JSES International 8 (2024) 1110–1114

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

The incidence and decompression rates of median and ulnar neuropathies following shoulder surgery

Karan Dua, MD[a], Omair Kazi, BS[b], John Hoy, BA[b], Brian Xu, BS[b], Nikhil N. Verma, MD[b], Robert W. Wysocki, MD[b], John J. Fernandez, MD[b], Mark S. Cohen, MD[b], Xavier C. Simcock, MD[b,*,1]

[a]Department of Orthopedic Surgery, Columbia University Medical Center, New York, NY, USA
[b]Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, IL, USA

ARTICLE INFO

Keywords:
Shoulder surgery
Peripheral neuropathy
Cubital tunnel syndrome
Carpal tunnel syndrome
Complications
Surgical decompression

Level of evidence: Level IV; Case Series; Descriptive Epidemiology Study

Background: Upper extremity peripheral neuropathy is a known, but uncommon complication that can occur after shoulder surgery. The incidence rate is well documented, and most of these cases historically have been treated conservatively. However, we hypothesize peripheral compression neuropathy requires a much higher need for surgical decompression than originally reported. The purpose of this study was to evaluate the incidence, decompression rates, and prognostic factors for developing median and ulnar neuropathies following shoulder surgery.

Methods: A retrospective chart review was performed examining patients who underwent open and arthroscopic shoulder surgery from a multisurgeon, single-institution database. Perioperative data and functional outcomes were recorded. Symptom resolution was assessed with both conservative and surgical management of compression peripheral neuropathy. Further analysis was made to compare open and arthroscopic procedures, the type of neuropathy developed, and electromyographic (EMG) severity.

Results: The incidence rates of compression peripheral neuropathy following open arthroplasty and arthroscopic procedures was 1.80% (31/1722) and 0.54% (44/8150), respectively. 73.33% (55/75) of patients developed ipsilateral disease, while 20.00% (15/75) of patients had bilateral disease. Amongst the 75 included patients, there were 99 cases of neuropathy. Carpal tunnel syndrome was more common than cubital tunnel syndrome, comprising 61.61% (61/99) cases of neuropathy. 12.00% (9/75) of patients developed both carpal tunnel syndrome and cubital tunnel syndrome. Four patients were lost to follow-up. Decompression surgery was performed for 36.84% (35/95) cases of neuropathy with >90% obtaining symptom resolution with surgery. 63.16% (60/95) cases of neuropathy were managed conservatively, 71.67% (43/60) of which had persistent symptoms. When comparing arthroscopic versus open procedures, patients who underwent open procedures were significantly older (68.62 vs. 49.78 years, $P < .001$) and developed peripheral neuropathy significantly faster after the index procedure (87.24 vs. 125.58 days, $P = .008$). EMG severity did not correlate with decompression rates or symptom resolution. There were no differences in the subgroup analyses between beach chair and lateral positioning in regard to the type of neuropathy, laterality of symptoms, and/or treatment received.

Conclusion: The overall incidence of peripheral neuropathy after shoulder surgery was 0.76% (75/9872). The development of peripheral neuropathy is multifactorial, with older patients undergoing open arthroplasty more at risk. Neuropathy symptoms were refractory to conservative management despite the type of shoulder surgery, type of neuropathy, or EMG severity. Decompression consistently led to resolution of symptoms.

Upper extremity nerve injuries are a known complication following shoulder surgery. They are mostly localized to the shoulder and involve the brachial plexus, musculocutaneous, axillary, and suprascapular nerves.[7,8,11,13,15,17] Many risk factors have been implicated as potential causes for these injuries including limb manipulation or traction during surgery, interscalene block

This study was approved by Rush University Medical Center; ORA# 21060901.

*Corresponding author: Xavier C. Simcock, MD, Department of Orthopaedic Surgery, Rush University Medical Center, 1611 W. Harrison St., Chicago, IL 60612, USA.
E-mail address: xavier.simcock@rushortho.com (X.C. Simcock).

[1] Primary Investigator.

https://doi.org/10.1016/j.jseint.2024.05.011

placement, and hematoma formation.[2,3,6-9,11,13,15,17] However, these only explain injuries around the shoulder girdle, and not downstream pathology.

