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Acupuncture Provides Short-term Pain Relief for Patients in a Total Joint Replacement Program

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Abstract

Objective—Given the risks of opioid medications, non-pharmacological strategies should be considered for total joint replacement patients. We investigated acupuncture as an adjunct therapy for post-surgical pain management in a total joint replacement program by examining which total hip and knee replacement patients elected to receive acupuncture and the effect of acupuncture on short-term pain.

Design—A total joint replacement program using fast-track physiotherapy offered elective post-surgical acupuncture to all patients, at no additional cost, as an adjunct therapy to opioids for pain management.

Setting—The Joint Replacement Center at Abbott Northwestern Hospital, a 630-bed teaching and specialty hospital in Minneapolis, Minnesota from 2010 to 2012.

Subjects—Our sample included 2,500 admissions of total hip and total knee replacement patients.

Methods—Self-reported pain was assessed before and after acupuncture using a 0-10 scale and categorized as none/mild (0-4) and moderate/severe pain (5-10).

Results—Seventy-five percent of admissions included acupuncture. Women (Odds Ratio: 1.48, 95% Confidence Interval: 1.22, 1.81) had higher odds of receiving acupuncture compared to men, and non-white patients (Odds Ratio: 0.55, 95% Confidence Interval: 0.39, 0.78) had lower odds of receiving acupuncture compared to white patients. Average short-term pain reduction was 1.91

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points (95% Confidence Interval: 1.83, 1.99), a 45% reduction from the mean pre-pain score. Forty-one percent of patients reported moderate/severe pain prior to receiving acupuncture, while only 15% indicated moderate/severe pain after acupuncture.

Conclusions—Acupuncture may be a viable adjunct to pharmacological approaches for pain management after total hip or total knee replacement.

Keywords

Acupuncture; total joint replacement; integrative medicine; post-operative pain; multi-modal pain management

Introduction

Total joint replacement programs that rely on fast-track physiotherapy are a promising option for improving short and long-term postsurgical recovery [1–5]. Total hip replacement (THR) and total knee replacement (TKR) patients participating in these fast-track programs have increased levels of short-term functionality [2,3,5] as well as decreased lengths of hospital stay [1–5] and reduced costs [4,5] compared to patients in traditional joint replacement settings. However, program staff and patients face the challenge of post-surgical pain, with one-third of total joint replacement patients suffering moderate to severe pain with activity [6]. Management of acute post-operative pain via opioid analgesics is less than optimal for total joint replacement patients because side effects, in particular sedation, can interfere with rehabilitation [7,8]. Current recommendations for TKR and THR patients in rehabilitation urge reducing the use of opioids by employing multi-modal medication approaches [2,7,8].

Acupuncture integrated into a fast-track total joint replacement program could contribute a nonpharmacological component to multi-modal strategies for pain management. Systematic reviews report beneficial outcomes from using acupuncture as an adjunct therapy to opioids for pain management among all-cause post-surgical patients [9–12]. To date, few studies have been conducted on acupuncture for post-surgical joint replacement patients. Two small randomized controlled trials reported no significant differences in pain between auricular acupuncture and sham acupuncture patients after total hip [13] and total knee [14] surgery. However, these studies were not specific to fast-track physiotherapy settings and they examined auricular acupuncture (i.e. using only points on the ears) in small samples of fewer than 60 patients.

In this study, we examine the addition of acupuncture as an elective option, available to patients at no additional charge, in a fast-track total joint replacement program at Abbott Northwestern Hospital (ANW), and we investigate how acupuncture may contribute to multi-modal acute postoperative pain relief. Specifically, we address two research questions: 1) which THR and TKR patients elect to receive acupuncture and 2) does receipt of acupuncture provide short-term, clinically meaningful pain relief for THR and TKR patients? To our knowledge, this is the first study of adjunctive acupuncture conducted in a fast-track joint replacement surgery setting. Given the expected quadruple increase in demand for total joint replacement procedures between 2010 and 2020 [15], studying

innovative, non-pharmacological approaches to managing postoperative pain after these procedures is warranted and timely.

