On average, the PCA was discontinued after 1.86 days, both before and after initiation of the pathway. The pre-emptive control of nausea called for in the clinical pathway did not decrease the incidence of nausea. In fact, 40.33% CG patients experienced nausea (as defined by the need to treat with anti-nausea medication), while 42.58% of SG patients were treated for nausea ($p=0.6526$). SG patients were able to transfer, use a walker, progressing to a cane, and finally navigating stairs at an earlier post-operative day (Table 2).

Finally, we intended to show that the clinical pathway at our institution would not result in a higher complication rate (Table 4). For the 17 post-operative complications identified, only one, perceived muscle weakness in the operative leg, was increased in the SG (14.8% to 23.1%; $p=0.0405$). Others, including pulmonary embolism, deep vein thrombosis, dislocation, fracture, and further surgery on the joint, were not increased. In all, there was no significant increase in complications using the new clinical pathway.

Discussion

This study was performed to assess the early results of a clinical pathway for TKR patients intended to improve hospital length of stay as well as diminish post-operative pain and nausea. The pathway built upon a prior pathway initiated in 1996 which was successful in reducing average length of stay from over 10 to 4.5 days. The old pathway incorporated a patient education program as well as epidural analgesia but did not attempt pre-hospitalization discharge planning or the use of pre-emptive medications to reduce post-operative pain and nausea. The new pathway incorporated these features and this early analysis suggests that these modifications can further reduce length of stay, lessen early post-op pain, and can hasten mobility without increasing post-operative complications. During this 3-month period of observation, the average length of stay was 3.77 days which was a reduction of 0.26 days when compared to the control group. Unfortunately, the incidence of post-op nausea which is severe enough to require anti-emetic medications continued to be experienced in approximately 40% of our TKR patients. This is a severe morbidity probably resulting from the use of narcotics and usually prevents affected patients from making progress with physical therapy until the symptoms abate. It

Table 2 LOS and post-operative day of physical therapy milestone achievement

Pre-pathway			Post-pathway			
	Number of observations	Mean LOS	Number of observations	Mean LOS	Total average LOS	*p* values
LOS	192	4.03	211	3.77	3.89	0.0073
	Number of observations	POD of milestone achievement	Number of observations	POD of milestone achievement	Overall average of milestone achievement	
TA	192	1.13	211	1.04	1.08	0.1018
TU	81	3.37	91	3.12	3.24	0.1189
WA	190	1.47	210	1.33	1.4	0.0351
WU	84	3.46	87	3.29	3.37	0.2430
CA	59	3.37	79	3.13	3.23	0.0883
CU	35	4.06	51	3.73	3.86	0.1113
STA	77	3.43	91	3.12	3.26	0.0141
STU	65	4.06	82	3.88	3.96	0.1994

LOS length of stay, *TA* transfer assisted, *TU* transfer unassisted, *WA* walker assisted, *WU* walker unassisted, *CA* cane assisted, *CU* cane unassisted, *STA* stairs assisted, *STU* stairs unassisted

Table 3 Pain and nausea results

Pre-pathway			Post-pathway		
Post-operative day	Number of observations	Mean pain (1–10)	Number of observations	Mean pain (1–10)	*p* value
0	182	2.807692	209	1.712919	<0.0001
1	182	3.576923	209	2.856459	0.0009
2	182	2.857143	208	2.586539	0.1902
3	176	2.460227	201	1.537313	<0.0001
4	133	1.81203	120	1.208333	0.0037
	182	1.862637[a]	208	1.855769[b]	0.9809
	181	73 (40.33%)[c]	209	89 (42.58%)[d]	0.6526[e]

[a] POD of PCA discharge
[b] POD of PCA discharge
[c] Nausea incidence
[d] Nausea incidence
[e] *p* value for chi-squared

seems to be clear that to further improve our patient experience and length of stay this problem will need to be solved.

There are several limitations in our study. Although the sample sizes are reasonably large, this is a report of our initial experience with data collected from a 3-month period which was compared to a control group treated during a 3-month period the year prior to initiation of this modified pathway. To be included they had to be entered into two databases one of which was an arthroplasty database and the other a database maintained by our physical therapy department. Not all surgeons at our hospital participate in these databases and not all surgeons agreed to allow their patients to be treated in accordance with the pathway. Pain VAS scores and episodes of nausea were identified by retrospective review of patient charts. Chart entries were made by many different observers so that there was no exact standardization for VAS scores and different physical therapists may have identified the achievement of milestones differently. Total narcotic usage was not analyzed as a variable which may have helped clarify the pain severity to a more accurate degree. In future studies we would plan to record total narcotic use. In addition, the surgeons that participated had different approaches to discharge planning which invariably created variability in the criteria for discharge. Furthermore, multiple elements of the pathway together likely contribute to the effectiveness, although the contribution of each is not determined by this study. In view of these limitations we approach these results as encouraging but preliminary. It is unlikely that we would pursue a randomized study design to assess the new pathway as it has now become more widely accepted by our TKR surgeons. However, we do plan future analysis collecting data from a longer period with longer follow-up and a larger sample size.