Peripheral neuropathy involving the median and ulnar nerves has been previously described following shoulder surgery, but is not well studied. These reports showed an incidence ranging from 0%-5.2% following total shoulder arthroplasty (TSA) and reverse total shoulder arthroplasty,[7,9,11,17] and 0-2% following arthroscopic procedures.[10,15] More recent studies have shown a higher incidence after shoulder arthroplasty (7.1%-12.3%) and arthroscopic rotator cuff repair (RCR) surgery (2.79%-14.6%).[5,16]

Despite the higher incidence, these studies report a predictable resolution of symptoms with nonoperative management. Thomasson and colleagues demonstrated approximately only 15% of patients who developed peripheral compressive neuropathy after shoulder arthroplasty required surgical decompression. In patients who underwent RCR, the incidence rate was 4.76%.[16] Horneff et al reported 14.6% (12/82) of patients developed peripheral neuropathy after RCR of which 92% had full resolution of symptoms within 12 weeks of nonoperative management.[5]

The purpose of this study was to evaluate the incidence and decompression rates of median and ulnar neuropathies following shoulder surgery. We hypothesize peripheral compression neuropathy is not a self-limiting and transient disease, and there is a much higher need for surgical decompression than previously reported.

Materials and methods

Patient selection

A retrospective review was performed of patients who underwent shoulder surgery at Rush University Medical Center from 2017-2021. The types of shoulder surgery included TSA, RSA, RCR, arthroscopic Bankart repair, and superior labrum anterior to posterior repair. Patients were excluded from the study if they had any neurologic symptoms or were diagnosed with carpal tunnel syndrome (CTS) or cubital tunnel syndrome (CuTS) prior to surgery, cubital tunnel release or carpal tunnel release (CTR) prior to shoulder surgery, and any confounding comorbidities that could result in peripheral neuropathy (ie, diabetes mellitus, alcoholism, thyroid disease, and trauma). Patients were further excluded if they developed symptoms greater than 6 months after shoulder surgery.

Study variables

Patient demographics were recorded including age, gender, and race. Perioperative data was collected including the type of shoulder procedure, patient positioning (beach chair vs. lateral), type of compression neuropathy (CTS, CuTS, or both), laterality in relation to the procedure (ipsilateral vs. contralateral), time elapsed between the index procedure to onset of symptoms, and total duration of follow-up.

The diagnosis of CTS or CuTS was made clinically by the presence of nerve paresthesias, pain, and/or motor weakness in the median and ulnar nerve distributions. Neuropathy symptom resolution ranged from complete absence of symptoms to resolution of night-time symptoms with occasional minor day-time symptoms. If an electromyographic (EMG) study was performed, the grade of severity (normal, mild, moderate, or severe) was included. EMG grading was grouped as normal/mild and moderate/severe based on the absence or presence of motor symptoms respectively.

Procedure details

An interscalene nerve block was performed on all patients preoperatively. All patients at our institution undergoing shoulder arthroplasty and arthroscopic RCR were positioned in beach chair. A robotic arm positioner is generally used on the ipsilateral arm and secured with coban extending above the elbow. The contralateral arm rests on an arm holder and the elbow is padded with foam. Arthroscopic Bankart repairs were performed in the lateral decubitus position. An axillary roll is always placed under the armpit. The ipsilateral, operative arm is suspended in the air using pulleys and weights, secured with coban that extends above the elbow, and the contralateral arm rests on an arm board with foam padding. Postoperatively after surgery, patients were placed into a sling with an abduction pillow, with the elbow generally in 90° of elbow flexion. The duration of immobilization was per the discretion of the primary surgeon. Patients were allowed to come out of the sling for elbow, wrist, and finger range of motion.

The diagnosis and initial treatment of peripheral neuropathy was first made and managed by the primary surgeon. There was no established protocol for management. In general, per our institutional norms, if conservative management such as nighttime splinting, bracing, physical therapy, oral medication, and/or corticosteroid injections failed, patients were referred to the hand surgeons for further management.

Statistical analysis

Continuous variables are presented as means with standard deviations. Qualitative variables are presented with frequency distribution and percentages. Statistical analysis was performed using two-tailed independent t-tests for continuous variables. Chi-squared was performed for categorical variables. All statistical analysis was performed on SPSS (version 26; IBM Corp., Armonk, NY, USA) with P values less than .05 indicating statistical significance.

