Single-Level Unilateral Biportal Endoscopic versus Tubular Microdiscectomy: Comparing Surgical Outcomes and Opioid Consumption

Yixuan Tong, Samuel Ezeonu, Yong H. Kim, Charla R. Fischer

■ BACKGROUND: **Unilateral biportal endoscopic (UBE) microdiscectomy is an emerging minimally invasive surgery technique for treating symptomatic lumbar disc herniation. There is limited literature regarding outcomes. Here, we assess surgical outcomes and pain medication consumption for UBE vs. tubular lumbar microdiscectomy.**

■ METHODS: **This was a retrospective cohort study of adult patients undergoing primary, single-level UBE or tubular lumbar microdiscectomy surgery at a high-volume institution between 2018 and 2023. Variables of interest included operative time, complications and reoperations, as well as postoperative opioid and nonopioid pain medication consumption from discharge to 6 months. Opioid consumption was converted to morphine milligram equivalents. Standard statistical analyses were performed for comparative analyses.**

■ RESULTS: **One hundred two patients—48 UBE and 54 tubular—were included. Average operative time (minutes) was higher for UBE patients (133.1 UBE vs. 86.6 tubular, $P < 0.001$), which trended downward over time but did not reach statistical significance ($P = 0.07$). There were no differences in complication or reoperation rates. Average daily MME was lower from discharge to 2-week follow-up in the UBE group (11.1 v. 14.1, $P = 0.02$), but were comparative thereafter. Nonopioid medication prescription was lower in the UBE cohort from discharge to 2 weeks (70.8% vs. 92.6%, $P = 0.01$) and 2 to 6 weeks (52.1% vs. 85.2%, $P < 0.001$), with no significant differences thereafter.**

■ CONCLUSIONS: **UBE microdiscectomy is associated with longer operating times. Both opioid and nonopioid pain medication consumption were lower for UBE patients during the initial postoperative period, perhaps owing to the less-invasive nature of the surgery.**

INTRODUCTION

The development of minimally invasive surgery (MIS) techniques was a major advancement in the field of spine surgery. Introduced in 1977, MIS lumbar discectomy surgery to treat symptomatic herniated discs aims to reduce procedural morbidity via smaller incisions and greater preservation of the paraspinous structures.[1-4] Tubular microdiscectomy is one popular MIS technique that involves the use of serial dilators for visualization of the pathology.[1,4,5] Prior literature has shown superior postoperative pain scores, shorter hospital stays and recovery time, and lower postoperative narcotic requirements when compared to traditional open microdiscectomy surgery.[6-11]

Fully endoscopic spine surgery is emerging as an innovative alternative to previous MIS techniques. Specifically, unilateral biportal endoscopy (UBE) is a novel technique for treatment of lumbar stenosis and disc herniation[12-14] that involves placement of same-sided viewing and working endoscopic portals for augmented visualization and flexibility. Theoretically, UBE technique would preserve more osseous and muscular structures compared to open and tubular approaches.[15] In fact, recent literature has reported improved pain and disability scores for UBE technique when compared to tubular technique for treatment of single-level

Key words
- Microdiscectomy
- Minimally invasive spine surgery
- MIS
- MLD
- UBE
- Unilateral biportal endoscopic decompression
- Tubular microdiscectomy

Abbreviations and Acronyms
BMI: Body mass index
MIS: Minimaly invasive surgery
MME: Morphine milligram equivalents
NSAIDs: Nonsteroidal anti-inflammatory drugs
UBE: Unilateral biportal endoscopy

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lumbar stenosis,[16] however patient-reported outcomes are largely comparable between UBE, tubular, and open techniques thus far for treatment of lumbar disc herniations.[17,18]

While the use of UBE has shown early potential, there is still a paucity of literature that compares its effectiveness to other MIS techniques, particularly when assessing patterns in postoperative pain medication use. Hence, in this study, we aimed to compare the surgical outcomes of UBE versus tubular microdiscectomy and to provide a robust comparison of postoperative pain medication consumption.

