Original Article

The effects of paravertebral nerve blockade on post-operative pain for patients undergoing simultaneous autologous rib grafting and orthognathic surgery: a retrospective pilot study

Andrew Robert Emery[1], Hao Deng[2], Qing Yang[3], Ariel Mueller[2], Timothy Houle[2], Jingping Wang[2]

[1]Department of Oral and Maxillofacial Surgery, Massachusetts General Hospital, Boston, MA, USA; [2]Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital, Boston, MA, USA; [3]Department of Anesthesiology, St. John's Hospital, Springfield, IL, USA

Contributions: (I) Conception and design: AR Emery, J Wang, Q Yang; (II) Administrative support: A Mueller, T Houle; (III) Provision of study materials or patients; None; (IV)Collection and assembly of data: AR Emery, H Deng; (V) Data analysis and interpretation: AR Emery, H Deng; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Jingping Wang, MD, PhD. Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital, 55 Fruit Street, GRB 444, Boston, MA 02114, USA. Email: jwang23@mgh.harvard.edu.

Background: Autologous costochondral grafts (CCG) are used for reconstructing the temporomandibular joint (TMJ) during orthognathic surgery. However, rib donor site pain often necessitates opioids for pain control. Paravertebral blocks (PVB) anesthetize multiple dermatomes thus necessitating fewer opioids after thoracic and breast surgeries. Given the paucity of oral and maxillofacial surgery (OMFS) literature describing PVB for CCG harvesting, we hypothesized that preoperative PVB would decrease opioid consumption following orthognathic surgery.

Methods: This retrospective cohort comprised patients who underwent orthognathic surgery with CCG between 1/1/2016 and 12/31/2020 and were organized into preoperative PVB and non-PVB groups. The primary and secondary outcomes were total morphine equivalent dose (MED) of opioids in the perioperative anesthesia care unit (PACU)/intensive care unit (ICU) and at 24 and 48 h post-operatively; pain scores in the PACU and at 24 and 48 h post-operatively; and hospital length of stay (LOS). Means and standard deviations (SDs) or medians, 25^{th}/75^{th} percentiles, and standardized mean differences (SMD) percentiles were used for descriptive stats. *T*-test, Wilcox test, Chi-square tests and Fishers' exact tests were performed.

Results: Our cohort totaled 19 patients with 13 in the non-PVB group and 6 in the PVB group. Comparing the non-PVB to PVB group, the median MED was 6.00 *vs.* 7.60 [95% confidence interval (CI): −16.24 to 11.72] for PACU/ICU stays, 17.00 *vs.* 14.89 (95% CI: −12.11 to 13.76) for 24 h post-operatively, and 26.53 *vs.* 30.64 (95% CI: −17.28 to 17.78) for 48 h post-operatively. The median pain score on a 0–10 point numerical rating scale (NRS) was 4.0 *vs.* 3.0 (95% CI: −1 to 5) for the PACU, 4.5 *vs.* 4.0 (95% CI: −1.68 to 5.00) for 24 h post-operatively, and 5.0 *vs.* 4.0 (95% CI: −1.98 to 5.49) for 48 h post-operatively. The median hospital LOS in h was 78.20 *vs.* 77.55 (95% CI: −24.7 to 21.9) and the median post-operative LOS was 64.40 *vs.* 65.05 (95% CI: −24.1 to 19.4).

Conclusions: This is a negative pilot study demonstrating no statistically significant difference in MED, pain scores, or LOS between preoperative PVB and non-PVB groups undergoing orthognathic surgery with CCG.

Keywords: Paravertebral block (PVB); costochondral graft (CCG); orthognathic surgery; oral and maxillofacial surgery (OMFS)

Received: 07 July 2022; Accepted: 22 December 2022; Published: 30 December 2022.

doi: 10.21037/joma-22-23

View this article at: https://dx.doi.org/10.21037/joma-22-23

Introduction

Background

Orthognathic surgery is performed around the world to correct and restore anatomy and function to a person's jaw. Depending on the specific indication for surgery, such as asymmetry or jaw pathology, it may be necessary to also reconstruct one or both temporomandibular joints (TMJ), either with artificial prostheses or transplanted tissue from the patient's own body (1). Patients who are not yet done growing are often recommended for autogenous grafts, specifically costochondral grafts (CCG), as this type of graft contains a bony rib segment and a cartilaginous cap that allows for continued growth as the patient's mandible and skeleton continue to mature (2-6). However, unlike allografts that do not require a second surgical site, autologous CCG are plagued by donor site pain (7) that frequently leads to opioid administration for pain control.

In other surgical specialties that operate around the chest wall, such as cardiothoracic and breast surgery, regional anesthesia techniques have been developed for improving surgical site analgesia, including erector spinae plane blocks, pectoral nerve blocks, serratus anterior plane blocks, and transverse thoracic plane blocks (8). Currently, the most common regional blocks for chest wall surgery are paravertebral blocks (PVB) and intercostal nerve blocks (INB) (8,9). A key differentiating factor between these two methods is that unlike INBs which require injecting multiple different anatomic levels (10), PVBs can anesthetize multiple spinal nerves and thus multiple dermatomes with a single injection, which several studies suggest provides superior and longer-lasting analgesic effects (11-13). Also, unlike thoracic epidural analgesia (TEA), PVB have a lower risk hypotension in cases where vasopressor and fluid administration could lead to worse outcomes (14). Fortunately, better post-operative pain control with preoperative regional anesthesia techniques has reduced post-operative opioid consumption for chest wall surgery, such as thoracic and breast surgeries (10).

Highlight box

Key findings

- This was a negative pilot study showing no statistically significant difference in MED, pain scores, or LOS between patients who received a PVB preoperatively for CCG donor site pain, versus those who did not, prior to orthognathic surgery.

What is known and what is new?

- Literature previously demonstrated that PVB decreases post-operative opioid use and pain in chest wall surgery.
- This is the first pilot study in OMFS literature investigating the role of PVB for CCG donor site pain in orthognathic surgery.

What is the implication, and what should change now?

- Although our results were not statistically significant, we have identified many areas of interest for future research to focus on to better assess the analgesic potential of PVB for CCG donor site pain following orthognathic surgery.

Rationale and knowledge gap

Despite evidence favoring regional anesthesia for thoracic surgical site pain, there are few studies investigating it for primary head and neck surgeries. One study in the *Plastic and Reconstructive Surgery* literature (7) described placement of a bupivacaine infusion catheter within costal cartilage donor sites prior to wound closure to reduce pain over the first 48 h post-operatively. However, this study did not perform PVB, nor did it evaluate for the effects of regional anesthesia on opioid consumption. In much the same way, there is a lack of maxillofacial surgery literature describing regional analgesia or PVB for CCG harvesting during orthognathic surgery.