Results

1722 open shoulder arthroplasties, 5205 RCR, and 2945 Bankart repairs were performed during 2017-2021. Patients were further queried by CPT codes for cubital tunnel release (CPT 64718) or carpal tunnel release (CPT 64721), and/or ICD-10 codes for CTS (G56.00, G56.01, G56.02), median neuropathy (G56.10, G56.11, G56.12), and/or ulnar neuropathy (G56.20, G56.21, G56.22). 75 patients were included in this study.

Demographics

Of the 75 patients included, 44 were men and 31 were women, with an average age of 58.32 ± 16.47 years. The majority of patients were white, 85.3% (64/75). 54.67% (41/75) of the patients who developed peripheral neuropathy underwent arthroscopic procedures (34 RCR and 7 Bankart repairs) and 45.33% (34/75) underwent open arthroplasty procedures (21 RSA and 13 TSA). Average interval from time of shoulder surgery to neuropathy presentation was 107.07 days ± 63.22. Patients undergoing open shoulder procedures were on average 18.8 years older ($P = .0003$) and developed neuropathy 40.4 days earlier ($P = .007$) compared to those undergoing arthroscopic procedures (Table I).

Incidence rate

A total of 9872 shoulder procedures were performed from the 4-year study period from 2017-2021. The incidence of peripheral neuropathy following shoulder surgery was 0.76% (75/9872). The incidence was 1.97% (34/1722) in the open shoulder procedure group compared to 0.50% (41/8150) in the arthroscopic group (Table I). A

Table I
Demographic data.

	Total (n = 75)	Arthroscopic (n = 41)	Open (n = 34)	*P* value
Rate of DPN*	0.76% (75/9872)	0.50% (41/8150)	1.97% (34/1722)	
Time from surgery to neuropathy†	107.07 (63.2)	130.3 (55.9)	89.9 (67.6)	.007‡
Age†	58.32 (16.47)	49.8 (16.2)	68.6 (8.4)	.0003‡
Follow-up time†	296 (233.9)	281.9 (229.7)	314.8 (244.4)	.55
Gender§				
Female	41.3% (31)	31.0% (13)	52.9% (18)	.05
Male	58.7% (44)	69% (29)	47.1% (16)	
Race§				
White	85.3% (64)	85.7% (36)	94.1% (32)	.11
Black	5.2% (4)	4.8% (2)	5.9% (2)	
Other	5.2% (4)	9.5% (4)	0% (0)	
	Cases of neuropathy (n = 99)	Arthroscopic	Open	*P* value
Neuropathy§				
CTS	61.6% (61/99)	45.2% (19)	61.8% (21)	.35
CuTS	38.4% (38/99)	38.1% (16)	29.4% (10)	
Both	9.1% (9/99)	16.7% (7)	8.8% (3)	
Laterality§				
Ipsilateral	75.8 (75)	76.2% (32)	70.6% (24)	.67
Bilateral	18.4% (14)	14.3% (6)	23.5% (8)	

DPN, distal peripheral neuropathy; *CTS*, carpal tunnel syndrome; *CuTS*, cubital tunnel syndrome; *Both*, cubital tunnel and carpal tunnel syndrome.
*Values are given as percentages with the proportions in parentheses.
†Values are given as the mean with standard deviation in parentheses.
‡*P* value < .05 indicating statistical significance.
§Values are given as percentages with the number in parentheses.

subgroup analysis of the arthroscopic group exhibited an incidence of 0.67% (34/5205) in those who underwent RCR compared to 0.24% (7/2945) in those who underwent Bankart repair.

Decompression rate

37.33% (28/75) of patients who developed peripheral compression neuropathy underwent surgical intervention. Decompression was performed in 26.57% (9/34) and 46.43% (19/41) of patients who underwent open and arthroscopic index shoulder procedures, respectively. There were no differences in the rate of surgical intervention for compression peripheral neuropathy between patients who underwent arthroscopic or open shoulder surgery ($P = .077$). Surgical release was performed for 37.70% (23/61) cases of CTS and 39.47% (15/38) of CuTS. There was no difference in decompression rates between CTS and CuTS ($P = .60$) (Table II).

In patients who had an EMG performed, 23% (13/34) with normal to mild EMG grading and 51.52% (17/33) with moderate to severe EMG grading underwent surgical decompression. There was no significant difference in decompression rates based on EMG severity ($P = .27$) (Table II).