MATERIALS AND METHODS

Patient Population

This was a retrospective cohort study of adult patients who underwent primary, elective, single-level UBE or tubular lumbar microdiscectomy surgery at a single tertiary academic institution between 2018 and 2023. All UBE cases were consecutive cases, and all microdiscectomy procedures and follow-up clinical visits were completed by experienced orthopedic spine surgeons. Patients were excluded if they had previously undergone surgery at the same lumbar level or underwent additional procedures at the same or additional levels during the same surgical event. Institutional review board approval was obtained prior to beginning the study.

Surgical Technique and Perioperative Protocol

Patients underwent either tubular or UBE microdiscectomy based upon surgeon's preference. Two board-certified orthopedic spine surgeons performed UBE procedures at our institution, and 3 surgeons performed the tubular procedures. For each type, there were neither significant variations in surgical technique nor in perioperative protocol. Intraoperatively, standard anteriorposterior and lateral fluoroscopy imaging were used to confirm correct operative level and positioning of key instrumentation in both techniques. Postoperatively, all patients were recommended to the same multimodal, opioid-sparing regimen. They also were advised to avoid strenuous activity in the initial postoperative period, as well as referred to physical therapy and counseled on lifestyle modifications to sustain long-term benefits. Standard postoperative follow-up visits were conducted.

Table 1. Overview of Patient Demographics for the UBE and Tubular Cohorts

	UBE	Tubular	*P*-Value
Age (years)	46.0 ± 18.2 (std)	45.5 ± 16.0	0.88
Gender (# female)	22 (45.8%)	28 (51.9%)	0.68
BMI (kg/m^2)	25.7 ± 26.7	28.7 ± 51.3	0.02*
Smoking Status	5 (10.4%)	11 (20.4%)	0.27
CCI	0.38 ± 0.32	0.41 ± 0.62	0.81
ASA class	1.81 ± 0.33	1.98 ± 0.40	0.16

UBE, Unilateral Biportal Endoscopic; std, standard deviation; BMI, Body Mass Index; CCI, Charlson Comorbidity Index; ASA, American Society of Anesthesiologists.
*$P < 0.05$.

Table 2. Overview of Surgical Variables for the UBE and Tubular Cohorts

	UBE	Tubular	*P*-Value
Preop Diagnoses*			
HNP	48 (100%)	54 (100%)	1.0
Radiculopathy	48 (100%)	51 (94.4%)	0.10
Stenosis	13 (27.1%)	14 (25.9%)	0.93
DDD	9 (18.8%)	11 (20.4%)	0.95
DSPL	1 (2.08%)	1 (1.85%)	0.53
Operative Level	-	-	0.93
L1/L2	0 (0%)	0 (0%)	1.0
L2/L3	1 (2.08%)	1 (1.85%)	0.53
L3/L4	6 (12.5%)	9 (16.7%)	0.55
L4/L5	18 (37.5%)	18 (33.3%)	0.66
L5/S1	23 (47.9%)	26 (48.1%)	0.98
Operative time (minutes)	133.1 ± 40.5	86.6 ± 26.5	< 0.001†
LOS (days)	0.47 ± 0.33	0.54 ± 0.53	0.41
Intraop complication	0 (0%)	2 (3.70%)	0.53
Comments	-	2 durotomies	-
Postop complication	1 (2.08%)	5 (9.26%)	0.26
Comments	1 synovial cyst	4 recurrent HNPs	-
Reop rate	0 (0%)	4 (7.41%)	0.16
Days to reop	-	10.7 ± 1698	-

UBE, Unilateral Biportal Endoscopic, Preop, Pre-operative, HNP, Herniated Nucleus Pulposus, DDD, Degenerative Disc Disease, DSPL, Degenerative spondylolisthesis, LOS, Length of stay, Intra-Op, Intra-operative, Post-Op, Post-operative, Reop, Reoperation.
*Patients may carry more than one preoperative diagnosis.
†$P < 0.05$.

