Journal of Hand Surgery Global Online 5 (2023) 624–629

Contents lists available at ScienceDirect

Journal of Hand Surgery Global Online

journal homepage: www.JHSGO.org

Original Research

The Incidence of Carpal Tunnel Syndrome Diagnosis Increases after Arthroscopic Shoulder Surgery

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A R T I C L E I N F O

Article history:
Received for publication May 4, 2023
Accepted in revised form May 7, 2023
Available online June 6, 2023

Key words:
Arthroscopic
Carpal
Shoulder
Surgery
Tunnel

Purpose: Arthroscopic shoulder surgery has been identified as a potential risk factor for carpal tunnel syndrome (CTS). The purposes of this study were as follows: to (1) examine the percentage of patients who underwent arthroscopic shoulder procedures and later developed ipsilateral CTS within 1 year of the procedure, (2) determine the percentage of those patients with CTS who subsequently underwent an injection or release, and (3) examine comorbidities associated with developing CTS after surgery.
Methods: Patients who underwent arthroscopic rotator cuff repair (RCR), labral repair, or biceps tenodesis were retrospectively identified in a national database. Within 1 year, we compared the rates of ipsilateral CTS diagnoses versus the contralateral side. The rates of comorbidities between those who did and did not develop CTS were also compared.
Results: Within 1 year, arthroscopic RCR patients (1.47% vs 1.00%; odds ratio [OR], 1.48; $P < .001$) and arthroscopic labral repair patients (0.76% vs 0.52%; OR, 1.47; $P < .001$) had a significantly higher rate of ipsilateral carpal tunnel diagnosis versus contralateral side diagnosis. Arthroscopic RCR patients were also significantly more likely to have ipsilateral carpal tunnel injection (0.16% vs 0.11%; OR, 1.45; $P < .001$) and release (0.46% vs 0.37%; OR, 1.24; $P < .001$). Patients who had an ipsilateral carpal tunnel diagnosis following arthroscopic RCR and labral repair were both significantly older (both $P < .001$), a higher percentage of women (both $P<.001$), and more likely to have had a preoperative nerve block (both $P < .05$). Both cohorts had significantly higher mean Elixhauser comorbidity Index ($P < .001$) and more comorbidities.
Conclusions: This study demonstrated a significantly higher incidence of operative side CTS within 1 year following arthroscopic RCR and labral repairs. Arthroscopic RCR was also demonstrated to result in significantly higher rates of injections and carpal tunnel release. The cohort that developed ipsilateral CTS was older, had higher percentage of women, and had more comorbidities.
Type of study/level of evidence: Prognostic III.

Carpal tunnel syndrome (CTS) is the most common neuropathy in the United States, with an incidence of one to three per 1000 per year and a prevalence of 50 cases per 1000 people.[1] This condition accounts for 90% of all presenting neuropathies in the United States.[2] The development of CTS is multifactorial in etiology. Specific known risk factors include obesity, pregnancy, repetitive wrist movements, rheumatoid arthritis, and inflammatory conditions.[1,3] The pathophysiology involves mechanical trauma, increased pressure, and ischemic damage to the median nerve within the carpal tunnel itself.[2,3]

Shoulder arthroscopy is the second most frequently performed hand surgery, with knee arthroscopy being the most common.[4,5] Shoulder pathology including rotator cuff pathology, labral tears, proximal biceps pathology, adhesive capsulitis, and subacromial impingement can be treated arthroscopically.[6] Although

Declaration of interests: No benefits in any form have been received or will be received related directly to this article.

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https://doi.org/10.1016/j.jhsg.2023.05.005
2589-5141/

arthroscopic techniques are highly successful in treating these conditions, risks associated with these arthroscopic procedures exist. These risks include stiffness, iatrogenic soft-tissue injury, neurovascular injury, and neuropraxia.[7,8] Smaller studies have also demonstrated that arthroscopic rotator cuff repair (RCR) is a possible risk factor for development of CTS.[9,10] It has also been demonstrated that older patients and those with comorbidities are at higher risk for complications following arthroscopic RCR.[11]