Objective

As such, the objective of this pilot study was to test the hypothesis that preoperative PVB would decrease post-operative opioid consumption by better pain control at the CCG donor site following orthognathic surgery. This study also aimed to assess for the effects of PVB on postoperative pain scores and hospital length of stay (LOS). We present the following article in accordance with the STROBE reporting checklist (available at https://joma.amegroups.com/article/view/10.21037/joma-22-23/rc).

Methods

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional board of Massachusetts General Hospital (No. #2020P002222) and individual consent for this retrospective analysis was waived.

Study design

To address the research aims, the study was designed as a single-center, retrospective cohort chart review in a large

urban teaching hospital with oral and maxillofacial surgery (OMFS) and anesthesia residency programs. Exemption for the study was granted by Institutional Review Board (protocol #2020P002222) at Massachusetts General Hospital, Boston, MA, USA.

Study sample

This study included all patients who were 16 years of age and older that underwent orthognathic surgery with simultaneous unilateral autologous CCG harvesting for mandibular condyle reconstruction between 1/1/2016 and 12/31/2020. All orthognathic and rib harvest surgeries were performed by oral and maxillofacial surgeons within a single department at the hospital where patients were treated. Eligible patients were identified by querying the electronic medical records using Current Procedural Terminology (CPT) codes. In addition, Structured Query Language (SQL) and procedure display names were also used to identify potential cases, which included the following: "costochondral graft", "rib graft", "autograft", "autogenous", and "autologous". CPT codes used to identify potential cases included: [21194], [21195], [21242], and [21247]. The study's inclusion criteria were as follows: orthognathic surgery involving removal of one or both mandibular condyles and replacement with autologous costochondral rib grafts. Patients were excluded if they were younger than 16 years old to prevent enrolling patients who were too young to consistently report numerical pain scores. Patients who received a preoperative PVB were retrospectively identified as the exposure group, and those who did not receive a preoperative PVB were identified as the control group.

PVBs were performed in the pre-operative holding area by the regional anesthesia team which consisted of an anesthesia resident and an anesthesia attending, utilizing ultrasound guidance and mild conscious sedation. For each PVB, the patient was placed in the prone position and an ultrasound was used to visualize the paravertebral space in the coronal plane, bound by the transverse process, pleura, and intercostal membrane. A needle was then inserted from lateral to medial via an in-plane approach. Using hydro-dissection and direct visualization, the needle position was confirmed to be in the paravertebral space. After negative aspiration, local anesthetic was injected incrementally in 3 cc aliquots for a total of ~20 cc. The spread of local anesthesia can be seen on ultrasound up to 1–2 levels above and below the site of the injection, and depression of the pleura was both visualized and confirmed by a supervising anesthesiologist. Patients who also had PVB catheters placed then had their catheters advanced over the needle which was then withdrawn, catheter secured, and the position of the catheter confirmed with normal saline visualization on the ultrasound screen. Our institutional protocol is to confirm each regional block location by ultrasound visualization of anesthetic solution spreading in the appropriate location and plane along with cold testing (i.e., using an alcohol swab) before the patient is brought into the operating room (OR). Pinprick test was usually not done, but patients often also reported subjective sensation of numbness across the dermatomes at the side of the chest and back.

Study outcomes, exposures, and confounders

Demographic information included patient age, gender, race, American Society of Anesthesiology (ASA) Physical Status Classification, height, weight, and body mass index (BMI). The primary study outcome was median opioid consumption in morphine equivalent dose (MED) in the perioperative anesthesia care unit (PACU) prior to meeting PACU discharge criteria. The secondary study outcomes were 24- and 48-h postoperative opioid consumption in MED, self-reported pain scores on a 0–10 numerical rating scale (NRS; i.e., where 0 is no pain and 10 is the worst pain possible), and post-operative versus total hospital LOS. Nursing in the PACU, intensive care unit (ICU), and on the recovery floors followed the NRS for assessing and administering pain medication, such that patients who reported pain scores of 1–3 (i.e., mild pain) received tylenol and non-steroidal anti-inflammatory medications (NSAIDs) such as ibuprofen or ketorolac, patients who reported scores of 4–6 (i.e., moderate pain) received oral opioids such as oxycodone; and patient who reported scores of 7–10 (i.e., severe pain) received stronger opioids such as oral and intravenous (IV) morphine or hydromorphone. All opioid medications administered were extracted from the medical records and converted to MED for comparison. All collected data were then reviewed and put into tables.

Power & statistical analysis

There were no a priori power analyses performed to guide the sample size determination, and we utilized all available eligible cases within the Epic Systems Corporation (Epic) electronic health record (EHR) for analyses. Although post-

Table 1 CPT codes and associated procedure descriptors/key words

Search query	Procedure
CPT code	
21194	Reconstruction of mandibular rami, horizontal, vertical, C, or L osteotomy; with bone graft (includes obtaining graft)
21195	Reconstruction of mandibular rami and/or body, sagittal split; without internal rigid fixation
21242	Arthroplasty, temporomandibular joint, with allograft
21247	Reconstruction of mandibular condyle with bone and cartilage autografts (includes obtaining grafts)
Procedure descriptors/key words	
Costochondral graft	–
Rib graft	–
Autograft	–
Autogenous	–
Autologous	–

CPT, Current Procedure Terminology.

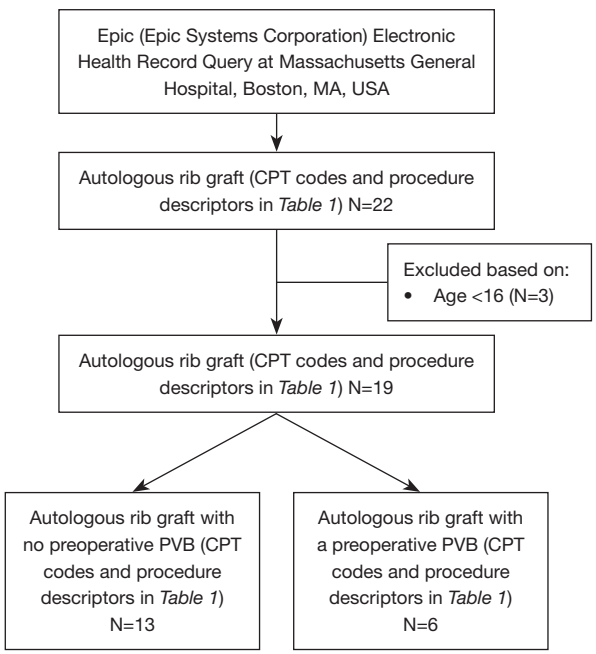

Figure 1 Flow diagram of patient selection. CPT, Current Procedure Terminology; PVB, paravertebral block.

hoc power analyses are generally not recommended, our collected study sample (N=19) would yield a study power =0.8 to detect a minimal effect size of mean difference =2.8 when comparing MED between two study groups utilizing two independent sample *t*-tests, assuming a pooled standard deviation (SD) of 3 and alpha =0.05. This detectable effect size was large and our study might be underpowered due to the limited sample size. Descriptive statistics were reported using either means and SDs or medians, $25^{th}/75^{th}$ percentile, and standardized mean differences (SMD) depending on the data distribution. Categorical variables were summarized using frequencies and percentages. Two independent sample *t*-tests or equivalent non-parametric tests (e.g., Wilcox tests, etc.) were performed to compare PVB and non-PVB groups for both primary and secondary outcomes. Chi-square tests or Fishers' exact tests were utilized. Corresponding effect sizes (e.g., bootstrapped median differences, etc.) and 95% confidence intervals (95% CI) and P values were reported for statistical significance. Alpha was set to 0.05, and no post-hoc corrections for multiplicity were performed. All analyses were performed using RStudio V2022.02 (RStudio PBC, Boston, MA, USA).