Data Collection

The patient electronic medical record system from our institution (Epic Caboodle. Version 15; Verona, Wisconsin) was utilized to collect data regarding patient demographic variables, surgical variables, and postoperative pain medication consumption.

Patient demographic variables included age at time of surgery, gender, body mass index (BMI, kg/m^2), smoking status, medical comorbidities, and American Society of Anesthesiologists classification score. Surgical variables included preoperative diagnosis, operative level (L1/L2 through L5/S1), operative time (minutes), hospital length of stay (days), intraoperative and postoperative complications, as well as reoperation rates. Preoperative diagnosis was subdivided into herniated nucleus pulposus, radiculopathy, spinal stenosis, degenerative disc disease, and degenerative spondylolisthesis.

Postoperative pain medication type, dosage, and duration were recorded for each patient across 4 time intervals: from discharge to 2 weeks, 2 weeks to 6 weeks, 6 weeks to 3 months, and 3 months to 6 months follow-up. Both opioid and nonopioid pain medication prescriptions were recorded. Pain medications were

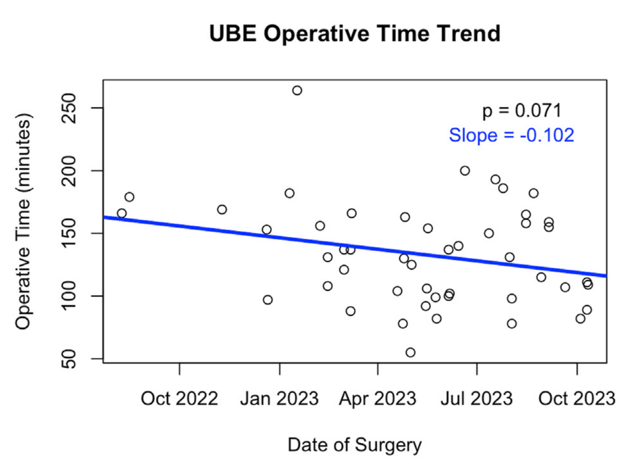

Figure 1. Operative times for UBE procedures, ordered chronologically. UBE, unilateral biportal endoscopy.

prescribed only by the patient's spine surgeon or pain management physician. Opioid consumption was converted to total morphine milligram equivalents (MME) to standardize further data analyses.[19]

Data Analysis

Patients were divided into the UBE and tubular cohorts for data analysis. Continuous variables were represented as means with standard deviations, and categorical variables were represented as frequencies with percentages. Statistical differences between the 2 cohorts for continuous variables were evaluated using independent sample t-tests and multivariate analysis of variance tests, and differences in categorical variables were evaluated using chi-squared (χ^2) tests. For operative times in the UBE cohort in particular, linear regression analysis was utilized to evaluate for a significant trend over time. P-values less than 0.05 were considered statistically significant. All patient data were organized and collected using Microsoft Excel software (Microsoft Corporation, Redmond, Washington). All statistical analyses were performed using SPSS Statistics (IBM, Armonk, New York, USA).

RESULTS

One hundred two patients were included in the study, with 48 consecutive patients in the UBE cohort and 54 patients in the tubular cohort. With respect to patient demographic variables, there were no statistically significant differences in patient age, gender, smoking status, Charlson Comorbidity Index score, or American Society of Anesthesiologists class between the 2 cohorts (Table 1). The only exception was average BMI, which was significantly lower in the UBE cohort (25.7 kg/m^2 UBE v. 28.7 kg/m^2 tubular, $P = 0.02$). With respect to surgical outcome variables, there were no significant differences in preoperative diagnoses, operative level, hospital length of stay, intraoperative or postoperative complications, or reoperation rates between the 2 cohorts (Table 2). Of note, average operative time was significantly higher in the UBE cohort (133.1 minutes UBE vs. 86.6 minutes tubular, $P < 0.001$). Operative times in the UBE cohort chronologically decreased over time but did not reach statistical significance ($r = 0.26$, slope $= -0.10$, $P = 0.07$) (Figure 1).