Type of neuropathy

Amongst the 75 patients, there were 99 cases of neuropathy, with a few patients having bilateral symptoms or double crush syndrome. 61.61% (61/99) developed CTS and 38.38% (38/99) had CuTS, ($P = .001$). 9 patients had concomitant CTS and CuTS (Table I). Mean age at the time of shoulder surgery was 62.61 ± 15.22 years for CTS cases and 54.55 ± 16.30 years for CuTS cases. Patients who developed CuTS were younger at the time of shoulder surgery than those who developed CTS ($P = .014$). The type of shoulder surgery did not influence the type of peripheral compression syndrome ($P = .27$).

Laterality

75.76% (75/99) of the cases were on the ipsilateral extremity ($P < .00001$). The laterality of symptoms was not influenced by the type of shoulder surgery performed ($P = .71$).

Table II
Surgical decompression.

	CTS	CuTS	*P* value
Decompression	37.70% (23/61)	39.47% (15/38)	.600
	Open	Arthroscopic	*P* value
Decompression	26.57% (9/34)	46.43% (19/41)	.077
	EMG normal/mild	EMG moderate/severe	*P* value
Decompression	38.23% (13/34)	51.52% (17/33)	.270

CTS, carpal tunnel syndrome; *CuTS*, cubital tunnel syndrome; *EMG*, electromyography.
Values are given as percentages with the proportions in parentheses.

Symptom resolution

Four patients were lost to follow-up. The mean age of patients with symptom resolution was 54.8 ± 2.56 years versus 62.77 ± 2.94 years with persistent symptoms. Younger patients were more likely to have symptom resolution ($P = .045$).

62.67% (47/75) of patients underwent conservative treatment, which was 63.16% (60/95) of the cases of neuropathy. 28.33% (17/60) of the neuropathy cases achieved symptom resolution through conservative treatment. For the cases of neuropathy undergoing conservative treatment, 58.33% (35/60) were CTS and 41.67% (25/60) were CuTS.

22.86% (8/35) of CTS cases and 36.00% (9/25) of CuTS cases achieved symptom resolution through conservative treatment ($P = .267$). In the conservative management cohort, 41.67% (25/60) of neuropathy cases occurred following arthroscopic shoulder surgery and 58.33% (35/60) occurred following open shoulder surgery. 48.00% (12/25) of the arthroscopic group and 14.29% (5/35) of the open group achieved symptom resolution through conservative therapy. Conservative management was more effective in patients after arthroscopic surgery than those who underwent open shoulder surgery ($P = .004$) (Table III).

58.33% (35/60) cases of neuropathy had EMG grading available. 54.29% (19/35) cases were graded as normal to mild and 45.71% (16/35) cases were graded as moderate to severe. 21.05% (4/19) of the normal to mild cases and 25% (4/16) of the moderate to severe cases

Table III
Symptom resolution with conservative management.

	CTS	CuTS	*P* value
Resolved	22.86% (8/35)	36.00% (9/25)	.267
	Open	Arthroscopic	*P* value
Resolved	14.29% (5/35)	48.00% (12/25)	.004*
	EMG normal/mild	EMG moderate/severe	*P* value
Resolved	21.05% (4/19)	25.00% (4/16)	.779

CTS, carpal tunnel syndrome; *CuTS*, cubital tunnel syndrome; *EMG*, electromyography.
Values are given as percentages with the proportions in parentheses.
*P value < .05 indicating statistical significance.

Table IV
Symptom resolution with surgical management.

	CTS	CuTS	*P* value
Resolved	95.45% (21/22)	76.92% (10/13)	.095
	Open	Arthroscopic	*P* value
Resolved	90.00% (9/10)	88.00% (22/25)	.865
	EMG normal/mild	EMG moderate/severe	*P* value
Resolved	100.00% (12/12)	76.47% (13/17)	.070

CTS, carpal tunnel syndrome; *CuTS*, cubital tunnel syndrome; *EMG*, electromyography.
Values are given as percentages with the proportions in parentheses.

achieved symptoms resolution through conservative treatment. EMG severity did not correlate with symptom resolution for neuropathy managed conservatively ($P = .779$) (Table III).

