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How Do Demographic, Surgical, Patient, and Cultural Factors Affect Pain Control After Unicompartmental Knee Arthroplasty? A Multivariable Regression Analysis

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ABSTRACT

Background: Controlling pain after unicompartmental knee arthroplasty (UKA) is essential for improving patient satisfaction, minimizing complications, and early rehabilitation. There is little literature available evaluating the effect of both treatment and patient characteristics on in-hospital pain after UKA. The purpose of this study was to examine the effect of patient and treatment characteristics on in-hospital pain after UKA. This study also evaluated the role of analgesic cocktail (traditional periarticular injection cocktail "[PAI]" vs cocktail including liposomal bupivacaine "[LBUP]").
Methods: The study sample included 442 consecutive UKA cases performed between December 2011 and August 2013. The primary outcome measures were the average Visual Analog Scale pain score and the percent of pain scores during hospitalization that were 0, that is, "no pain." Multivariable regression analyses were implemented to investigate associations between patient demographics and analgesic group with the outcomes. For the analgesic groups, the "PAI" group received injections of a cocktail including Marcaine, ketorolac, and morphine, the "LBUP" group received injections of LBUP.
Results: Postoperative pain was higher in females ($P < .001$) and younger patients ($P = .002$). The patient group treated with LBUP injection technique had similar overall average Visual Analog Scale pain scores to patients in the PAI group ($P = .729$); however, there was also a significant improvement in pain scores over time (as the study progressed) for patients in the LBUP group relative to the PAI group ($P = .003$), potentially indicating better outcomes with more experience with the injection technique. When compared individually by day, the LBUP group had lower pain scores from day 1 to 3 ($P < .024$).
Conclusion: The results showed that in patients undergoing UKA, postoperative pain was lower in males, older patients, patients with lower body mass index, and those treated with LBUP over the study period. Understanding these associations is necessary to effectively manage pain and encourage earlier ambulation and physiotherapy after UKA.

Although unicompartmental knee arthroplasty (UKA) has a faster short-term recovery and a decreased postoperative morbidity and pain compared to total knee arthroplasty [1], controlling pain after UKA is essential for patient satisfaction, minimizing complications, and early rehabilitation. Length of hospital stay in UKA has been reduced in recent years because of implementation of rapid recovery pathways, better patient selection, and improved pain control techniques, although surgeons are still striving to reduce this further [1]. Many centers routinely perform them as outpatient procedures [1].

It has been reported that patient demographics, such as age, gender, race, and ethnicity, may play a role in pain-related outcomes after knee arthroplasty [2]. Previous studies have hypothesized that causative factors for these associations include lower expectations

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before surgery, potential surgical delays, and worse preoperative osteoarthritis status among certain groups [3]. Other works have reported differences in the experience of pain by certain patients and the management of that pain [4,5]. Placing more emphasis on patient demographics as a factor contributing to outcomes may help surgeons identify high-risk patients for better counseling and treatment [6]. To date, the available literature has limited data on risk factors for pain after UKA, including a lack of focus on in-hospital postoperative pain.

The purpose of this study was to examine the effect of patient characteristics on measured postoperative pain after UKA using standardized postoperative pain control protocols. This study also evaluated the role of the analgesic cocktail on pain outcomes, including direct comparison of a traditional periarticular injection cocktail ("PAI" group) vs a cocktail including liposomal bupivacaine ("LBUP" group). The study incorporated a multivariable regression model to control for patient and treatment factors.

Materials and Methods

The study sample included 442 consecutive UKA cases in the period between December 2011 and August 2013. Four surgeons in a dedicated arthroplasty practice provided cases for this study. All patient information was deidentified, and this is an institutional review board–approved study via exemption. The study included patients who demonstrated full thickness cartilage loss in the affected compartment with functionally intact cartilage in the remaining compartments. Patients were excluded if they did not have an intact anterior cruciate ligament. Patients were not excluded based on age, body mass index (BMI), or activity level.

The primary outcome measures were the average Visual Analog Scale (VAS) pain score for each patient per day and the percent of VAS pain scores during hospitalization that were 0 per day, which is a result of a patient answering that they had "no pain." VAS pain data were collected at every instance in which nursing personnel had contact with the patient, resulting in multiple VAS scores for each day of hospital stay. The collection of VAS pain scores was implemented through a robust prospective data gathering system. VAS data and other relevant medical parameters are collected routinely on every case that passes through the study center.