Most prior studies of intensified perioperative interventions have documented shortened length of stay and

Table 4 Complications

Complication	Pre-pathway		Post-pathway		
	N=182		*N*=208		
	Incidence	Percentage (%)	Incidence	Percentage (%)	*p* value*
PE	0	0.0	0	0.0	–
DVT	4	2.2	1	0.5	0.1892
Infection around joint	2	1.1	5	2.4	0.4563
Pneumonia	0	0.0	2	1.0	0.5009
Stroke	2	1.1	2	1.0	1
MI	0	0.0	0	0.0	–
Dislocation of joint	0	0.0	0	0.0	–
Fracture of or around joint	0	0.0	1	0.5	1
Persistent pain from joint replacement	28	15.4	24	11.5	0.2973
Need for a brace or assistive device for walking	8	4.4	17	8.2	0.1498
More joint stiffness than you would like	54	29.7	65	31.3	0.7424
Muscle weakness in the leg of the joint replacement	27	14.8	48	23.1	0.0405
Muscle paralysis from your surgery	0	0.0	0	0.0	
Difference in leg-length since the surgery	12	6.6	10	4.8	0.5125
Limping	30	16.5	13	6.3	0.0018
Change in sensation around joint replacement	77	42.3	100	48.1	0.2637
More surgery on the joint	3	1.6	8	3.8	0.2315

improved management of pain but few have specifically analyzed multicomponent interventions and most have analyzed total hip and total knee replacement patients together. Studies have documented that pre-op education programs and accelerated rehab regimes shorten length of stay, improve patient outcomes and are cost effective [7, 8, 10, 12–16, 18, 19]. These types of interventions typically reduce length of stay to a range of 3–4 days. Our older pathway reduced length of stay for TKR patients to between 4 and 5 days using these types of interventions. It was our experience that pain, nausea, and orthostatic dizziness prevented many of our patients from participating in physical therapy until post-op day2. This older pathway relied on epidural analgesia for pain management which has been associated with better relief of pain than intravenous or parenteral narcotics but complicated by puritis and problematic nausea [4, 6]. Additionally, at least one study reported a benefit of local and intra-articular infiltration after THR but the effectiveness in TKR has not been sufficiently studied [1].

It appears that to reduce length of stay consistently below 4 days for TKR patients this pain and nausea must be addressed. There is now good evidence that pre-emptive regimens that include anti-inflammatory agents given before surgery help reduce post-op pain following total joint replacement [3, 5, 6, 9, 17]. These studies combine THR and TKR patients and document reduced length of stay to approximately 3 days. We adopted this approach for TKR to reduce our reliance on epidural analgesia which allowed removal of the epidural by noon of post-op day 2 without an increase in pain scores but nausea continued to be problematic in spite of the addition of low-dose dexamethasone and ondansetron prophylatically. Low dose dexamethasone (6 mg p.o.) has been found helpful in reducing nausea without causing increased complications [2, 9]. Although a higher dose of pre-op dexamethasone (40 mg i.v.) may be more effective [9], we believe that further reduction in the administration of narcotics while maintaining good pain relief will be necessary to eliminate this problem.

One element of this new pathway that has not been studied was the effort to begin the discharge planning process in the pre-admission period. It was our experience that many patients are unaware of what level of function they will have at discharge following TKR and enter the hospital expecting to be discharged to acute rehabilitations facilities. Medicare regulations have made this process more difficult and many private and managed care insurance carriers deny this benefit routinely. It has been our experience that hospital days are often wasted awaiting insurance approval or bed availability. This new pathway incorporated an aggressive effort to inform patients of what functional level they should expect at discharge and the likelihood of their eligibility for admission to an acute rehab facility. In this way a discharge plan was in place upon admission which we believe contributed to a smoother discharge process and shorter length of stay.

In conclusion, efforts to improve better discharge planning, addition of pre-emptive analgesia, and nausea prevention and earlier mobilization can result in reduction in the average length of stay following TKR. Although the average reduction of 0.26 days seems modest it does add important increased bed capacity. This reduced length of stay if applied to all TKR patients during a 3-month period would have allowed an additional 43 admissions. As demand for our services grow, even small reductions in length of stay add considerably to our productivity which is vital for the economic health of our institution. Our experience suggests that post-operative nausea continues to be an impediment to mobilization of TKR patients.