37.33% (28/75) of patients underwent surgical decompression. This comprised 36.84% (35/95) of the cases of neuropathy. 88.57% (31/35) of the neuropathy cases achieved symptom resolution through surgical decompression. Within this cohort, 22 cases were CTS and 13 cases were CuTS. 95.45% (21/22) of CTS cases and 76.92% (10/13) of CuTS cases achieved symptom resolution through surgical management. There was no difference in symptom resolution from surgical decompression for CTS compared to CuTS ($P = .095$). 71.43% (25/35) and 28.57% (10/35) of neuropathy cases managed surgically were status-post arthroscopic and open shoulder surgery, respectively. 88.00% (22/25) arthroscopic cases and 90.00% (9/10) open cases achieved symptom resolution through surgical management. Arthroscopic and open cases achieved symptom resolution at similar rates through surgical management ($P = .865$) (Table IV).

EMG grading was available for (29/35) cases of neuropathy managed surgically. 41.38% (12/29) cases of neuropathy were graded as normal to mild and 58.62% (17/29) cases were graded as moderate to severe. 100% (12/12) of normal to mild cases and 76.47% (13/17) of moderate to severe cases achieved symptom resolution through surgical management. EMG severity did not correlate with symptom resolution for neuropathy managed surgically ($P = .070$) (Table IV).

Severity

EMG data was available for 60.00% (45/75) of patients, comprising 67.68% (67/99) of the neuropathy cases. 50.75% (34/67) of the neuropathy cases were graded as normal to mild and 49.25% (33/67) were graded as moderate to severe. More severe neuropathy on EMG grading was not related to the type of shoulder surgery undergone, open or arthroscopic ($P = .548$). CTS cases resulted in normal to mild and moderate to severe neuropathy at similar rates ($P = .142$). CuTS preferentially resulted in normal to mild neuropathy ($P = .039$) (Table V). Patients with more severe neuropathy on EMG grading did not undergo decompression at a greater rate ($P = .274$) (Table II).

Table V
Electromyography (EMG) severity grading.

	EMG normal/mild	EMG moderate/severe	*P* value
Age*	62.61 ± 15.22	54.55 ± 16.3	.014†
Type of surgery‡			
Open	31.3% (14/30)	15.2% (16/30)	.603
Arthroscopic	30.3% (20/37)	23.2% (17/37)	.484
Type of neuropathy‡			
CTS	69.57% (16/23)	30.43% (7/23)	.039
CuTS	40.91% (18/44)	59.09% (26/44)	.142

CTS, carpal tunnel syndrome; *CuTS*, cubital tunnel syndrome; *EMG*, electromyography.
Values are given as means with standard deviations for age and percentages with the proportions in paratheses for cases.
*Values are given as the mean and standard deviation.
†*P value* < .05 indicating statistical significance.
‡Values are given as percentages with the proportion in parentheses.

Discussion

The goal of this study was to investigate the incidence of median and ulnar neuropathy following shoulder surgery, the rate of intervention, and assess factors contributing to treatment outcomes. Our primary findings show that the incidence rate of compression peripheral neuropathy is similar to previous reports. However, unlike previous studies, our hypothesis was proven true in that conservative management demonstrated poor outcomes with only 28.33% of patients exhibiting full resolution of symptoms. Surgical management in patients with refractory symptoms is extremely successful, in which 88.57% of patients in our cohort had complete resolution of symptoms.

The overall incidence of developing compressive peripheral neuropathy was 0.76%, with 0.41% of patient developing CTS (Table I). These findings are similar to older reports with incidence rates ranging from 0%-5.2%.[7,9,11,17,1,5] Two recent studies reported a higher incidence rate of with TSA and RSA ranging from 7.1%-12.3%[5,16] and arthroscopic RCR surgery ranging from 2.79%-14.6%. The lower incidence reported in our study can possible be attributed to more stringent exclusion criteria. Patients with known comorbidities that can be confound study results such as diabetes were excluded. In addition, any patients with neuropathic symptoms or previous EMG study were also not included in this study. Furthermore, this study retrospectively reviewed 9872 shoulder procedures compared to Thomasson et al's 895 total procedures and Horneff et al's 101 RCR procedures.[5,16] Bilateral disease was prevalent in 20% of patients, and this is likely underappreciated in postsurgical patients as it is in our general patient population.[12]

The strength of this study is the robust cohort of 9872 patients who underwent open and arthroscopic shoulder procedures at a single institution. In addition, this is the first study to compare laterality of neuropathy relative to the surgical procedure and EMG severity grading.