Table 3. Postoperative Opioid Pain Medication Consumption Patterns Across Four Time Intervals

	UBE	Tubular	*P*-Value
Comparison of Opioid Consumption in MME Between Cohorts			
Average Daily MME			
Discharge to 2 weeks	11.1 ± 5.60	14.1 ± 6.86	0.02*
2 weeks to 6 weeks	0.13 ± 0.73	1.70 ± 7.94	0.16
6 weeks to 3 months	0	0.81 ± 4.02	0.15
3 months to 6 months	0	0.03 ± 0.24	0.32
ANOVA *P*-value	< 0.001*	< 0.001*	-
Percentage of Patients with Opioid Prescriptions			
Discharge to 2 weeks	45 (93.8%)	53 (98.1%)	0.25
Oxycodone	44 (91.7%)	50 (92.6%)	0.86
Hydromorphone	0 (0%)	3 (5.55%)	0.09
Hydrocodone	1 (2.08%)	0 (0%)	0.29
Tramadol	0 (0%)	4 (7.40%)	0.054
Morphine	0 (0%)	0 (0%)	1.0
2 weeks to 6 weeks	2 (4.17%)	8 (14.8%)	0.07
Oxycodone	2 (4.17%)	3 (5.55%)	0.75
Hydromorphone	0 (0%)	1 (1.85%)	0.34
Hydrocodone	0 (0%)	1 (1.85%)	0.34
Tramadol	0 (0%)	2 (3.70%)	0.18
Morphine	0 (0%)	1 (1.85%)	0.34
6 weeks to 3 months	0 (0%)	4 (7.40%)	0.054
Oxycodone	0 (0%)	1 (1.85%)	0.34
Hydromorphone	0 (0%)	0 (0%)	1.0
Hydrocodone	0 (0%)	1 (1.85%)	0.34
Tramadol	0 (0%)	2 (3.70%)	0.18
Morphine	0 (0%)	1 (1.85%)	0.34
3 months to 6 months	0 (0%)	1 (1.85%)	0.34
Oxycodone	0 (0%)	1 (1.85%)	0.34
Hydromorphone	0 (0%)	0 (0%)	1.0
Hydrocodone	0 (0%)	0 (0%)	1.0
Tramadol	0 (0%)	0 (0%)	1.0
Morphine	0 (0%)	0 (0%)	1.0

UBE, Unilateral biportal endoscopic; MME, morphine milligram equivalent; ANOVA, analysis of variance.
*$P < 0.05$.