Results

A total of 22 eligible patients were identified using CPT codes and procedural descriptors (see *Table 1* and *Figure 1*). Three patients were excluded for being younger than 16 years of age leaving a final cohort of 19 patients, of which 6 patients received a preoperative PVB and 13 received no pre-operative PVB (*Table 2*).

The demographics of the groups are presented in *Table 2*. There was no statistically significant difference between

Table 2 Patient demographics for non-PVB and PVB groups

Variable	Non-PVB group (n=13)	PVB group (n=6)	P	SMD
Age (years), median [IQR]	21.00 [18.00, 30.00]	19.50 [16.75, 20.75]	0.271	0.582
Gender, n (%)				
Female	9 (69.2)	5 (83.3)	0.929	0.336
Male	4 (30.8)	1 (16.7)		
Race, n (%)				
Asian	1 (7.7)	1 (16.7)	0.246	0.740
Black or African American	0 (0.0)	1 (16.7)		
White	12 (92.3)	4 (66.7)		
ASA classification, n (%)				
1	4 (30.8)	3 (50.0)	0.767	0.400
2	9 (69.2)	3 (50.0)		
Opioid consumption in past 6 months, n (%)				
No	5 (38.5)	6 (100.0)	0.043	1.789
Yes	8 (61.5)	0 (0.0)		
Height (cm), median [IQR]	165.00 [163.00, 173.00]	166.50 [160.00, 173.75]	0.965	0.004
Weight (kg), median [IQR]	63.50 [53.52, 67.13]	58.97 [53.18, 60.67]	0.219	0.621
BMI, kg/m^2 mean (SD)	21.22 [20.19, 23.65]	20.50 [18.92, 22.00]	0.188	0.759

PVB, paravertebral block; SMD, standardized mean difference; IQR, interquartile range (25th/75th percentile); ASA, American Society of Anesthesiology; BMI, body mass index; SD, standard deviation.

the two patient groups based on age, gender, race, ASA classification, height, weight, and BMI (*Table 2*). The median age for the non-PVB group was slightly higher than for the PVB group (21.00 *vs.* 19.50 years). Patients enrolled in the study were predominantly female, consisting of 69.2% of the non-PVB group and 83.3% of the PVB group. When comparing the race of the non-PVB group to the PVB group, Whites were the most common (12 *vs.* 4), followed by Asians (1 *vs.* 1), and then Black or African American (0 *vs.* 1). All patients were assigned to either ASA class 1 or 2. Interestingly, there was a statistically significant difference in opioid consumption in the 6 months prior to surgery with 61.5% of the non-PVB patients having consumed opioids and none of the PVB patients having any documented opioid use, which was statistically significant with a P value of 0.043. Lastly, median BMI values were not statistically different between groups with values of 21.22 *vs.* 20.50 for the non-PVB group and PVB group, respectively.

Of the 6 patients who received a PVB, 3 patients had a single shot block and 3 patients had a single shot block followed by catheter placement, which were all removed by post-operative day 2 (*Table 3*). Five of the 6 patients in the PVB group and all 13 patients in the non-PVB had documentation of 0.5% lidocaine 1:200,000 epinephrine solution injected by the surgeon into and around the CCG donor, without notation of exact volumes administered. One of the patients in the PVB group had no documentation of local anesthesia given by the surgical team at the donor site. Additionally, unspecified volumes of 0.5% lidocaine 1:200,000 epinephrine were also injected by the surgeons into the tissues around the maxilla, mandible, and chin (if genioplasty performed) for all patients.

The characteristics of the different pre-operative diagnoses, surgical procedures performed, and ribs harvested are presented in *Table 4*. The median length of surgery for each of the two groups was 596.0 min for non-PVB group *vs.* 454.5 min for the PVB group, which produced a statistically non-significant difference of medians of 141.5 with a 95% CI of –92 to 223. Since some patients remained intubated after surgery in the ICU for airway watch, the median

Table 3 PVB procedures and perioperative management for each of the 6 PVB patients

Patient identifier	Location of PVB	Depth of needle insertion	Block or infusion catheter	Local anesthetic type and volume	Preop bolus volume	Intra-op infusion rate and bolus volume	Post-op infusion rate and bolus volume	Date of catheter removal
Patient #1	T5–T6	8 cm	Block and catheter	0.5% bupivicaine with 1:400k epinephrine	20 cc	None	8 cc/h of 1 mg/mL (0.1%) bupivicaine without epi	POD 2
Patient #2	T3–T4	Not documented	Block only	0.5% bupivicaine with 1:400k epinephrine	20 cc	n/a	n/a	n/a
Patient #3	T3–T4 and T6	8 cm	Block only	0.5% bupivicaine with 1:400k epinephrine	30 cc	n/a	n/a	n/a
Patient #4	T5–T6	Not documented	Block and catheter	0.5% bupivicaine with 1:400k epinephrine	10 cc	Infusion of 1 mg/mL (0.1%) bupivicaine with 1:400k epinephrine (total volume 20.83 cc) and a 15 cc bolus of 0.25% bupivicaine 1:400k epinephrine	Infusion of 10 cc/h of 0.1 mg/mL (0.1%) bupivicaine without epinephrine, which was adjusted to 8 cc/h on POD 1	POD 2
Patient #5	T5–T6	8 cm	Block and catheter	0.5% bupivicaine without epinephrine	18 cc	None	15.1 cc bolus immediately in recovery in the PACU; 8 cc/h of 0.1 mg/mL (0.1%) bupivicaine without epinephrine	POD 2
Patient #6	T4–T5	8 cm	Block only	0.5% bupivicaine with 1:400k epinephrine	20 cc	n/a	n/a	n/a

PVB, paravertebral block; POD, post-operative day; n/a, not available; PACU, perioperative anesthesia care unit.

length of intubation was also measured for each group with values of 596.0 and 499.0 min for the non-PVB group and PVB group, respectively. This resulted in a difference of medians of 97 with a 95% CI of −508 to 220, which was also not statistically significant given this range included 0. The diagnoses of the patients in the non-PVB group were most notable for 5 patients with juvenile idiopathic arthritis and 3 with degenerative arthritis, as compared to 2 patients with juvenile idiopathic arthritis and 1 patient with degenerative arthritis in the PVB group. These arthritis conditions are inflammatory in nature and may carry with them an association of chronic pain for some patients. The average number of procedures performed were also similar between groups with 4.00 procedures per person in the non-PVB group and 4.83 procedures per person in the PVB group. All patients had either 1 or 2 ribs harvested from the right anterior 5th or 6th ribs, with similar numbers of ribs harvested for each group (1.85 ribs/patient for the non-PVB group compared to 2.00 ribs/patient in the PVB group). The average length of the ribs harvested from each experimental group were essentially the same (6.78 *vs.* 6.67cm).