There were certain risk factors associated with developing compression peripheral neuropathy in our study. Older patients undergoing open arthroplasty procedures are at an increased risk of developing peripheral neuropathy. The patients who underwent open arthroplasty procedures were on average 18.8 years older and developed neuropathy 40.4 days earlier than the arthroscopic cohort. (Table I) However, open arthroplasty procedures did not

increase the risk of needing surgical intervention for CTS or CuTS despite the higher incidence. Older patients are more likely to develop CTS, and on average were eight years older than patients who were diagnosed with CuTS.

There are several possible explanations for these findings. We surmise this could be because of postoperative downstream hand swelling and prolonged immobilization in a sling resulting in peripheral nerve compression both at the carpal tunnel and cubital tunnel.[18] Older patients are at higher risk for developing peripheral neuropathy.[4,14] They likely have less reserve and postoperatively are more susceptible to fluid changes. In addition, peripheral neuropathy most commonly occurred in the ipsilateral extremity. The use of a robotic arm positioner with the tight wrapping of the hand, forearm and elbow could possibly contribute to development of symptoms. Aside from age and time from surgery to development of neuropathy, there were no differences to suggest patient positioning in a beach chair or lateral decubitus position and/or type of shoulder surgery contributed to the development of symptoms.

There are reportedly good outcomes in patients treated conservatively after developing compression neuropathy.[5,16] Thomasson et al reported only 14.3-16.7% of arthroplasty patients, and 4.76% RCR patients with neuropathic symptoms needed decompression. Horneff et al reported only 1/31 patients had persistent neuropathic symptoms following conservative management without any patients necessitating surgery. In contrast, our study shows that peripheral compression neuropathy is not a self-limiting and transient disease and that there is a much higher need for surgical decompression than originally reported. Our cohort exhibited a higher rate of decompression with an overall rate of 37.33% (28/75) which confirmed our hypothesis. EMG severity was not linked to the type of surgery being performed. Furthermore, type of neuropathy showed similar proportions between conservative management and surgical decompression with CTS comprising the majority, followed by CuTS, then concomitant disease.

88.57% (31/35) of patients had full resolution of symptoms with surgical intervention. In contrast, 28.33% (17/60) who were treated conservatively had complete resolution. Younger patients and those who underwent arthroscopic shoulder surgery were more likely to resolve symptoms with conservative management.

There are several limitations in this study. This is a retrospective study which has its inherent limitations. Surgeons who are not actively probing patients about peripheral neuropathy symptoms may miss the diagnosis or attribute it to being normal in the postoperative period. In addition, the number of patients who had preoperative symptoms could be underrepresented if providers were not focused on eliciting this information. Furthermore, some patients who were treated conservatively were lost to follow-up which could attribute to the lower percentage in symptom resolution achieved with conservative management. No EMGs were available preoperatively for baseline comparisons and only 67.68% (67/99) cases of neuropathy had EMG findings which further limited our study. However, the authors maintain this is a clinical diagnosis, and the decision to intervene is predicated on the reported symptoms. All patients should trial conservative management, but surgeons should be aware if symptoms continue to persist, surgical decompression is a viable option with superior outcomes.

Conclusion

The overall incidence of peripheral neuropathy after shoulder surgery was 0.76% (75/9872). The development of peripheral neuropathy is multifactorial, with older patients undergoing open arthroplasty more at risk on the ipsilateral extremity. Neuropathy symptoms were often refractory to conservative management despite the type of shoulder surgery, type of neuropathy, or EMG severity. Surgical decompression is a viable treatment option for peripheral compression neuropathies after shoulder surgery with nearly 90% of patients achieving full symptom resolution.