However, there is a paucity of literature on the rate and risk factors for CTS diagnoses following several arthroscopic shoulder procedures. Understanding the risk of developing CTS after surgery is a helpful addition to preoperative counseling. The purposes of this study were as follows: to (1) examine the percentage of patients who underwent arthroscopic shoulder procedures and later had an ipsilateral CTS diagnosis within 1 year of their procedure, (2) determine the percentage of patients with a postoperative CTS diagnosis who underwent an injection or carpal tunnel release, and (3) examine what comorbidities were associated with developing ipsilateral CTS after these procedures. It was hypothesized that patients undergoing an arthroscopic shoulder procedure would be more likely to develop ipsilateral CTS after surgery and that the patients who did develop ipsilateral CTS would have higher rates of comorbidities commonly associated with CTS.

Methods

Data source and study design

Patient records were queried from the PearlDiver Mariner Database (PearlDiver Inc), a commercially available administrative claims database that contains deidentified patient data from the inpatient and outpatient settings. The database contains the medical records of patients across the United States from 2010 through the first quarter of 2021, which were collected by an independent data abstractor. This study used the "M151Ortho" data set within PearlDiver, which contains a random sample of 151 million patients. All types of health insurance payors are represented, including commercial, private, and government plans. Researchers extracted data using the current procedural technology (CPT) and International Classification of Diseases, Ninth and Tenth Revision (ICD-9/ICD-10) diagnosis and procedural codes. Institutional Review Board exemption was granted as provided data were deidentified and compliant with the Health Insurance Portability and Accountability Act. No outside funding was received for this study.

A retrospective cohort study was conducted to investigate the rate of ipsilateral CTS diagnosis following several arthroscopic shoulder procedures. Using CPT codes, patients who underwent arthroscopic RCR (CPT-29827), biceps tenodesis (CPT-29828), and/or labral repair (CPT-29806 or CPT-29807) were identified and filtered for the first instance of each CPT code. For the RCR cohort, patients were still included if they had additional same-day procedures, whereas for the biceps tenodesis cohort, patients with same-day RCR and/or labral repair were excluded. For the labral repair cohort, patients with same-day RCR and/or biceps tenodesis were excluded. These exclusions were chosen to evaluate isolated biceps tenodesis and labral repair while allowing for analysis of the impact of additional procedures on CTS risk following RCR repair. In order to ensure laterality, patients were required to have an ICD-10 diagnosis code for a right- or left-sided rotator cuff tear, biceps tendon injury, or labral tear on the same day of the respective CPT codes to be included. The requirement for each patient to have an ICD-10 diagnosis code limited the beginning of study period to October 1, 2015. Patients that had a code for unspecified side or bilateral diagnoses were excluded. Additionally, patients who had a code for a contralateral rotator cuff tear, biceps tendon injury, or labral tear within 1 year were excluded to ensure that complications could be tied to the operative arm. Patients with a previous diagnosis of CTS were excluded. Codes to define each cohort are provided in Appendix A.

To limit potential transfer bias, only patients with continuous database enrollment for at least 2 years after the index procedure were included. Patients were additionally required to have an active enrollment for 3 months prior to the procedure to ensure capture of comorbidities for analysis. Subsequently, patients who had a CTS diagnosis on the ipsilateral side as their operative shoulder or on the contralateral side within 1 year of their index procedure were identified. Among those with a diagnosis, patients who underwent an injection (CPT-20526) or operative carpal tunnel release (CPT-29848 or CPT-64721) within 1 year of their CTS diagnosis were identified. Rates of comorbidities among the cohort that developed ipsilateral CTS were compared with those who did not have a CTS diagnosis after surgery. The mean Elixhauser comorbidity index (ECI) was also calculated by PearlDiver software and compared between the two groups.[12] Codes to define comorbidities and complications are provided in Appendix B.

Statistical analysis

Statistical analyses were performed using Microsoft Excel (Microsoft Corporation) and R statistical software (Version 4.1.0; R Project for Statistical Computing) that are integrated within PearlDiver software with an α level set to 0.05. The rates of ipsilateral CTS diagnoses as the operative shoulder versus the contralateral side and the rates of treatment of CTS with injection or carpal tunnel release were compared using odds ratios (ORs). For cohort comorbidities, categorical variables were compared with a chi-square test, and continuous variables were compared with Welch's t tests or the Mann−Whitney U tests. An *a priori* power analysis was conducted to determine the minimal sample size required to detect significant differences in complication rates between groups and to achieve 80% power. To detect a 1% difference in the rate of postoperative CTS diagnoses, assuming a 1:1 enrollment ratio, a minimum of 2,318 patients would be required. To detect a 0.5% difference in the rate of postoperative CTS diagnoses, assuming a 1:1 enrollment ratio, a minimum of 7,750 patients would be required.