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References

1. Andersen KV, Pfeiffer-Jensen M, Haralstadt V, Soballe K, Reduced hospital stay and narcotic consumption and improved mobilization with local and intrarticular infiltration after total hip arthroplasty: a randomized clinical trial of an intraarticular technique versus epidural infusion in 80 patients. Acta. Orthop. 2007; 78: 180–186
2. Bergeron SG, Kardash KJ, Huk OL, Zukor DJ, Antoniou J, Perioperative Dexamethasone does not affect functional outcome in total hip arthroplasty. Clin. Orthop. Relat. Res. 2009; 467: 1463–1467
3. Buvanendran A, Kroin JS, Tuman KJ, Lubenow TR, Elmofty D, Moric M, Rosenberg AG, 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: 2411–2418
4. Choi PT, Bhandari M, Scott J, Douketis J, Epidural analgesia for pain relief following hip or knee replacement. Cochrane Database Syst Rev. 2003; 3: CD003071
5. Duellman TJ, Gaffigan C, Milbrandt JC, Allan DG, Multimodal, pre-emptive analgesia decreases the length of hospital stay following total joint arthroplasty. Orthopedics. 2009; 32 (3): 167
6. Hebl JR, Dilger JA, Byer DE, Kopp SL, Stevens SR, Pagnano MW, Hanssen AD, Horlocker TT, A pre-emptive multimodal pathway featuring peripheral nerve block improves perioperative outcomes after major orthopedic surgery. Reg. Anesth. Pain Med. 2008; 33: 510–517
7. Husted H, Holm G, Jacobsen S, Predictors of length of stay and patient satisfaction after hip and knee replacement surgery. Acta. Orthopedica. 2008; 79: 168–173
8. Iyengar KP, Nadkarni JB, Ivanovic N, Mahale A, Targeted early rehabilitation at home after total hip and knee joint replacement: Does it work?. Disabil. Rehabil. 2007; 29(6): 495–502
9. Kardash KJ, Sarrazin F, Tessler MJ, Velly AM, Single dose dexamethasone reduces dynamic pain after total hip arthroplasty. Anesth Analg. 2008; 106: 1253–1257
10. Khan F, Ng L, Gonzalez S, Hale T, Turner-Stockes L, Multidisciplinary rehabilitation programmes following joint replacement at the hip and knee in chronic arthropathy. Cochrane Database Syst. Rev. 2008; 16: CD004957
11. Kurtz S, Ong K, Lau E, Mowat F, Halpern M, Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J. Bone Jt. Surg. Am. 2007; 89: 780–5
12. Larsen K, Hvass KE, Hansen TB, Thomsen PB, Søballe K, Effectiveness of accelerated perioperative care and rehabilitation intervention compared to current intervention after hip and knee arthroplasty. A before-after trial of 247 patients with a 3-month

follow-up. BMC Musculoskelet. Disord. 2008; 9: 59, doi:10.1186/1471-2474-9-59
13. Larsen K, Sørensen OG, Hansen TB, Thomsen PB, Søballe K, 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(2): 149–59
14. Larsen K, Hansen TB, Thomsen PB, Christainsen T, Soballe K, Cost-effectiveness of accelerated perioperative care and rehabilitation after total hip and knee arthroplasty. J. Bone Jt. Surg. 2009; 91: 761–772
15. McDonald S, Hetrick S, Green S, Pre-operative education for hip or knee replacement. Cochrane Database Syst. Rev. 2004; (1): CD003526
16. Petersen MK, Andersen NT, Soballe K, Self-reported functional outcome after primary total hip replacement treated with two different perioperative regimes. Acta. Orthopedica. 2008; 79: 160–167
17. Reuben SS, Buvenandran A, Katz B, Kroin JS, A prospective randomized trial on the role of perioperative celecoxib administration for total knee arthoplasty: improving clinical outcomes. Anesth. Anal. 2008; 106: 1258–1264
18. Walter FL, Bass N, Bock G, Markel DC, Success of clinical pathways for total joint arthroplasty in a community hospital. Clin. Orthop. Relat. Res. 2007; 457: 133–7
19. Yoon RS, Nellans KW, Geller JA, Kim AD, Jacobs MR, Macaulay W, Patient Education Before Hip or Knee Arthroplasty Lowers Length of Stay. J. Arthroplasty. 2009 May 6. [Epub ahead of print]