Tables 5,*6* describe the post-operative use of narcotics for pain control for each group of patients in the PACU or ICU and during the first 24 and 48 h after surgery. Please see *Table 7* for opioid conversion chart used to determine MED totals for each patient. Comparing the non-PVB group to the PVB group, there was no statistically significant difference in median MED requirements during PACU/ICU hours (6.00 *vs.* 7.60, 95% CI: −16.24 to 11.72), 24 h after surgery (17.00 *vs.* 14.89, 95% CI: −12.11 to 13.76), and 48 h after surgery (26.53 *vs.* 30.64, 95% CI: −17.28 to 17.78). Looking at only those patients who went to the

Table 4 Characteristics of treatments rendered for non-PVB and PVB groups

Procedure variables	Non-PVB group (n=13)	PVB group (n=6)	P	SMD
Length of surgery & intubation time (min), median [IQR]				
Length of surgery	596.0 [388.0, 622.0]	454.5 [399.8, 508.5]	0.188	0.646
Length of time spent intubated	596.0 [388.0, 622.0]	499.0 [412.5, 534.5]	0.539	0.100
Diagnosis/pathology (0 for no, 1 for yes), total sum (average per person)				
Hemifacial/craniofacial microsomia	0 (0.00)	2 (0.33)	–	–
TMJ ankylosis	0 (0.00)	2 (0.33)	–	–
Idiopathic condylar resorption of the TMJ	6 (0.46)	3 (0.50)	–	–
Idiopathic aseptic necrosis of bone of the mandibular condyle	1 (0.08)	0 (0.00)	–	–
Juvenile idiopathic arthritis of the TMJ	5 (0.38)	2 (0.33)	–	–
Degenerative arthritis of TMJ	3 (0.23)	1 (0.17)	–	–
Maxillary asymmetry or deficiency/excess (in transverse, sagittal, or vertical planes)	11 (0.85)	4 (0.67)	–	–
Mandibular asymmetry or deficiency/excess (in transverse, sagittal, or vertical planes)	11 (0.85)	4 (0.67)	–	–
Procedures performed during operation that were not rib grafts (where applicable, 0 for none, 1 for yes or unilateral, 2 for bilateral), total number of procedure performed (average procedure per person within group)				
LeFort 1 osteotomy	6 (0.46)	1 (0.17)	–	–
Mandibular sagittal split osteotomy	1 (0.08)	0 (0.00)	–	–
Genioplasty	8 (0.62)	3 (0.50)	–	–
Chin implant	0 (0.00)	1 (0.17)	–	–
TMJ condylectomy	24 (1.85)	12 (2.00)	–	–
Temporalis myofascial flap	8 (0.62)	4 (0.67)	–	–
Coronoidectomy	1 (0.08)	4 (0.67)	–	–
Number of teeth extracted	2 (0.15)	4 (0.67)	–	–
Total number of procedures per group	52 (4.00)	29 (4.83)	–	–
Rib grafts, total sum (average per person)				
Number of individual ribs harvested	24 (1.85)	12 (2.00)	–	–
Cumulative rib length harvested in centimeters	135.5 (6.78)	80.0 (6.67)	–	–

For TMJ condylectomies, myofascial flaps, coronoidectomies, and tooth extractions, a unilateral procedure was counted as 1 and bilateral procedure counted as 2. PVB, paravertebral block; SMD, standardized mean difference; IQR, interquartile range (25^{th}/75^{th} percentile); TMJ, temporomandibular joint.

PACU post-operatively, there again was no statistically significant difference in median MED values of 4.68 *vs.* 7.60 (P=0.610) for the non-PVB group and PVB group, respectively. Similarly, comparing only those patients who went to the ICU postoperatively for the non-PVB group and PVB group respectively, there was no statistically significant difference in median MED values of 18.03 *vs.* 18.05 (P=0.845). Of the 6 patients who underwent PVB, 3 had just a single shot block and 3 had catheters subsequently placed after the block was administered, which produced no statistically significant differences in median MEDs for the PACU/ICU (5.68 *vs.* 8.38, P=0.127), 24 h after surgery (11.28 *vs.* 24.32, P=0.275), or 48 h after surgery (27.50 *vs.* 38.35, P=0.275) for the PVB group with catheters *vs.* PVB

Table 5 Opioid use in MED for PACU, 24, and 48 hours post-operatively

Measurement time point	Non-PVB group	PVB group	P	SMD
n, PACU or ICU	13	6		
MED, PACU or ICU, [median IQR]	6.00 [3.35, 18.03]	7.60 [5.99, 8.34]	0.965	0.360
n, PACU	8	4		
MED, PACU, median [IQR]	4.68 [3.18, 11.83]	7.60 [6.62, 8.28]	0.610	0.483
n, ICU	5	2		
MED, ICU, median [IQR]	18.03 [4.00, 22.03]	18.05 [9.02, 27.07]	0.845	0.229
MED, 24 h, median [IQR]	17.00 [12.20, 22.03]	14.89 [9.10, 22.86]	0.759	0.394
MED, 48 h, median [IQR]	26.53 [19.50, 33.78]	30.64 [19.91, 37.21]	0.861	0.377

MED reported in milligrams of morphine. MED, morphine equivalent doses; PACU, perioperative anesthesia care unit; PVB, paravertebral block; SMD, standardized mean difference; ICU, intensive care unit; IQR, interquartile range (25^{th}/75^{th} percentile).