Methods

Study Setting

We conducted this retrospective, observational study at the Joint Replacement Center at ANW, a 630-bed teaching and specialty hospital in Minneapolis, Minnesota. ANW adopted a fast-track, total joint replacement program in 2008 and has since garnered the Joint Commission's Gold Seal of Approval for providing a high-level of quality and patient safety [16]. In 2010, the hospital began offering acupuncture as part of the program to aid in post-operative pain relief and facilitate rehabilitation.

Patients are admitted to the total joint replacement program Monday through Friday and are typically in the hospital for two to three days after the day of surgery (mean length of stay is 3.3 days), although patients may stay longer if experiencing slow progress in therapy. Surgery is performed on the first day of the admission and physical rehabilitation begins the next morning. Providers treat all patients according to a standard multimodal pain control protocol utilizing acetaminophen, non-steroidal anti-inflammatories, gabapentin, muscle relaxants, and as needed, periarticular injections, peripheral nerve blocks, and short- and long-acting opioid pain medication. All patients also receive an order for acupuncture. An acupuncturist visits patients the morning of the first day post-surgery to provide additional information about acupuncture and invite each patient to participate in an afternoon group acupuncture session.

A group physical therapy session is held daily from 1:30 until 2:15 PM. As the group physical therapy is finishing, the acupuncturist confirms whether patients would like to participate in a group acupuncture session. Patients, who elect to receive acupuncture, rest with acupuncture needles in place while lights are lowered and a relaxation video plays on a projection screen.

The afternoon group physical therapy session occurs every day of the week (including weekends) with group acupuncture offered Tuesday through Friday. Patients can elect to receive group acupuncture after each afternoon group physical therapy session during their admission on those days. Thus, patients with a surgery on Monday, Tuesday, or Wednesday have the opportunity to receive group acupuncture on both their first and second day post-surgery during the typical stay. Patients with a Thursday surgery generally can only receive group acupuncture one time on Friday, and patients with Friday surgery can only receive acupuncture if their admission lasts into the next week.

Individual acupuncture sessions are also offered on the same Tuesday through Friday schedule. During the initial morning visit to invite each patient to participate in group acupuncture, practitioners may offer patients individual integrative medicine therapies such as massage, mind-body (e.g. relaxation therapy), acupressure, aromatherapy, Korean hand therapy, and in some cases individual acupuncture if patients present with pain, nausea, or other symptoms. Although our data did not allow us to distinguish between group and

individual acupuncture sessions, the acupuncturists in our study note that acupuncture outside of the group therapy sessions occurs in less than 10% of all THR and TKR admissions.

Acupuncture Treatments

Acupuncture treatments are provided by six acupuncturists who are certified by the National Certification Commission for Acupuncture and Oriental Medicine and who had between four to 18 years of experience as of the start of data collection. In order to provide efficient and safe treatments in the group setting, the 10 acupuncturists employed by ANW have developed a consensus protocol based in Traditional Chinese Medicine channel theory and the treatment of Bi syndrome. Points include: LI11, LI4 bilaterally; ST 36, GB34, SP6 and LV 3 on the non-surgical extremity; and auricular points Hip or Knee Joint and Ear Shen Men. Point variations from this protocol do occur either due to a patient's clinical status (e.g. P6 added for patients with severe nausea), placement of dressings or intravenous lines that obstruct point access, or practitioner's judgment. Adjustments to the protocol also include using only upper body points when the patient has had bilateral replacement surgery. On average patients received 9.0 needle insertions (standard deviation of 2.8 needle insertions).