Results

Study populations

Overall, the study identified 704,242 patients identified who underwent arthroscopic RCR, 188,467 who underwent arthroscopic biceps tenodesis, and 231,347 patients who underwent arthroscopic labral repair. Among the biceps tenodesis patients, 48,618 did not have a concomitant labral repair or RCR. Among the labral repair patients, 180,202 did not have a concomitant biceps tenodesis or RCR. After excluding patients without an ICD-10 diagnosis code to ensure laterality of the procedure, 154,653 patients were remaining who underwent arthroscopic RCR, 3,649 underwent arthroscopic biceps tenodesis, and 30,407 underwent arthroscopic labral repair. After excluding patients with previous CTS diagnoses, 195,847 patients were in the final arthroscopic RCR cohort, 3,443 patients in the final biceps tenodesis cohort, and 29,708 patients in the final labral repair cohort.

Rate of postoperative carpal tunnel diagnosis and treatment

Within 1 year of arthroscopic RCR, patients had a significantly higher rate of ipsilateral CTS diagnosis versus contralateral side

Table 1
Rates of Same Side Versus Contralateral Side Carpal Tunnel diagnoses, Injections, and Release Following Arthroscopic Shoulder Surgery*

Type of Arthroscopic Shoulder Surgery	Same Side CT		Contralateral CT		OR (Ref Cohort, Same Side CT)	P Value
	n	%	n	%		
Carpal tunnel syndrome diagnosis						
Rotator repair (n = 195,847)	2,876	1.47%	1,954	1.00%	1.48 (1.40–1.57)†	<.001†
Labral repair (n = 29,708)	227	0.76%	155	0.52%	1.47 (1.20–1.80)†	<.001†
Biceps tenodesis (n = 3,443)	51	1.48%	42	1.22%	1.22 (0.81–1.84)	.348
Carpal tunnel injection						
Rotator repair	312	0.16%	215	0.11%	1.45 (1.22–1.73)†	<.001†
Labral repair	21	0.07%	19	0.06%	1.11 (0.60–2.06)	.737
Biceps tenodesis	<11	-	<11	-	n/a	n/a
Carpal tunnel release						
Rotator repair	894	0.46%	724	0.37%	1.24 (1.12–1.36)†	<.001†
Labral repair	70	0.24%	60	0.20%	1.17 (0.83–1.65)	.380
Biceps tenodesis	28	0.81%	20	0.58%	1.40 (0.79–2.50)	.249

CT, carpal tunnel.
* PearlDiver software does not report exact patient counts when defined groups are <11.
† Indicates statistically significant results.

diagnosis (1.47% vs 1.00%; OR, 1.48; 95% confidence interval [CI], 1.40–1.57) (Table 1). Within 1 year of CTS diagnosis, a significantly higher percentage of ipsilateral side patients underwent carpal tunnel injection (0.16% vs 0.11%; OR, 1.45; 95% CI, 1.22–1.73) and carpal tunnel release (0.46% vs 0.37%; OR, 1.24; 95% CI, 1.12–1.36).

Within 1 year of arthroscopic labral repair, patients had a significantly higher rate of ipsilateral CTS diagnosis versus contralateral side diagnosis (0.76% vs 0.52%; OR, 1.47; 95% CI, 1.20–1.80). Within 1 year of CTS diagnosis, 0.07% of ipsilateral side patients and 0.06% of contralateral side patients underwent injection (OR, 1.11; 95% CI, 0.60–2.06). Within 1 year of CTS diagnosis, 0.24% of ipsilateral side patients and 0.20% of contralateral side patients underwent carpal tunnel release (OR, 1.17; 95% CI, 0.83–1.65).