Table 6 Opioid use in MED for PACU, 24, and 48 hours post-operatively for PVB with catheter versus PVB without catheter

Measurement time point	PVB with catheter (n=3)	PVB without catheter (n=3)	P	SMD
MED, PACU or ICU, median [IQR]	5.68 [2.84, 6.96]	8.38 [7.66, 22.24]	0.127	1.041
MED, 24 h, median [IQR]	11.28 [5.64, 14.89]	24.32 [16.34, 28.08]	0.275	1.079
MED, 48 h, median [IQR]	27.50 [16.00, 30.64]	38.35 [27.86, 41.46]	0.275	0.775

MED reported in milligrams of morphine. MED, morphine equivalent doses; PACU, perioperative anesthesia care unit; PVB, paravertebral block; SMD, standardized mean difference; ICU, intensive care unit; IQR, interquartile range (25^{th}/75^{th} percentile).

group without catheters, respectively. Of note, there was one patient in each group who had a prolonged stay in the PACU overnight before going to the floor on post-operative day 1. Similarly, there was one patient in each group who remained intubated in the ICU until post-operative day 1 making them unable to report their pain levels to the nursing staff or request pain medication during that time.

A NRS for pain scores was used to report patient pain levels, with 0 being no pain at all and 10 being the worst pain imaginable (*Table 8*). Comparing the non-PVB group to the PVB group, the median pain scores were consistently higher, but not statistically significantly different for PACU/ICU (4.0 *vs.* 3.0, 95% CI: –1 to 5), 24 h post-operatively (4.5 *vs.* 4.0, 95% CI: –1.68 to 5.00), and 48 h post-operatively (5.0 *vs.* 4.0, 95% CI: –1.98 to 5.49).

Lastly, *Table 9* describes the median LOS for patients from hospital arrival to hospital discharge, and from the time they left the operating room until hospital discharge. Comparing the non-PVB group to the PVB group, the median overall LOS were not statistically significant (78.20 *vs.* 77.55 h, 95% CI: –24.7 to 21.9), and neither was the post-operative LOS (64.40 *vs.* 65.05 h, 95% CI: –24.1 to 19.4).

Discussion

Key findings

The purpose of this study was to provide a pilot framework for assessing the effects of preoperative PVB on post-operative opioid consumption for patients undergoing orthognathic surgery with CCG. Pain scores and LOS in the hospital were also evaluated. For all the measured outcomes, there was no statistically significant difference between the group that underwent preoperative PVB compared to the group that did not. Arguably the most notable take away from this study was the framework it established for scaling up future research on this topic and the identification areas for improvement to better assess the potential benefits of PVB.

Strengths and limitations

This study has many notable strengths allowing it to make a positive contribution to the OMFS literature, but also several limitations worth discussing, due in part to the retrospective nature of the study and pilot design.

Table 7 MED conversions

Medication	Route of administration	Class	Conversion factor
Codeine	IV/IM	Short acting	1 mg = 0.08 MED (15)
Codeine	PO	Short acting	1 mg = 0.05 MED (15)
Fentanyl	IV	Short acting	1 mg = 100 MED (15)
Hydrocodone	PO	Short acting	1 mg = 0.27 MED (15)
Hydromorphone	IV	Short acting	1 mg = 6.7 MED (15)
Hydromorphone	PO	Short acting	1 mg = 1.3 MED (15)
Meperidine	IV/IM	Short acting	1 mg = 0.13 MED (15)
Meperidine	PO	Short acting	1 mg = 0.03 MED (15)
Morphine	IV/IM	Short acting	1 mg = 1 MED (15)
Morphine	PO	Short acting	1 mg = 0.3 MED (15)
Oxycodone	PO	Short acting	1 mg = 0.45 MED (16)
OxyContin: oxycodone hydrochloride	PO	Long acting	1 mg = 0.45 MED (17)
MS Contin: morphine sulfate	PO	Long acting	1 mg = 0.3 MED (15)
Methadone	IV/IM	Long acting	1 mg = 1 MED (15)
Methadone	PO	Long acting	1 mg = 0.8 MED (15)
Nalbuphine	IV/IM	Long acting	1 mg = 0.09 MED (15)
Buprenorphine/naloxone	Transdermal patch	Long acting	1 mg = 25.38 MED (18)

IV/IM morphine equivalent dose in milligrams. MED, morphine equivalent doses; IV/IM, intravenous/intramuscular; PO, per os (i.e., "by mouth").

Table 8 Post-operative pain scores for PACU/ICU, 24, and 48 hours post-op

Measurement time point	Non-PVB group (n=13)	PVB group (n=6)	P	SMD
Pain score, PACU/ICU, median [IQR]	4.0 [3.0, 5.0]	3.0 [0.5, 4.4]	0.401	0.453
Pain score, 24 h, median [IQR]	4.5 [3.0, 6.0]	4.0 [1.0, 4.4]	0.355	0.528
Pain score, 48 h, median [IQR]	5.0 [3.0, 6.0]	4.0 [1.0, 4.0]	0.249	0.631

Pain scores are based on a 0 to 10 NRS, where 0 is no pain and 10 is the worse pain imaginable. PACU, perioperative anesthesia care unit; ICU, intensive care unit; post-op, post-operative; PVB, paravertebral block; SMD, standardized mean difference; IQR, interquartile range (25^{th}/75^{th} percentile); NRS, numerical rating scale.

Table 9 Total and post-operative LOS

Measurement time point	Non-PVB group (n=13)	PVB group (n=6)	P	SMD
Total LOS (h), median [IQR]	78.20 [55.20, 79.80]	77.55 [62.42, 79.70]	0.661	0.003
Post-operative LOS (h), median [IQR]	64.40 [44.80, 67.00]	65.05 [51.55, 69.92]	0.661	0.023

LOS, length of stay; PVB, paravertebral block; SMD, standardized mean difference; IQR, interquartile range (25^{th}/75^{th} percentile).

Strengths of this study include that it is the first study to assess PVB prior to CCG and simultaneous orthognathic surgery. As such, it provided the groundwork for future research and identified many areas for improvement, which is crucial when investigating new ideas. This study is also applicable to other surgical fields which are similar

to OMFS, such as plastic and reconstructive surgery and otolaryngology, who operate around the head and neck and also perform CCG.

Although this study provides a springboard for future research, it also has several notable limitations. One of the most obvious limitations of this study is the small sample size. Unfortunately, CCG during orthognathic surgery at our institution is relatively infrequent, which explains why only patients younger than 16 years of age were excluded and all other patients included. Given the small sample size, our study shall only be interpreted as a pilot study for the guidance of future research efforts (e.g., power analysis for sample size estimation). A larger-scale prospective study with a greater sample size (e.g., n>50), potentially utilizing a multi-center approach, would be helpful to determine any potential pain relieving benefit or opioid sparing effect PVB may have for CCG.

Another study limitation was the lack of homogeneity among procedures performed for each patient. Although all patients had to have undergone CCG and orthognathic surgery to be included, there were additional procedures that only certain patients underwent, such as chin implant, genioplasty, and dental extractions. Performing various combinations of procedures for each patient could potentially result in differing amounts of inflammation and post-operative pain. Future prospective studies should attempt to match patients based on surgical procedures to be performed to reduce confounders that can affect patient post-operative pain scores, opioid requirements, and potentially hospital LOS.