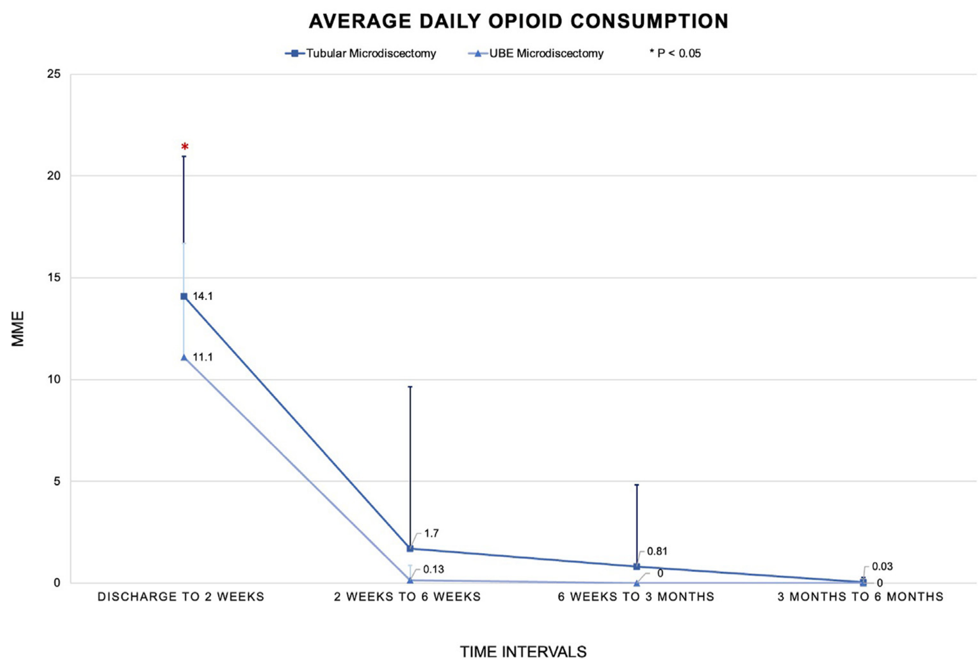

Figure 2. Average daily opioid consumption for UBE versus tubular cohorts, divided by 4 time intervals. UBE, unilateral biportal endoscopy.

With respect to postoperative pain medication prescription (Table 3), opioid consumption significantly decreased over time within both cohorts (Figure 2). Patients who underwent UBE microdiscectomy consumed on average 11.1 daily MMEs from discharge to 2-week follow-up, 0.13 average daily MMEs from 2 to 6 weeks, and 0 MMEs from six weeks to three months and three months to 6 months follow-up ($P < 0.001$). Similarly, average daily MME for patients who underwent tubular microdiscectomy decreased from 14.1 to 1.70, then 0.81, and then 0.03 over the 4 time intervals ($P < 0.001$). When comparing between the 2 cohorts, average daily MME was significantly lower from discharge to 2-week follow-up in the UBE cohort (11.1 UBE vs. 14.1 tubular, $P = 0.02$). However, there were no significant differences in the time intervals thereafter. Prescribed opioid medications included oxycodone, hydromorphone, hydrocodone, tramadol, and morphine, with a similar proportion of opioid agents prescribed at all-time points.

For nonopioid pain medication prescriptions (Table 4), common medications included acetaminophen, various nonsteroidal anti-inflammatory drugs (NSAIDs) such as meloxicam and ibuprofen, gabapentin or pregabalin, and various muscle relaxants and steroid agents. Overall, a smaller proportion of patients in the UBE group were prescribed nonopioid medications from discharge to 2 weeks (70.8% UBE v. 92.6% tubular, $P = 0.01$) and 2 weeks to 6 weeks (52.1% UBE vs. 85.2% tubular, $P < 0.001$) follow-up, with no further differences thereafter (Figure 3). More specifically, a smaller proportion of patients in the UBE cohort were prescribed acetaminophen (18.8% UBE vs. 37.0% tubular, $P = 0.04$), NSAIDs (41.7% UBE vs. 64.8% tubular, $P = 0.02$), and muscle relaxant medication (18.8% UBE vs. 61.1% tubular, $P < 0.001$) from discharge to two weeks as well as from 2 weeks to 6 weeks (acetaminophen 4.17% UBE vs. 16.7% tubular, $P = 0.04$; NSAIDs 27.1% UBE vs. 64.8% tubular, $P < 0.001$; muscle relaxants 12.5% UBE vs. 46.3% tubular, $P < 0.001$). Although there were no overall differences between cohorts at later time intervals, UBE patients were prescribed less gabapentin/pregabalin from 6 weeks to 3 months (4.17% UBE vs. 24.1% tubular, $P < 0.01$) and from 3 months to 6 months (0% UBE v. 9.26% tubular, $P = 0.03$).