Within 1 year of arthroscopic biceps tenodesis, patients had statistically equivalent rates of ipsilateral CTS diagnosis versus contralateral side diagnosis (1.48% vs 1.22%; OR, 1.22; 95% CI, 0.81–1.84). Within 1 year of CTS diagnosis, 0.81% of ipsilateral side patients and 0.58% of contralateral side patients underwent carpal tunnel release (OR, 1.40; 95% CI, 0.79–2.50).

Comorbidities associated with postoperative ipsilateral side carpal tunnel diagnosis

Patients who had an ipsilateral side CTS diagnosis following arthroscopic RCR were significantly older ($P < .01$), higher percentage of women ($P < .01$), were more likely to have had a preoperative nerve block without (CPT-64415) ($P < .01$) or with a catheter (CPT-64416) ($P = .01$). Additionally, these patients had significantly higher mean ECI ($P < .01$) and rates of several comorbidities listed in Table 2. No difference exists in the rate of same-day biceps tenodesis, labral repair, or subacromial decompression between the cohort that had an ipsilateral side postoperative CTS diagnosis versus no diagnosis.

Patients who had an ipsilateral side CTS diagnosis following isolated arthroscopic labral repair were significantly older ($P < .01$), higher percentage of women ($P < .01$), and were more likely to have had a preoperative nerve block with a catheter ($P = .01$). Additionally, these patients had significantly higher mean ECI ($P < .001$) and rates of several comorbidities listed in Table 3.

Patients who had an ipsilateral side CTS diagnosis following isolated arthroscopic biceps tenodesis were not significantly different in age ($P = .26$), a percentage of women ($P = 1$), or rate of preoperative nerve block without ($P = 1$) or with a catheter ($P = 1$). Additionally, these patients had a statistically similar mean ECI ($P = .62$) and rates of several comorbidities listed in Table 4.

Discussion

This study demonstrated that patients who underwent arthroscopic RCR and isolated arthroscopic labral repair exhibit significantly higher rates of operative side CTS diagnoses after surgery. This is consistent with previous literature demonstrating that the incidence of compressive neuropathy increases following shoulder surgery. Yian et al[13] demonstrated that 2.5% of patients who underwent shoulder arthroplasty had postoperative compressive peripheral neuropathy within 1 year compared with 1.3% in the matched nonsurgical control group. At a mean follow-up of 12 months, Thomasson et al[14] demonstrated that 21 of 753 (2.79%) arthroscopic RCRs were diagnosed with distal peripheral neuropathy, of which the most common was CTS. The same study demonstrated that 7.1% of total shoulder arthroplasty patients and 12.3% of reverse total shoulder arthroplasty patients developed neuropathy; however, the most common in these patients was cubital tunnel syndrome.[14] As such, the results of this present study highlight the underrecognized incidence of CTS diagnoses following arthroscopic shoulder surgery and the importance of screening prior to and after arthroscopic shoulder surgery. Additionally, the yearly incidence of developing CTS in the general population is roughly 0.3%, highlighting the increased incidence of developing CTS following shoulder arthroscopy.[1]

Interestingly, concomitant procedures along with arthroscopic RCR such as subacromial decompression, biceps tenodesis, or labral repair were not associated with operative CTS. Longer operative time has been demonstrated to be associated with increased complications following several surgical procedures of the hand, including RCR, knee arthroscopy, anterior cruciate ligament reconstruction, and total joint arthroplasty.[15–18] As concomitant procedures add to the operative time, it would be expected to find higher rates of CTS. The present study also demonstrated that patients who underwent arthroscopic RCR or isolated labral repair with a preoperative nerve block were more likely to develop CTS. Droog et al[19] demonstrated that the risk of all-cause nerve injury following elective distal upper-extremity surgery was 4.7%, and no association was found between specific anesthetic or regional anesthetic use and the development of new-onset nerve injury. Borgeat et al[20] demonstrated that four of 520 (0.8%) patients who underwent elective shoulder surgery with an interscalene plexus block were diagnosed with CTS after surgery. Additionally, Kim et al[21] demonstrated that regional anesthesia using a brachial