Prior to treatment patients receive education on the theory of Traditional Chinese Medicine in a pre-operative education session and an individual session with the acupuncturist prior to treatment. Patients are treated using either DBC™ Spring Ten 0.18 × 30 mm or Seirin 0.16×30mm and 0.20×30m needles. The average treatment time was 41.3 minutes (standard deviation of 12.5 minutes). Manipulation is either manual manipulation of insertion or with no stimulation in the Matsumoto style, and response sought varies by practitioner. Needle depth also varies by practitioner and is not specifically measured for each treatment, but all needles used in group treatments are 30mm or less in length.

Study Population

All inpatients age 18 years or older undergoing total knee or total hip replacement using International Classification of Disease, 9th Revision, Clinical Modification procedures codes, 81.54 and 81.51, who were admitted between January 1, 2010 and December 31, 2012, were included in the study population. We retrospectively identified our study population using electronic medical records. All patients whose data were obtained had provided written permission upon admission to ANW for their medical records to be used for general research purposes. In addition, the Institutional Review Board of Allina Health approved this specific study with a waiver of informed consent.

Of 3,320 joint replacement admissions in the study population, we excluded 387 performed by surgeons that did not participate in the group-based total joint replacement program. Additionally, 432 admissions were excluded for patients receiving surgery on Friday, because nearly all of these patients were discharged prior to being able to receive acupuncture. Lastly, we excluded one admission due to that patient's illness severity being indeterminable in the medical record. The final sample included 2,500 admissions from 2,282 unique patients.

In our sample, practitioners provided 2,861 applications of acupuncture, where ‘application’ refers to a unique administration of acupuncture to one patient. In our analyses of pain reductions, 631 applications (22%) were excluded because either a pre- or post-pain score was not collected or recorded. Additionally, we did not utilize 254 applications (9%) with pre-pain scores equal to zero as these patients could not report any reduction in pain. These exclusions resulted in a sample of 1,977 applications of acupuncture for the pain reduction analyses.

Measurements

Pain Scores—Acupuncturists collected patients’ self-reported pain scores directly prior to and after each application of acupuncture. Acupuncturists requested patients to indicate the level of pain they were currently experiencing on an 11-point numeric rating scale where 0 was defined as ‘no pain’ and 10 was defined as ‘worst pain imaginable’. In alignment with the Joint Replacement Center’s protocols for TKR and THR, pain scores from 0-4 were categorized as none/mild pain and pain scores from 5-10 were listed as moderate/severe pain.

Demographic and Hospital Admission Characteristics—Data extracted from electronic medical records included joint replacement types (knee or hip), patients’ ages at time of hospital admission, sex, race (white or non-white) and marital status (married or not married). Our data included the All Patient Refined Diagnostic Related Groups (APR-DRG) severity of illness measures calculated from patients’ diagnoses codes [17]. The measure includes four categories of APR-DRG severity: 1) minor, 2) moderate, 3) major, and 4) extreme. Because extreme severity is rare in the case of total joint replacement, we combined the major and extreme categories.

Statistical Analysis

Acupuncture Utilization—We identified each admission in which the patient elected to receive acupuncture, how many times each patient received acupuncture, and on which days relative to the day of surgery acupuncture applications occurred. Logistic regression was used to predict the probability of receiving any acupuncture during a hospital admission as a function of joint replacement type, patient demographics, and APR-DRG severity. Odds ratios were calculated for each covariate. To correct for serial correlation among patients with multiple hospital admissions, standard errors were clustered by patient. We used a Hosmer-Lemeshow to test the fit of our model [18].

Pain Reductions—To determine if acupuncture was associated with reductions in pain, we report the mean reduction in pain reported after acupuncture applications. A t-test was used to determine significant differences in pain reduction between TKR and THR patients. Because acupuncture may be more effective at different times over the course of an admission, we also tested whether pain reductions reported on the first day post-surgery were significantly different from pain reductions reported on second day post-surgery or later.