DISCUSSION

In recent years, unilateral bilateral endoscopy has emerged as a promising MIS alternative to already established techniques (e.g. tubular microdiscectomy) for treating lumbar disc herniations and spinal stenosis pathology. For treatment of lumbar disc herniations in particular, UBE has been shown to be noninferior to tubular microdiscectomy in areas such as surgical complications, hospital length of stay, blood loss, and operative time.[18,20] UBE technique was also reported to yield comparable patient-reported pain and disability scores for up to 6 months following surgery.[18,20] Our study results are consistent with previous findings demonstrating comparable clinical outcomes. In fact, when compared to results from a systematic review by Lin et al. 2019, our UBE complication rates and hospital length of stay were lower by approximately 7% and 3 days, respectively.[21] However, UBE procedures in our cohort took significantly

Table 4. Postoperative Nonopioid Pain Medication Consumption Patterns Across 4 Time Intervals

	UBE	Tubular	*P*-Value
Discharge to 2 weeks	34 (70.8%)	50 (92.6%)	0.01*
Acetaminophen	9 (18.8%)	20 (37.0%)	0.04*
NSAIDs	20 (41.7%)	35 (64.8%)	0.02*
Gabapentin/pregabalin	10 (20.8%)	15 (27.8%)	0.42
Muscle relaxant	9 (18.8%)	33 (61.1%)	<0.001*
Steroid	8 (16.7%)	16 (29.6%)	0.12
2 weeks to 6 weeks	25 (52.1%)	46 (85.2%)	<0.001*
Acetaminophen	2 (4.17%)	9 (16.7%)	0.04*
NSAIDs	13 (27.1%)	35 (64.8%)	<0.001*
Gabapentin/pregabalin	10 (20.8%)	17 (31.5%)	0.22
Muscle relaxant	6 (12.5%)	25 (46.3%)	<0.001*
Steroid	2 (4.17%)	6 (11.1%)	0.19
6 weeks to 3 months	13 (27.1%)	21 (38.9%)	0.21
Acetaminophen	0 (0%)	0 (0%)	1.0
NSAIDs	6 (12.5%)	10 (18.5%)	0.40
Gabapentin/pregabalin	2 (4.17%)	13 (24.1%)	<0.01*
Muscle relaxant	5 (10.4%)	7 (13.0%)	0.69
Steroid	1 (2.08%)	6 (11.1%)	0.07
3 months to 6 months	3 (6.25%)	9 (16.7%)	0.10
Acetaminophen	0 (0%)	0 (0%)	1.0
NSAIDs	1 (2.08%)	4 (7.41%)	0.21
Gabapentin/pregabalin	0 (0%)	5 (9.26%)	0.03*
Muscle relaxant	2 (4.17%)	3 (5.56%)	0.75
Steroid	1 (2.08%)	0 (0%)	0.29

Patients are often prescribed more than one nonopioid pain medication.
UBE, Unilateral Biportal Endoscopic; NSAIDs, non-steroidal anti-inflammatory drugs.
*$P < 0.05$.

longer— on average around 46 minutes longer—compared to tubular procedures. Our mean operative time of 133.1 minutes was also longer than the mean time of 79.2 minutes that was reported by Lin et al.[21] This difference is most likely due to the steep learning curve associated with UBE technique. Indeed, UBE spine surgery involves learned proficiency with different equipment and working instruments, route of approach and visualization, and operative technique, as well as training the surgical assistant and other operating room staff.[22] As evidenced by our downward trend in operative times, the learning curve for UBE technique impacted the length of surgery, however it did not seem to impact the quality of surgery given the comparable complication and reoperation rates.