There were 2 differing multimodal analgesia treatment protocols used over the study period. In the period between December 2011 and October 2012, 195 consecutive UKA cases were performed using a well-established multimodal analgesia (including PAI with Marcaine, ketorolac, and morphine) and therapy protocols (referred to as the "PAI" group). For the period which immediately followed (October 2012-August 2013), 247 consecutive UKA cases were performed with similar therapy protocols, but substituting the established PAI for an Food and Drug Administration–approved liposomal bupivacaine surgical site soft tissue injection technique (EXPAREL, Pacira Pharmaceuticals, Parsippany, NJ), as part of their multimodal analgesia protocol ("LBUP" group). The procedures covered during both periods were performed by the same 4 surgeons. As almost 200 patients were recruited for each group, this study has over 80% power at an alpha level of 0.05 to detect an effect size of 0.40 in the average VAS pain score based on post hoc power calculations.

The procedures were primarily medial mobile bearing (50% of procedures, Oxford Partial Knee; Biomet, Inc, Warsaw, IN) and medial fixed bearing (45% of procedures, Vanguard M; Biomet, Inc; EPIK Knee System; DJO Global, Vista, CA). The remaining 5% of procedures were mixed among patellofemoral (Vanguard PFR, Biomet, Inc) and lateral fixed bearing procedures (Vanguard M, Biomet, Inc; EPIK Knee System). Medial and patellofemoral procedures were done through a limited medial parapatellar approach. Lateral procedures were done through a limited lateral parapatellar approach.

As age, BMI, length of stay (LOS), and pain scores were not normally distributed, Wilcoxon rank-sum tests were applied to compare the distributions between PAI and LBUP. For categorical variables, chi-square tests were used. Multivariable regression analyses were implemented to investigate associations between patient demographics, surgery, or treatment group with pain scores and percent of zero pain scores in patients staying 6 days or less. The mixed model included fixed effects for patient characteristics and a random subject effect to account for variation within patients. Variables in the regression analysis included race, BMI, gender, surgeon, PAI/LBUP, patient age at surgery, day since surgery, and interactions of treatment with patient demographics. Sensitivity analyses included restricting the analysis to LOS within 2 days and fitting a binary logistic mixed model for VAS 0 scores to confirm the significance of the results and the magnitude of the observed trend. Statistical significance was assessed at an alpha level of 0.05. Statistical analysis was performed with SAS software (SAS Institute Inc, Cary, NC), version 9.4.

Results

There were no differences in age, BMI, gender, or race between groups ($P > .079$; Table 1). The LBUP group had a shorter hospital LOS (1.7 days vs 1.9 days, $P = .017$).

The regression analysis demonstrated that overall postoperative pain was higher in females ($P < .001$) and younger patients ($P = .002$; Table 2). Patients treated by surgeon 1 experienced lower overall postoperative pain scores ($P < .001$) relative to patients treated by surgeon 3. The LBUP patient group had similar overall average VAS pain scores to patients in the PAI group ($P = .729$), however, when broken out by day and compared, the LBUP group had lower pain scores from day 1 to 3 ($P < .024$; Fig. 1). There was also a significant improvement in pain scores over time (as the study progressed) for patients in the LBUP group relative to the PAI group ($P = .003$), potentially indicating better outcomes with more experience with the injection technique. No other interaction terms were significant in the model. Sensitivity analyses restricting the outcomes to VAS data within 2 days of surgery did not show any major deviations to the results presented here, other than age no longer being a significant factor.

The trends observed for average pain scores were similar for the percentage of VAS 0 scores per patient across their stay (Table 3). Table 4 shows the percent of VAS pain scores that were 0 reported by day and by gender for each treatment group. If all other variables are controlled for, the percentage of VAS 0 scores is higher for males ($P = .001$), older patients ($P = .012$), and patients treated by surgeon 1 (relative to surgeon 3, $P = .042$). Two interaction terms were significant in the model. First, female patients in the LBUP group reported zero pain scores more frequently than males ($P = .034$). In

Table 1
Difference in Age, BMI, LOS, Race, and Gender Between PAI and LBUP Patients Using Chi-Square and Wilcoxon Rank-Sum Tests.

	PAI		LBUP		*P*
	Average	Range	Average	Range	
Age, y	67.1	40-88	66.9	38-88	.897
BMI	30.1	19.2-55.3	30.1	19.5-51.8	.619
LOS	1.9	0-6	1.7	1-5	.017
Race (% white)	93.3		88.3		.079
Gender (% males)	44.1		44.5		.928

BMI, body mass index; LBUP, liposomal bupivacaine; LOS, length of stay; PAI, periarticular injection.