Table 2
Rotator Cuff Repair Cohort Comorbidities

Type of Arthroscopic Shoulder Surgery	Same Side (n = 2,876)		No CT (n = 191,860)		P Value
	N	%	N	%	
Age (y)	60.7 ± 9.6	-	59.8 ± 10.1	-	<.001*
Women	1,567	54.49%	92,733	48.33%	<.001*
Nerve block (CPT-64415)	1,360	47.29%	83,716	43.63%	<.001*
Nerve block with a catheter (CPT-64416)	162	5.63%	8,699	4.53%	.006*
Hypertension	2,222	77.26%	136,614	71.21%	<.001*
Rheumatoid arthritis	173	6.02%	7,721	4.02%	<.001*
Obesity	1,432	49.79%	81,772	42.62%	<.001*
Diabetes	1,305	45.38%	74,472	38.82%	<.001*
Chronic kidney disease	394	13.70%	21,918	11.42%	<.001*
Congestive heart failure	141	4.90%	7,906	4.12%	.041*
Hypothyroidism	806	28.03%	47,466	24.74%	<.001*
Biceps tenodesis	661	22.98%	41,615	21.69%	.100
Labral repair	140	4.87%	10,078	5.25%	.381
Subacromial decompression	2,460	85.54%	162,301	84.59%	.173
ECI (mean ± SD)	4.53 ± 3.31	-	3.94 ± 3.10	-	<.001*

CT, carpal tunnel; CPT, current procedural technology; ECI, Elixhauser comorbidity index.
* Indicates statistically significant results.

Table 3
Labral Repair Cohort Comorbidities*

Type of Arthroscopic Shoulder Surgery	Same Side (n = 227)		No CT (n = 29,406)		P Value
	n	%	N	%	
Age (y)	45.9 ± 13.2	-	35.9 ± 15.4	-	<.001†
Women	105	46.26%	9,733	33.10%	<.001†
Nerve block (CPT-64415)	103	45.37%	13,632	46.36%	.819
Nerve block with a catheter (CPT-64416)	17	7.49%	1,158	3.94%	.010†
Hypertension	138	60.79%	9,528	32.40%	<.001†
Rheumatoid arthritis	<11	-	406	1.38%	.441
Obesity	101	44.49%	7,840	26.66%	<.001†
Diabetes	76	33.48%	4,618	15.70%	<.001†
Chronic kidney disease	13	5.73%	1,017	3.46%	.093
Congestive heart failure	<11	-	380	1.29%	.038†
Hypothyroidism	46	20.26%	3,600	12.24%	<.001†
ECI (mean ± SD)	3.66 ± 2.92	-	2.22 ± 2.42	-	<.001†

CT, carpal tunnel; CPT, current procedural technology; ECI, Elixhauser comorbidity index.
* PearlDiver software does not report exact patient counts when defined groups are <11. The software uses the actual patient count in the statistical analysis.
† Indicates statistically significant results.

plexus block has various side effects including peripheral neuropathy. These results suggest that preoperative nerve blocks may increase the risk for patients to develop CTS after surgery.

This study demonstrated that patients who subsequently received a CTS diagnosis following arthroscopic RCR were older, more likely to be women, and had more comorbidities. This is consistent with previous literature demonstrating the demographics and comorbidities of patients who are likely to be diagnosed with CTS. Bahar-Moni et al[22] demonstrated that 80% of the patients undergoing carpal tunnel surgery in their cohort were women, with most belonging to the 41- to 60-year-old age group. Additionally, they found that hypertension, dyslipidemia, and diabetes were also significant risk factors.[22] Rhee et al[23] also demonstrated that women, patients with obesity, and those with rheumatoid arthritis were more likely to develop CTS. Having a complete understanding of each patient's demographics, comorbidities, and pre- and intraoperative care are vital in explaining potential risks of developing CTS following these procedures.