Additionally, we used logistic regression to determine the odds of reducing pain from moderate/severe to none/mild. Using the sample of acupuncture sessions for which patients reported moderate/severe pain prior to receiving acupuncture, we estimated the odds of reporting none/mild pain after the session. We controlled for joint replacement type, patient demographics, and APR-DRG severity. Again, because acupuncture may be more effective at certain times relative to when the surgery was performed, this analysis was repeated for acupuncture applications on the first day post-surgery and for sessions on the second day post-surgery or later. We clustered standard errors by patient and tested the goodness-of-fit of our model using a Hosmer-Lemeshow test [18].

All analyses were conducted using Stata Version 13 (StataCorp LP; College Station, TX).

Results

Acupuncture Utilization

Of 2,500 joint replacement surgeries, 1,867 or 75% elected to receive acupuncture during admission (Table 1). Patients with Monday through Wednesday surgeries, who could typically receive acupuncture on two days, elected to have acupuncture at least once in 76% of admissions. Election of acupuncture was slightly lower for patients with Thursday surgeries at 69% as acupuncture was generally only available once (i.e. on Friday) for these patients. Of Monday through Wednesday patients, who could potentially receive acupuncture twice, 56% received acupuncture a second time during their admission.

Acupuncturists administered a total of 2,861 applications of acupuncture during the study period. Conditional on having acupuncture at least once, patients received an average of 1.5 applications of acupuncture. Sixty percent of acupuncture applications occurred on the first day after surgery and 32% occurred on the second day after surgery. Patients in the hospital for three days or more after the day of surgery, an uncommon occurrence, accounted for the remaining 8% of applications.

Seventy-seven percent of women received at least one application of acupuncture compared to only 71% of men (Table 2). For race, 76% of admissions for white patients received acupuncture, while only 64% of admissions for non-white patients received acupuncture. The rate of receiving any acupuncture was similar for TKR and THR patients at 75% and 74%, respectively. Only 66% of admissions with major or extreme APR-DRG severity received acupuncture, which was less than admissions with minor severity (77%) and moderate severity (76%).

The results of our logistic regression confirm the descriptive findings (Table 3). Female admissions had 48% higher odds of receiving acupuncture (odds ratio (OR): 1.48, 95% Confidence Interval (CI): 1.22, 1.81) compared to male admissions. Admissions of non-white patients had lower odds of receiving acupuncture (OR: 0.55, 95% CI: 0.0.39, 0.78) than admissions of white patients. Compared to admissions with minor APR-DRG severity, admissions with major or extreme severity had lower odds of receiving acupuncture (OR: 0.60, 95% CI: 0.45, 0.80). There was no significant difference on use of acupuncture between TKR and THR patients. The p-value of the Hosmer-Lemeshow test was 0.300

indicating a goodness-of-fit, or that the covariates of our model correctly predict the probability of receiving acupuncture.

Pain Reduction

For the 1,977 applications of acupuncture with a pre-pain score greater than zero, the average short-term reduction in pain after receiving an application of acupuncture was 1.91 points (95% CI: 1.83, 1.99) as reported in Table 4. For the average pre-pain score in the sample, 4.23, this reduction represents a 45% decrease in pain. Pain reduction was significantly greater (p -value<0.001) for acupuncture applications occurring on the second day after surgery or later (2.14, 95% CI: 2.01, 2.26) compared to acupuncture received on the first day post-surgery (1.79, 95% CI: 1.69, 1.89).

We found that THR patients had a significantly higher (p -value=0.005) mean pain reduction (2.09, 95% CI: 1.95, 2.22) than TKR patients (1.84, 95% CI: 1.74, 1.94). However, this significant difference was only observed for acupuncture applications on the first day after surgery. For acupuncture applications on the second day after surgery or later, THR patients (2.13, 95% CI: 1.92, 2.35) and TKR patients (2.14, 95% CI: 1.98, 2.22) did not have significantly different reductions in pain. TKR patients experienced a significantly greater (p -value<0.001) pain reduction on the second day or later after surgery (2.14, 95% CI: 1.98, 2.29) compared to the first day after surgery (1.66, 95% CI: 1.54, 1.79).