Disclaimers:

Funding: No funding was disclosed by the authors.
Conflicts of interest: The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

References

1. Blumenthal S, Herskovitz S, Verghese J. Carpal tunnel syndrome in older adults. Muscle Nerve 2006;34:78-83. https://doi.org/10.1002/mus.20559.
2. Borgeat A, Ekatodramis G, Kalberer F, Benz C. Acute and nonacute complications associated with interscalene block and shoulder surgery: a prospective study. Anesthesiology 2001;95:875-80.
3. Fredrickson MJ, Kilfoyle DH. Neurological complication analysis of 1000 ultrasound guided peripheral nerve blocks for elective orthopaedic surgery: a prospective study. Anaesthesia 2009;64:836-44. https://doi.org/10.1111/j.1365-2044.2009.05938.x.
4. Hicks CW, Wang D, Windham BG, Matsushita K, Selvin E. Prevalence of peripheral neuropathy defined by monofilament insensitivity in middle-aged and older adults in two US cohorts. Sci Rep 2021;11:19159. https://doi.org/10.1038/s41598-021-98565-w.
5. Horneff JG, Pepe M, Tucker B, Tjoumakaris F, Lombardi N, Wowkanech C, et al. Distal mononeuropathy before and after arthroscopic rotator cuff repair: a prospective investigation. Arthroscopy 2018;34:1186-91. https://doi.org/10.1016/j.arthro.2017.10.046.
6. Hughes MS, Matava MJ, Wright RW, Brophy RH, Smith MV. Interscalene brachial plexus block for arthroscopic shoulder surgery: a systematic review. J Bone Joint Surg Am 2013;95:1318-24. https://doi.org/10.2106/JBJS.L.01116.
7. Lädermann A, Lübbeke A, Mélis B, Stern R, Christofilopoulos P, Bacle G, et al. Prevalence of neurologic lesions after total shoulder arthroplasty. J Bone Joint Surg Am 2011;93:1288-93. https://doi.org/10.2106/JBJS.J.00369.
8. Lenters TR, Davies J, Matsen FA. The types and severity of complications associated with interscalene brachial plexus block anesthesia: local and national evidence. J Shoulder Elbow Surg 2007;16:379-87. https://doi.org/10.1016/j.jse.2006.10.007.
9. Lynch NM, Cofield RH, Silbert PL, Hermann RC. Neurologic complications after total shoulder arthroplasty. J Shoulder Elbow Surg 1996;5:53-61.
10. Matthews GS, Kiani B, Wuertzer SD, Powell JA, Roller BL, Lenchik L, et al. MRI of the wrist: algorithmic approach for evaluating wrist pain. Radiographics 2019;39:447-8. https://doi.org/10.1148/rg.2019180157.
11. Nagda SH, Rogers KJ, Sestokas AK, Getz CL, Ramsey ML, Glaser DL, et al. Neer Award 2005: peripheral nerve function during shoulder arthroplasty using intraoperative nerve monitoring. J Shoulder Elbow Surg 2007;16(3 Suppl):S2-8. https://doi.org/10.1016/j.jse.2006.01.016.
12. Padua L, Padua R, Nazzaro M, Tonali P. Incidence of bilateral symptoms in carpal tunnel syndrome. J Hand Surg Br 1998;23(5):603-6.
13. Pitman MI, Nainzadeh N, Ergas E, Springer S. The use of somatosensory evoked potentials for detection of neuropraxia during shoulder arthroscopy. Arthroscopy 1988;4(4):250-5.
14. Povlsen B. High incidence of absent nerve conduction in older patients with bilateral carpal tunnel syndrome. Ann R Coll Surg Engl 2010;92(5):403-5. https://doi.org/10.1308/003588410X12628812460092.
15. Small NC. Complications in arthroscopic surgery performed by experienced arthroscopists. Arthroscopy 1988;4:215-21.
16. Thomasson BG, Matzon JL, Pepe M, Tucker B, Maltenfort M, Austin L. Distal peripheral neuropathy after open and arthroscopic shoulder surgery: an under-recognized complication. J Shoulder Elbow Surg 2015;24:60-6. https://doi.org/10.1016/j.jse.2014.08.007.
17. Walch G, Bacle G, Lädermann A, Nové-Josserand L, Smithers CJ. Do the indications, results, and complications of reverse shoulder arthroplasty change with surgeon's experience? J Shoulder Elbow Surg 2012;21:1470-7. https://doi.org/10.1016/j.jse.2011.11.010.
18. Yian EH, Dillon M, Sodl J, Dionysian E, Navarro R, Singh A. Incidence of symptomatic compressive peripheral neuropathy after shoulder replacement. Hand (N Y) 2015;10:243-7. https://doi.org/10.1007/s11552-014-9701-3.