Although our study showed no statistically significant difference between the groups in terms of length of surgery, it may serve as a useful metric for future studies. Furthermore, length of surgery may be of greater importance when evaluating single shot PVB compared to catheter-based PVB since longer surgeries allow more time for the PVB block to wear off, and may lead such patients to need opioid pain medication earlier in the post-operative period.

Also, given the retrospective nature of this study, the assignment of patients to the PVB group was not protocoled leading to possible selection bias. Patients were offered PVB at the discretion of the anesthesia providers assigned to the regional anesthesia team each day. To remedy this, randomized, double-blinded protocols, utilizing either normal saline versus local anesthetic for the PVB, may be help blind the patient and provider to the treatment (i.e., true PVB or placebo PVB) being rendered. Unfortunately, however, regional anesthesia often requires patients to confirm analgesia has taken effect before going to surgery by testing various pain stimuli in the corresponding dermatomal distribution, which my ultimately preclude fully blind patients to their treatment assignment.

Additionally, the skill level of the surgical teams and anesthesia teams performing respective procedures could be standardized by restricting these roles to a select few providers. Similarly, future studies should strive to achieve consistency for when PVB infusion catheters are used or not used. For example, within the PVB group, 3 of the 6 patients had a single shot block, while 3 had a catheter placed and infused postoperatively. Given that a single shot block of 0.5% bupivacaine on average lasts 9.9 h (19), infusion through a catheter certainly has the potential to prolong the analgesic effect beyond 10 h, which complicates comparison between the two subgroups. A larger sample size would be expected to result in larger subgroup populations and better statistical comparison between groups such as single shot PVB and single shot PVB with catheter placement. Of note, local anesthesia administration via PVB infusion catheters can accumulate over time leading to systemic circulation that provides analgesic effects in the face, as well as the chest. These systemic effects would be important to acknowledge when assessing the continuous PVB group in future studies.

It is also worth highlighting the variation seen among PVB puncture locations for each patient (*Table 3*) despite all patients having ribs 5 and/or 6 harvested. Variations in the anatomic puncture locations of the PVB and the use of both single shot blocks and continuous PVB could affect the success of the PVB. Standardizing the location and type of PVB are important considerations for creating consistent and comparable treatment protocols.

Another issue was the variation in post-operative dispositions for patients. Most patients went from the PACU to the floor, while two patients stayed in the PACU overnight due to logistical issues, such as the lack of inpatient beds. The extended PACU stays of some patients in our study makes it difficult to compare their PACU times and pain scores to those of other patients on non-PACU floors, partly because of the ICU level of care that can be delivered in a PACU and more routine use of stronger opioids for pain control. Furthermore, patients who remain intubated post-operatively are often given opioids for reasons other a subjective report of pain, such as when enhancing ventilator synchrony. Similarly, patients may also be withheld opioids despite an inability to provide

verbal pain scores, such as when they are sedated with other medications and are unable to talk. Thus, recruiting sufficient numbers of patients into a study to either exclude protocol outliers or perform further subgroup analyses would help to improve the consistency and validity of the study results.

Attrition bias was also a concern given that 5 patients from the non-PVB block group were discharged prior to 48 h post-operatively (i.e., at 41.3, 44.2, 45.1, 44.8, and 43 h post-operative), compared to 2 patients from the PVB group (i.e., at 44.5 and 47.6 h). As a result of our small sample size, we were not able to exclude these patients from the study. It is possible that if all patients had stayed the full duration of the 48 h post-operatively, the median MED and pain scores may have been different between the groups. It is also true that this study was only able to look at in hospital opioid consumption, although most patients were discharged with a prescription for oral opioid that future studies may want to track to guide perioperative opioid prescribing habits.

Missing data also impacted our study. For patients with missing data, individual charts were manually searched by an OMFS provider for data points of interested that were documented in alternative locations, such as in notes. For example, when assessing the success of the PVB block, there was a lack of clear documentation for how long each PVB worked or the exact depth and location of anesthetic needle insertion, so anesthesia notes were manually searched for this information. Similarly, there was also a large variety of CPT codes used for each surgery, with many being manually modified. Many surgeries were missing the appropriate CPT codes for each procedure performed, but were ultimately identified based on searches of the procedure names or descriptions. It is important for future studies to consider multiple methods of searching electronic health records to identify eligible cases, especially given they are relatively rare in OMFS and case easily be miscoded.

Lastly, the generalizability of this study is likely limited given the resource intensive nature of these surgical procedures, which often require hospitalization, and thus are frequently referred to tertiary or quaternary referral centers such as the hospital in this study. Thus, these study results are most applicable high volume OMFS centers, likely with OMFS residency programs, that also have the resources and expertise to carry out such a procedure.

Comparison with similar research

To the best of our knowledge, this is the first study to assess PVB for CCG in patients undergoing orthognathic surgery.

Prior studies outside of OMFS have investigated CCG donor site pain during head and neck surgeries, including one study from plastic and reconstructive surgery that found less post-operative pain when harvesting split thickness costal cartilage grafts (20). Similarly, a pilot study in the otolaryngology literature described PVB for reducing CCG pain for stage 1 microtia repair. However, neither of these surgeries harvest costal bone, which is a necessary component of CCG when reconstructing the TMJ during orthognathic surgery.

Our study found no difference in MED requirements between the two groups, although other studies have found opioid reducing benefits of PVB in similar chest wall surgery (21-23). As such, there is promise that larger OMFS studies based on our design may demonstrate the beneficial role of PVB when operating around the chest wall that has been found in these other surgical specialties.

Additionally, the median hospital LOS in our study of ~3 days is comparable to literature range of ~1.2–8.5 days (24). These findings demonstrate no LOS advantage with PVB when performing CCG, a finding that was previously described for costal cartilage harvest during microtia repair (23).

Lastly, there were no known complications of PVB in our study, but other studies have reported potential complications including pneumothorax, pleural puncture, and vascular puncture (14,25). Given the risk of complications such as pneumothorax, some have advocated for only using PVB for more invasive chest wall procedures (e.g., mastectomy) and avoiding PVB for minor surgeries like lumpectomy, quadrantectomies, radiographic wire localized breast biopsies (25). The authors of this study would argue that CCG consisting of bone and cartilage removal is an invasive chest wall procedure, which would justify PVB by the aforementioned criteria. Additionally, there is a risk that the PVB will fail to provide adequate analgesia in about 6–10% of patients (14), which is equivalent to the failure rate of thoracic epidurals. However, this risk could likely be ameliorated by adequate testing of the block in the pre-operative setting or intra-operative local anesthesia administered directly at the CCG donor site.