We tested for the possibility that the difference by days since surgery is driven by patients who respond well to acupuncture on the first day after surgery electing to receive acupuncture again, while patients who respond poorly elect to forgo acupuncture a second time. We found that for patients who elected to receive a second application of acupuncture, the first day post-surgery pain reduction (1.88, 95% CI: 1.74, 2.01) was greater compared to patients who forwent acupuncture on the second day after surgery or later (1.70, 95% CI: 1.55, 1.85), but this difference was not significant at conventional levels (p -value=0.092). Additionally, for patients receiving acupuncture twice, the pain reduction on the second day post-surgery or later (2.08, 95% CI: 1.95, 2.21) was still significantly greater (p -value=0.038) than their pain reduction on the first day after surgery (1.88 95% CI: 1.74, 2.01).

Of patients with reported pain scores, 41% (801/1,977) had moderate/severe pain (pain scores 5-10) prior to receiving acupuncture. Only 15% (296/1,977) of patients with a reported pain score indicated moderate/severe pain after receiving acupuncture. Table 5 (column 1) presents the adjusted odds ratios of reporting a decrease from moderate/severe pain to none/mild pain. Each additional year in age was associated with a 2% (OR: 1.02, 95% CI: 1.01, 1.04) increase in the odds of reducing pain from moderate/severe to none/mild. In applications of acupuncture for THR patients, odds were higher for a pain level reduction than in applications for TKR patients (OR: 2.08, 95% CI: 1.42, 3.05). Next we stratified the analysis by the first day post-surgery (Table 5, column 2) and the second day post-surgery or later (Table 5, column 3). Results indicate that THR patients were more likely to have pain reduced from moderate/severe to none/mild on the first day post-surgery (OR: 2.24, 95% CI: 1.47, 3.40) than TKR patients. However, no significant difference existed between THR and TKR patients on the second day post-surgery or later.

The p-value for the Hosmer-Lemeshow was 0.916 for the model including applications on any day post-surgery, 0.660 for application on the first day post-surgery, and 0.997 for applications on the second day post-surgery or later. These p-values indicate a good fit for each model.

Discussion

Postoperative pain can be particularly detrimental to total joint replacement patients who rely on physical therapy to recover after surgery. Acute post-operative pain can slow recovery and lead to chronic post-operative pain [6,19,20]. Adequate pain control is a principal concern for patients undergoing total joint replacement procedures [21,22]; furthermore, patients may be poorly prepared for post-operative pain due to inaccurate expectations or poor recall of perioperative information [23,24].

In the present study, we found that patients in a fast-track total joint replacement program commonly elected to receive acupuncture when it was offered as part of a clinical program and, on average, pain was reduced in the short-term by 45% after receiving acupuncture. Of all admissions, 75% of patients elected to receive acupuncture, and 56% of patients who could receive acupuncture twice elected to receive acupuncture for a second time. Admissions for women and white patients both had increased odds of receiving acupuncture, while patients with major or extreme illness severity had decreased odds of receiving acupuncture.

Acupuncture has been shown to reduce the use of opioid analgesics as well as to aid in alleviating post-operative medication side effects including sedation, nausea, vomiting, and dizziness [10,13,25–27]. Of note in our study was the clinically meaningful finding that acupuncture contributed to lowering pain below the threshold at which patients would receive intravenous narcotics beyond the initial post-operative standard dose. Per the ANW Joint Replacement Center's protocol, patients who report moderate/severe pain for four hours or more receive an increase in intravenous narcotic analgesics, whereas nurses reduce intravenous narcotic analgesics for patients who report none/mild pain for 12 hours or more. In our study, 41% of patients who received acupuncture had moderate/severe pain prior to receiving acupuncture and only 15% of patients had moderate/severe pain after receiving acupuncture. While we did not conduct follow-up measurements with patients in this study to assess whether pain medications were decreased over time, the threshold in the program's medication protocol serves as a useful proxy for beginning to understand how acupuncture may influence opioid management in this study setting.