Pain medication consumption served as the proxy metric for postoperative pain in this study. This method was chosen in part due to the limited patient response to pain and disability surveys at our institution. None of the patients to our knowledge were taking high-dose narcotic medications preoperatively; however, we do acknowledge that different patients have different pain tolerance thresholds, which may have influenced the results in our study. In addition to opioid prescription decreasing over time to 0 or near 0 MME at 6 months follow-up in both cohorts, prescription was significantly lower in the early period following surgery for UBE patients by an average of 3 MMEs. This decrease in opioid usage suggests that the less minimally invasive nature of the UBE surgery may be associated with less postoperative pain from the get-go, which is encouraging especially in the face of a national opioid crisis.[23] This difference may also have prevented some opioid-related adverse symptoms. In fact, Zhao et al. 2004 reported that a 3 to 4 null mg increase in opioid consumption could be associated with one additional clinically meaningful event.[24] However, investigators have also cited an absolute reduction of 10 MMEs in the first 24 hours following surgery as the minimally important difference threshold,[25] yet this value

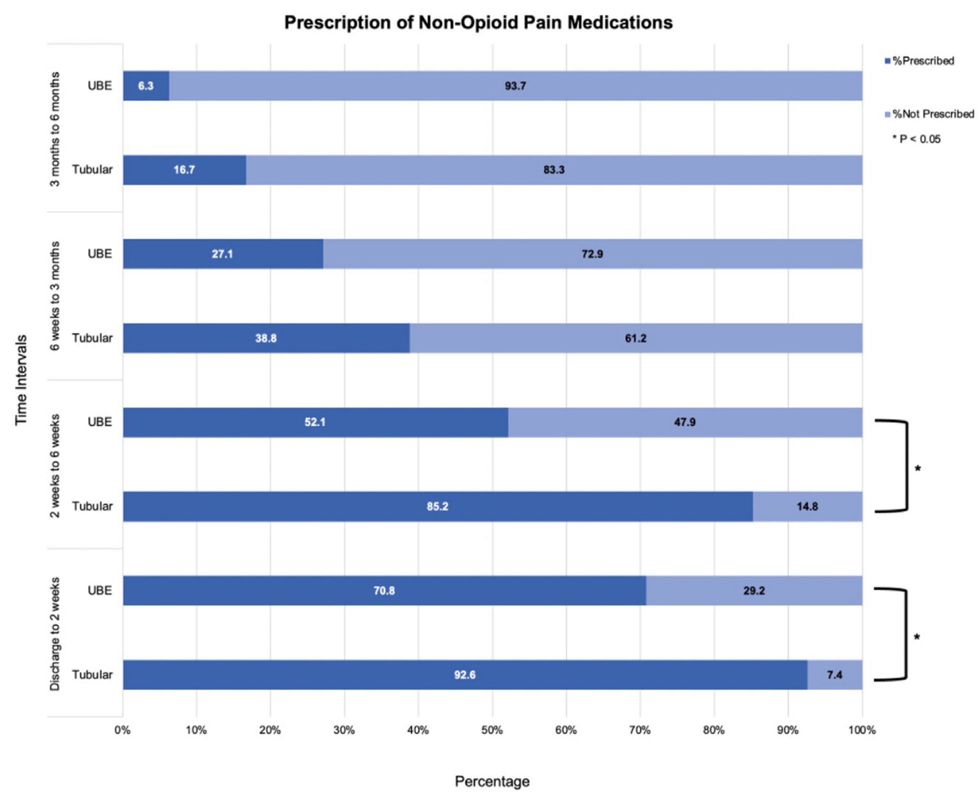

Figure 3. Prescription of nonopioid pain medications across 4 time intervals in the UBE versus tubular cohorts. UBE, unilateral biportal endoscopy.

would have been difficult to obtain with our retrospective study design, as most patients were discharged to home on postoperative day 0. Nevertheless, it has been shown previously that postoperative opioid prescription of less than 225 MMEs per week was associated better patient-reported outcome scores and less 90-day opioid dependency for elective spine procedures[26]; both patient cohorts in this study had less than 200 weekly MMEs of prescribed opioid medications at any time point, which bodes well for patient satisfaction.