Explanation of findings

MED

We hypothesized that patients who received a PVB preoperatively would have less pain at the rib graft donor

site post-operatively and thus require fewer opioids. However, the results of this study failed to show a statistically significant difference in the average MED for the PACU/ICU, 24 h post-operatively, and 48 h post-operatively between the PVB and non-PVB groups (see *Table 4*). Our study faced unique challenges that may have hindered getting statistically significant results. Firstly, one patient from each group remained intubated post-operatively until post-operative day 1 making them unable to participate in pain scoring in the early post-operative period to guide narcotic administration. Given the analgesic effects of some sedating medications used for intubated patients versus the occasional need for narcotics to maintain ventilator synchrony, these two patients may have falsely elevated (or lowered) the MED requirements of each group, although this potential biased is balanced between study groups. Additionally, one patient in each group stayed in the PACU overnight before going to the floor the next day. Despite nurses in the PACU and on the recovery floors using the same NRS for assessing pain, the patient population in the PACU differs from the mix of surgical and non-surgical patients on the floor, which likely influences nursing bias and threshold for selecting various pain medications. By recruiting a larger sample size, future prospective studies may dilute out such outlier patients.

It is also wise to consider the analgesic effects of non-opioid medications when evaluating opioid utilization. However, although there are published conversion factors for comparing opioids (15-18), there are no such conversion factors for non-opioid analgesics such as toradol, ibuprofen, acetaminophen, gabapentin, or ketamine. Therefore, this study was not able to control for or compare non-opioid analgesics between groups and weigh their impact on post-operative pain control. However, since most post-operative patients at our institution receive acetaminophen as a first line analgesic by convention, most patients requiring opioids were likely also receiving acetaminophen prior to or in addition to narcotics. Future studies would be wise to tightly regulate non-opioid analgesic administration to thus highlight the specific opioids needs among patients.

Pain scores

This study also assessed pain scores post-operatively in the PACU/ICU, 24 h post-operatively, and 48 h post-operatively. We hypothesized that the PVB group may have improved pain control and thus lower patient reported pain scores. This study found that pain scores were lower for the PVB compared to the non-PVB group at all time points, however, there was no statistically significant difference between the groups. One confounding factor was that pain assessment did not document the location of the pain. When considering orthognathic surgeries that also involve CCGs, patients have two surgical sites (i.e., chest and face) and may experience pain at both sites. It is thus conceivable that patients who received PVBs may have had less or more pain at the rib harvest site compared to the face, but because only a single pain score was recorded, we could not differentiate the predominant pain source.

Also, the ability to participate in pain scoring is a requisite for data collection. Our study had 1 patient in the non-PVB group and 1 patient in the PVB group that remained intubated until post-operative day 1, thus making them unable to participate in pain scoring in the early post-operative period. These patients were ultimately included in the study given the small study sample size, but future research with larger sample sizes would likely allow for such patients to be excluded thus creating more comparable treatment protocols. Similarly, there was no set protocol dictating when or how frequently nursing staff assessed NRS pain scores, which requires attention in future studies. Additionally, given the subjectivity and variation in pain experiences between individuals, it would be useful for future prospective studies to calibrate participants response or sensitivity to pain prior to surgery by methods such as the sphygmomanometer test (26), which involves recording individual pain responses to a tight blood pressure cuff.

LOS

The average LOS for orthognathic surgery patients has been documented in the literature as ~28.8–204 h (24,27), which is slightly less than the 77–78 h median value that was demonstrated in our study. At our institution, a patient meets discharge criteria when they are able to void (i.e., urinate) on their own, ambulate to the restroom/around the floor, and tolerate more than ~200 cc of oral fluid intake, and have pain that is controlled on an oral regiment without the need for intravenous medications. Considering all barriers to discharge in future studies may help isolate the role of pain on LOS, and any potential influence PVB may have to reduce LOS.

Implications and actions needed

Although our study lacks the size and statistical significance needed to best assess the role of PVB in CCG during orthognathic surgery, it has provided useful recommendations

for future studies to consider, which we list below:

- Maximize sample size either via longer enrollment periods, collaboration with other institutions, and/or using multiple methods of searching electronic health records to identify eligible cases, especially those that are alternatively labeled or under non-traditional CPT codes. Greater numbers of patients would also make it more feasible to exclude outliers or perform subgroup analyses.
- Separately assess pain scores in the face and in the chest to specifically isolate CCG donor site pain. Isolation of chest wall pain may be enhanced by performing ultrasound-guided trigeminal nerve blocks (28) to optimally minimize facial pain.
- Try to use a single pain assessment scoring system and establish set protocols for how frequently nursing staff assess patient pain scores.
- Establish a pain sensitivity baseline for each patient, such as via the sphygmomanometer test (26), and use that to help match patients to control and experimental groups.
- Patients should also be matched based on the exact location and amount of facial surgical procedures endured, length of surgery, and PVB type (single injection versus catheter-based infusion).
- Consider assessing specific barriers to hospital discharge to better understand influences on LOS, including if PVB provides improved pain control over non-PVB patients to shorten LOS.
- Consider assessing post-hospital discharge opioid consumption to evaluate both short- and long-term effects of PVB on pain control and opioid requirements.
- Consider prospective studies such as randomized, double-blinded protocols (with saline versus local anesthetic) in order to blind the patient and provider to the treatment (i.e., true PVB or placebo PVB) being rendered. Restricting the surgical team and anesthesia teams to only a select few providers to perform all procedures would help standardize the skill level of the treatment teams. It would also be helpful to standardize the exact location of the PVB for each patient.

Conclusions

In summary, this is the first study looking at the effects of pre-operative PVB on patients undergoing CCG during simultaneous orthognathic surgery. Our study serves as a negative pilot study showing no statistically significant difference in MED, pain scores, or LOS between patients who received a PVB preoperatively for CCG donor site pain, versus those who did not, prior to orthognathic surgery. Although various limitations exist, this study has formed the foundation from which future research may set forth to better quantify the effects of PVB and optimize the comfort of patients undergoing CCG and orthognathic surgery.

Acknowledgments

Prior presentations: an ePoster based on a smaller sample population of the current study was presented at the Anesthesiology 2021 Annual Meeting (Emery A, Deng H, Yang Q, Mueller A, Houle T, and Wang J. Single-shot Paravertebral Blockade For Autogenous Costochondral Graft Site Pain In Maxillofacial Surgery. Posterior session presented at: Anesthesiology 2021 Annual Meeting; 2021 Oct 9-13; San Diego, CA, USA).
Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, *Journal of Oral and Maxillofacial Anesthesia,* for the series "Opioid-free Anesthesia and Opioid-sparing Anesthesia in OMF Surgery". The article has undergone external peer review.

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://joma.amegroups.com/article/view/10.21037/joma-22-23/rc

Data Sharing Statement: Available at https://joma.amegroups.com/article/view/10.21037/joma-22-23/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://joma.amegroups.com/article/view/10.21037/joma-22-23/coif). The series "Opioid-free Anesthesia and Opioid-sparing Anesthesia in OMF Surgery" was commissioned by the editorial office without any funding or sponsorship. JW serves as the unpaid editorial board member of *Journal of Oral and Maxillofacial Anesthesia* from August 2021 to July 2023 and served as unpaid Guest Editor of the series. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional board of Massachusetts General Hospital (No. #2020P002222) and individual consent for this retrospective analysis was waived.