Curbing the total amount of opioid analgesics may help assuage medication-related side effects that can interfere with the rehabilitation and recovery process throughout an admission. While not focused on acupuncture or other integrative medicine modalities, recent reports on perioperative pain management for total knee [7] and total hip [8] replacement recommend post-arthroscopic surgery rehabilitation that minimizes the use of opioids, as opioid usage can prolong length of stay and inhibit patient mobilization. Opioids are more effective for patients at rest than those engaged in activity, and side effects such as sedation can interfere with rehabilitation [7,8]. Furthermore, qualitative interviews with

patients awaiting and recovering from total joint replacement indicate that patients struggle with concerns about side effects and addiction from using prescription-strength analgesics [21].

On average, pain reductions in our sample were greater on the second day after surgery or later compared to the first day, although fewer patients elected to receive acupuncture a second time. Our findings on differences by post-surgical day echo results reported by Bauer and colleagues (2010) in an integrative medicine study of medical massage among postoperative cardiac patients. In that study, massage was more effective for pain reduction on days three and four after cardiac surgery than on day two, when patients were groggy and encumbered by lines and tubes [28]. While that study was in a different surgical population, the pattern of slight delay after surgery before the optimal delivery of integrative medicine therapy may be noteworthy. Providers offering acupuncture to total joint replacement patients may want to inform patients that pain reductions can be greater on the second day after surgery, especially for TKR patients. In particular, this information could be beneficial since about half of all patients elect not to receive acupuncture a second time.

THR patients had greater pain reduction when receiving acupuncture compared to TKR patients, although there was no significant difference in pain reduction on the second day after surgery or later. As indicated by the pre-pain scores in our study and previous literature, TKR patients are more likely to have moderate or severe pain after surgery than THR patients [6]. Our results suggest that the higher initial pain levels of TKRs may mask some of the benefits of acupuncture, although TKR patients still experienced pain reductions after receiving acupuncture.

The successful integration of acupuncture into the total joint replacement program at ANW stands as an example of an innovative and feasible approach to multi-modal pain management and mitigation of continued opioid delivery after the initial post-surgical protocol. Other such acupuncture-inclusive programs, if they exist, have not been reported on in the medical literature thus far. However, in the context of an ever-increasing demand for total joint replacement procedures [15], novel programs with proven outcomes will become increasingly important for reducing post-operative pain to improve patients' acute recovery and rehabilitation phase.

Some limitations are present in this study. First, response bias may be present because pain scores are self-reported. Pain reductions could be overestimated if patients found it socially desirable to express to the acupuncturist that the therapy was effective. However, ANW as well as other hospitals use self-reported scores to make decisions regarding the care received by patients (e.g. amount of intravenous narcotic analgesics). Although not present in our data, ANW nurses assess TKR and THR patients' pain on a regular basis during each admission, using the same 0-10 rating scale used in this study. Therefore these self-reported scores maintain a high-level of clinical relevance. Second, this study was limited to short-term pain relief because the post-pain measure was obtained directly after receiving acupuncture. Future studies could explore pain outcomes at various times during the admission to determine the lasting effect of pain relief. Such investigations would benefit from the use of a control group (i.e. patients not receiving acupuncture). Given the potential

value of acupuncture in mitigating opioid use, subsequent studies could investigate the impact of post-surgical pain relief via acupuncture on short and long term medication use. Future work could also explore the effect of acupuncture on other post-operative outcomes that interfere with recovery such as nausea and vomiting. Lastly, our study was conducted in one hospital; therefore our results may not be generalizable to other settings or other joint replacement populations.