Moreover, prescription of nonopioid pain medications decreased over time, with less than 20% of patients in either cohort requiring prescriptions at 3 to 6 months postoperatively. Similar to the trend in opioid medication prescription, a significantly smaller proportion of UBE patients were prescribed nonopioid pain medications of any type in the discharge to 2-week postoperative period, as well as from 2 to 6 weeks follow-up time period. This difference appears to be mainly driven by a decrease in prescription of acetaminophen, NSAIDs, and muscle relaxant agents when compared to the tubular patient cohort. Indeed, the efficacy of a multimodal approach to pain control in spine surgery has already been demonstrated.[27] The fact that both opioid and nonopioid pain prescriptions decreased in the UBE cohort during the early postoperative period indicates that the UBE procedure may be more pain sparing. There could also be an associated "ceiling effect." That is, there may be limited "room" to begin with for further decreasing pain medication consumption for such minimally invasive procedures.

Physicians must prioritize identifying effective strategies for enhancing pain management, as uncontrolled pain not only poses physical burdens but also carries significant financial implications. While both MIS techniques of UBE and tubular microdiscectomy are designed to reduce iatrogenic injury, patients still can experience significant back pain requiring intervention. A systematic review in 2008 assessing the health resource utilization of lower back pain in the US and internationally reported an economic burden as high as $624.8 billion, with 13% allocated to prescription pharmaceutical costs.[28] Moreover, Weir et al. 2017[29] in a study that tracked healthcare costs following lumbar surgery in the UK, found that persistent postoperative back pain was associated with a three-fold increase in drug prescription costs. Considering the additional financial toll brought on by pain medications, the findings of our study imply that UBE may not only facilitate reduced pain but also provide greater cost-benefit by relieving patients of further postdischarge pain requirements.

Finally, this study had several limitations. First, as there are a limited number of spine surgeons who perform the UBE and tubular procedures at our institution, our patient sample size was limited, with associated patient selection bias. We plan to continue following patients who receive both types of surgeries, and particularly the UBE procedure, in order to obtain a larger study population, greater effect size, and longer time outcome data. Regardless, we believe that our patient cohorts in this study were sufficiently similar to each other (Table 1) so as to not have influenced our primary outcomes. We believe that, with the exception of BMI, there were no statistically or clinically significant differences. Yet the higher average BMI for the tubular cohort may be a confounding variable here; there is some evidence that higher pain sensitivity in obese individuals.[30] Although average BMI is not in the obese range, a confounding effect should still be considered here.

A future study that includes both patient-reported pain scores as well as postoperative pain medication prescription would aim to bridge the gap between patients' need for pain control and the actual amount of medication prescribed. Indeed, there are a limited number of conclusions that can be drawn from a retrospective study. The decision to adopt one MIS technique over another continues to largely depend on surgeon comfort and proficiency as well as institutional or cost-related constraints. As the UBE procedure continues to become established, a future prospective and/or randomized controlled trial would provide an even more robust comparison of existing MIS techniques, such as UBE versus tubular microdiscectomy.

CONCLUSIONS

UBE microdiscectomy is associated with longer operating times. Operative times trended downward over time, suggesting a learning curve with the newer UBE technique. Otherwise, clinical outcomes for UBE vs. tubular microdiscectomy were comparable, as is consistent with previously published literature. There is lower opioid and nonopioid pain medication consumption for UBE patients in the early postoperative period, which may be attributed to the less-invasive nature of the UBE surgery. Pain medication consumption is comparable thereafter, and pain medication requirement overall is minimal at 6 months follow-up.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Yixuan Tong: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Samuel Ezeonu:** Data curation, Project administration, Resources, Writing – original draft. **Yong H. Kim:** Conceptualization, Supervision, Validation, Writing – review & editing. **Charla R. Fischer:** Conceptualization, Methodology, Resources, Supervision, Writing – review & editing.

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