References

1. Choi MG. Temporomandibular joint reconstruction with costochondral graft: case series study. J Korean Assoc Oral Maxillofac Surg 2021;47:128-34.
2. Khadka A, Hu J. Autogenous grafts for condylar reconstruction in treatment of TMJ ankylosis: current concepts and considerations for the future. Int J Oral Maxillofac Surg 2012;41:94-102.
3. Kelley BW, Haggerty CJ. Costochondral Graft. In: Atlas of Operative Oral and Maxillofacial Surgery. Hoboken, NJ, USA: John Wiley & Sons, Inc., 2015:495-8.
4. Emery AR, Deng H, Yang Q, et al. Single-shot Paravertebral Blockade For Autogenous Costochondral Graft Site Pain in Maxillofacial Surgery. Anesthesiology 2021. Annual Meeting: San Diego, CA, USA: 2021 Oct 9-13.
5. James DR, Irvine GH. Autogenous rib grafts in maxillofacial surgery. J Maxillofac Surg 1983;11:201-3.
6. Sharma H, Chowdhury S, Navaneetham A, et al. Costochondral Graft as Interpositional material for TMJ Ankylosis in Children: A Clinical Study. J Maxillofac Oral Surg 2015;14:565-72.
7. Uppal RS, Sabbagh W, Chana J, et al. Donor-site morbidity after autologous costal cartilage harvest in ear reconstruction and approaches to reducing donor-site contour deformity. Plast Reconstr Surg 2008;121:1949-55.
8. Sharma R, Louie A, Thai CP, et al. Chest Wall Nerve Blocks for Cardiothoracic, Breast Surgery, and Rib-Related Pain. Curr Pain Headache Rep 2022;26:43-56.
9. D'Ercole F, Arora H, Kumar PA. Paravertebral Block for Thoracic Surgery. J Cardiothorac Vasc Anesth 2018;32:915-27.
10. Huan S, Deng Y, Wang J, et al. Efficacy and safety of paravertebral block versus intercostal nerve block in thoracic surgery and breast surgery: A systematic review and meta-analysis. PLoS One 2020;15:e0237363.
11. Wu C, Ma W, Cen Q, et al. A comparison of the incidence of supraventricular arrhythmias between thoracic paravertebral and intercostal nerve blocks in patients undergoing thoracoscopic surgery: A randomised trial. Eur J Anaesthesiol 2018;35:792-8.
12. Hutchins J, Sanchez J, Andrade R, et al. Ultrasound-Guided Paravertebral Catheter Versus Intercostal Blocks for Postoperative Pain Control in Video-Assisted Thoracoscopic Surgery: A Prospective Randomized Trial. J Cardiothorac Vasc Anesth 2017;31:458-63.
13. Ouerghi S, Frikha N, Mestiri T, et al. A prospective, randomised comparison of continuous paravertebral block and continuous intercostal nerve block for post-thoracotomy pain. Southern African Journal of Anaesthesia and Analgesia. 2008;14:19-23.
14. Piraccini E, Pretto EA Jr, Corso RM, et al. Analgesia for thoracic surgery: the role of paravertebral block. HSR Proc Intensive Care Cardiovasc Anesth 2011;3:157-60.
15. Leung JM, Sands LP, Chen N, et al. Perioperative Gabapentin Does Not Reduce Postoperative Delirium in Older Surgical Patients: A Randomized Clinical Trial. Anesthesiology 2017;127:633-44.
16. Reddy A, Vidal M, Stephen S, et al. The Conversion Ratio From Intravenous Hydromorphone to Oral Opioids in Cancer Patients. J Pain Symptom Manage 2017;54:280-8.
17. Rauck RL, Bookbinder SA, Bunker TR, et al. A randomized, open-label study of once-a-day AVINZA (morphine sulfate extended-release capsules) versus twice-a-day OxyContin (oxycodone hydrochloride controlled-release tablets) for chronic low back pain: the extension phase of the ACTION trial. J Opioid Manag 2006;2:325-8, 331-3.
18. Mercadante S, Ferrera P, Villari P, et al. Frequency, indications, outcomes, and predictive factors of opioid switching in an acute palliative care unit. J Pain Symptom Manage 2009;37:632-41.
19. Karmakar MK. Thoracic paravertebral block. Anesthesiology 2001;95:771-80.
20. Gaba S, Gupta R, Mishra B, et al. Harvesting split thickness costal cartilage graft. Indian J Plast Surg

2017;50:79-81.
21. Wang L, Wang Y, Zhang X, et al. Serratus anterior plane block or thoracic paravertebral block for postoperative pain treatment after uniportal video-assisted thoracoscopic surgery: a retrospective propensity-matched study. J Pain Res 2019;12:2231-8.
22. Rivedal DD, Nayar HS, Israel JS, et al. Paravertebral block associated with decreased opioid use and less nausea and vomiting after reduction mammaplasty. J Surg Res 2018;228:307-13.
23. Shaffer AD, Jabbour N, Visoiu M, et al. Paravertebral Nerve Block for Donor Site Pain in Stage I Microtia Reconstruction: A Pilot Study. Otolaryngol Head Neck Surg 2016;154:898-901.
24. Bowe CM, Gurney B, Sloane J, et al. Operative time, length of stay and reoperation rates for orthognathic surgery. Br J Oral Maxillofac Surg 2021;59:163-7.
25. Terheggen MA, Wille F, Borel Rinkes IH, et al. Paravertebral blockade for minor breast surgery. Anesth Analg 2002;94:355-9, table of contents.
26. Butler S, Draleau K, Heinrich R, et al. Evaluation of Using the Sphygmomanometer Test to Assess Pain Sensitivity in Chronic Pain Patients vs Normal Controls. Pain Med 2020;21:2903-12.
27. Chang FS, Burrows SA, Gebauer DP. Patient-Controlled Analgesia and Length of Hospital Stay in Orthognathic Surgery: A Randomized Controlled Trial. J Oral Maxillofac Surg 2019;77:818-27.
28. Kumar A, Sinha C, Kumar A, et al. Ultrasound-guided trigeminal nerve block and its comparison with conventional analgesics in patients undergoing faciomaxillary surgery: Randomised control trial. Indian J Anaesth 2018;62:871-5.

doi: 10.21037/joma-22-23
Cite this article as: Emery AR, Deng H, Yang Q, Mueller A, Houle T, Wang J. The effects of paravertebral nerve blockade on post-operative pain for patients undergoing simultaneous autologous rib grafting and orthognathic surgery: a retrospective pilot study. J Oral Maxillofac Anesth 2022;1:32.