As a non-pharmacological adjunct, acupuncture has considerable potential for aiding in pain reduction without adding to the burden of opioid usage. This study found that nearly three-fourths of patients elected to receive acupuncture in a total joint replacement program. Acupuncture was beneficial to patients as it supported pain relief in the short term and potentially improved patients' capacity to perform physiotherapy during the initial post-surgical recovery period. Acute post-operative pain is a common challenge after total joint replacement surgery, and these results can aid providers seeking innovative methods to manage pain and improve the patient experience.

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Frequency of Admissions and Acupuncture Applications in the Abbott Northwestern Total Joint Replacement Program, January 1st, 2010 to December 31, 2012

Table 1

Surgery Day	Admissions	Admissions Receiving Acupuncture (%)	All Days-post Surgery	Acupuncture Applications by Day		
				1st Day-post Surgery	2nd Day-post Surgery	3rd Day-post Surgery or Later
Monday	830	653 (78.7)	1,116	601	411	104
Tuesday	943	701 (74.4)	1,150	622	446	82
Wednesday	136	104 (76.5)	160	87	71	2
<u>Thursday</u>	<u>591</u>	<u>409 (69.3)</u>	<u>435</u>	<u>406</u>	<u>0*</u>	<u>29</u>
Total	2,500	1,867 (74.7)	2,861	1,716	928	217

Notes: Includes total hip and total knee replacement admissions. Friday surgeries are excluded.

* The total joint replacement program did not offer acupuncture sessions on the 2nd day-post surgery (i.e. Saturday) for surgeries occurring on Thursday.

Table 2

Characteristics of Total Joint Replacement Admissions

	Admissions Electing No Acupuncture (N=633)	Admissions Electing Acupuncture (N=1,867)	p-value
Age (Years \pm Standard Deviation)	66.7 (\pm 11.8)	66.0 (\pm 10.4)	0.132
Sex (column %, row %)			
Female	345 (54.5, 22.8)	1,171 (62.7, 77.2)	<0.001
Male	288 (45.5, 29.3)	696 (37.3, 70.7)	<0.001
Race (column %, row %)			
White	569 (89.9, 24.5)	1,755 (94.0, 75.5)	<0.001
Non-white	64 (10.1, 36.4)	112 (6.0, 63.6)	<0.001
Marital Status (column %, row %)			
Married	381 (60.2, 24.5)	1,175 (62.9, 75.5)	0.218
Not Married	252 (39.8, 26.7)	692 (37.1, 73.3)	0.218
Joint Replacement Location (column %, row %)			
Knee	423 (66.8, 25.0)	1,272 (68.1, 75.0)	0.544
Hip	210 (33.2, 26.1)	596 (31.9, 73.9)	0.560
APR-DRG Severity Level (column %, row %)			
Minor	142 (22.4, 23.0)	476 (25.5, 77.0)	0.123
Moderate	360 (56.9, 24.0)	1,137 (60.9, 76.0)	0.074
Major or Extreme	131 (20.7, 34.0)	254 (13.6, 66.0)	<0.001

APR-DRG = All patient refined diagnostics-related group.

Notes: Includes total hip and total knee replacement admissions in the total joint replacement program at Abbott Northwestern Hospital between January 1st, 2010 and December 31st, 2012. Friday surgeries are excluded.

Table 3
Adjusted Odds-Ratios for Election of Acupuncture During Total Joint Replacement Admissions

	Adjusted Odds Ratio (95% CI)	p-value
Age (years)	0.99 (0.98, 1.00)	0.138
Female (reference=male)	1.48 (1.22, 1.81)	<0.001
Non-white (reference=white)	0.55 (0.39, 0.78)	0.001
Not Married (reference=married)	0.87 (0.71, 1.06)	0.166
Hip Replacement (reference=knee replacement)	0.96 (0.79, 1.18)	0.716
<i>APR-DRG Severity Level (reference=minor severity)</i>		
Moderate	0.94 (0.75, 1.18)	0.596
Major or Extreme	0.60 (0.45, 0.80)	0.001

APR-DRG = All patient refined diagnostics-related group; CI = Confidence Interval.

Notes: Includes 2,500 total hip and total knee replacement admissions who could elect to receive acupuncture in the total joint replacement program at Abbott Northwestern Hospital between January 1st, 2010 and December 31st, 2012. Confidence intervals and p-value calculated using standard errors clustered by patient.

Table 4
Pain Reduction During Total Joint Replacement Admissions Receiving Acupuncture

Day	#Acupuncture Applications	Mean Pre-Pain Level	Mean Pain Reduction After Acupuncture (95% CI)	p-value
<i>Hip and Knee Admissions</i>				
Any Day-post Surgery	1,977	4.23	1.91 (1.83 - 1.99)	<0.001
1st Day-post Surgery	1,259	4.61	1.79 (1.69 - 1.89)	<0.001
2nd Day-post Surgery or Later	718	3.57	2.14 (2.01 - 2.26)	<0.001
<i>Knee Admissions</i>				
Any Day-post Surgery	1,395	4.41	1.84 (1.74 - 1.94)	<0.001
1st Day-post Surgery	872	4.84	1.66 (1.54 - 1.79)	<0.001
2nd Day-post Surgery or Later	523	3.67	2.14 (1.98 - 2.29)	<0.001
<i>Hip Admissions</i>				
Any Day-post Surgery	584	3.80	2.09 (1.95 - 2.22)	<0.001
1st Day-post Surgery	388	4.06	2.06 (1.89 - 2.23)	<0.001
2nd Day-post Surgery or Later	196	3.28	2.13 (1.92 - 2.35)	<0.001

CI = Confidence Interval.

Notes: Includes total hip and total knee replacement admissions that elected acupuncture in the total joint replacement program at Abbott Northwestern Hospital between January 1st, 2010 and December 31st, 2012. Excludes all acupuncture applications for patients with a missing pre- or post-pain score or who indicated no pre-pain prior to receiving acupuncture.

Adjusted Odds-Ratios for Reducing Pain from Moderate/Severe to None/Mild after Receiving Acupuncture During Total Joint Replacement Admissions

	Any Day-post Surgery (N=801)		1st Day-post Surgery (N=603)		2nd Day-post Surgery or Later (N=198)	
	Adjusted Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Age (years)	1.02 (1.01, 1.04)	0.005	1.03 (1.01, 1.04)	0.002	1.00 (0.96, 1.04)	0.982
Female (reference=male)	1.17 (0.84, 1.62)	0.354	1.21 (0.84, 1.75)	0.296	0.95 (0.41, 2.20)	0.908
Non-white (reference=white)	1.12 (0.64, 1.97)	0.695	1.51 (0.73, 3.12)	0.263	0.45 (0.16, 1.25)	0.126
Not Married (reference=married)	0.72 (0.52, 0.99)	0.042	0.73 (0.51, 1.04)	0.078	0.49 (0.23, 1.08)	0.077
Hip Replacement (reference=knee replacement)	2.08 (1.42, 3.05)	<0.001	2.24 (1.47, 3.40)	<0.001	1.89 (0.76, 4.71)	0.172
<i>APR-DRG Severity Level (reference=minor severity)</i>						
Moderate	1.17 (0.82, 1.67)	0.393	1.18 (0.80, 1.74)	0.405	0.91 (0.34, 2.46)	0.853
Major or Extreme	0.97 (0.58, 1.62)	0.901	0.77 (0.44, 1.35)	0.362	1.06 (0.30, 3.78)	0.932

APR-DRG = All patient refined diagnostics-related group; CI = Confidence Interval

Notes: Includes 801 acupuncture applications for total hip and total knee replacement admissions in the total joint replacement program at Abbott Northwestern Hospital between January 1st, 2010 and December 31st, 2012, for which patients indicated moderate/severe pre-pain score (5-10 on a 0-10 numerical rating scale) and our data included a non-missing post-pain score. Confidence intervals and p-value calculated using standard errors clustered by patient.