There are multiple possible contributing factors to the increased risk of postoperative CTS demonstrated in this study. Compressive neuropathies such as CTS develop beginning with the breakdown of the blood-nerve barrier and endoneurial edema, followed by perineurial thickening and localized demyelination.[24] Following surgery, it is possible the endoneurial edema accelerates from soft-tissue swelling and advances the downstream portion of pathology. Boardman et al[25] demonstrated that mechanical nerve injury, such as damage to the musculocutaneous nerve, during rotator cuff repairs occurs in 1% to 2% of patients. A systematic review by Nammour et al[26] also demonstrated anterior interosseous nerve palsy to be a rare but a possible result of shoulder arthroscopy secondary to mechanical trauma, compressive hematoma, and anesthetic neurotoxicity. Nerve injuries can also occur secondary to patient positioning during surgery.[27] Yian et al[13] also described postoperative mechanisms such as sling use, swelling, and repetitive rehabilitation exercises as potential risk factors for the development of compressive neuropathies following shoulder surgery. Another possible contributing factor is the concept of distracting injuries. Distracting injuries generally apply to trauma patients where up to 7% of injuries are initially missed because of the patient not reporting pain.[28] However, it is possible the patient's shoulder pathology could be acting as a distractor from already existing or worsening carpal tunnel pathology, which is then noticed by the patient after their shoulder is treated. Additionally, traction injuries could be a causative factor in the development of proximal nerve pathology and subsequent CTS after surgery. Even further, these traction injuries or patient positionings may also lead to proximal nerve changes that may cause greater susceptibility to compressive ischemia of distal nerve damage as a result. This study also supports the increased risk

Table 4
Biceps Tenodesis Cohort Comorbidities*

Type of Arthroscopic Shoulder Surgery	Same Side (n = 51)		No CT (n = 3,370)		P Value
	n	%	N	%	
Age (y)	57.1 ± 8.6	-	55.7 ± 11.8	-	.259
Women	20	39.22%	1,299	38.55%	1
Nerve block (CPT-64415)	23	45.10%	1,517	45.01%	1
Nerve block with a catheter (CPT-64416)	<11	-	153	4.54%	1
Hypertension	39	76.47%	2,249	66.74%	.188
Rheumatoid arthritis	<11	-	128	3.80%	.687
Obesity	23	45.10%	1,426	42.31%	.798
Diabetes	18	35.29%	1,210	35.91%	1
Chronic kidney disease	<11	-	344	10.21%	1
Congestive heart failure	<11	-	122	3.62%	1
Hypothyroidism	14	27.45%	789	23.41%	.611
ECI (mean ± SD)	3.67 ± 2.46	-	3.84 ± 3.08	-	.624

CT, carpal tunnel; CPT, current procedural technology; ECI, Elixhauser comorbidity index.
* PearlDiver software does not report exact patient counts when defined groups are <11. The software uses the actual patient count in the statistical analysis.

of developing CTS in those with comorbidities, as patients with higher rates of several comorbidities and ECI scores had higher rates of CTS. As such, the development of CTS following arthroscopic shoulder surgery is likely multifactorial in etiology but may also be related to factors such as postoperative swelling, rehabilitation, compression during surgical positioning, or patient comorbidities.

Limitations

This study has several limitations. First, the possibility of coding errors is inherent in any analysis of administrative claims data. Such instances are rare and made up only 0.7% of Medicare and Medicaid payments in 2021.[29] However, because this analysis relied on claims data, it is possible that uncharted CTS diagnoses, injections, or carpal tunnel release procedures were not captured. Second, this study could not evaluate other possible contributing factors to the risk of CTS diagnosis including but not limited to the length of surgery, patient positioning, specific shoulder pathology, or operative technique. The study was not able to evaluate the severity of the CTS symptoms such as constancy of symptoms and sensory or motor loss. Additionally, the information in the database did not contain information on the rate of spontaneous resolution of CTS symptoms without any intervention. It is also possible that a CTS diagnosis was made before surgery before the patient entered the database and would therefore be erroneously captured as a new complication. This study also was unable to comment on confirmatory testing to firmly establish a diagnosis of CTS. This study was also unable to examine the effectiveness of each treatment for postoperative CTS because this information is not available through a claims-based database. It has also been demonstrated that traction nerve injuries are more common in the lateral decubitus position compared with the beach chair position.[30] However, in this study, we could not obtain information on patient positioning in surgery, and thus, it is unknown whether patient positioning may be related to higher risk for development of postoperative CTS. Additionally, this study limited the specific procedures to rotator cuff repairs, labral repairs, and biceps tenodesis. Therefore, it is important to note that the results of this study may not be generalized to other arthroscopic shoulder surgeries not included in this list. Also, although the differences in rates of CTS following RCR and labral repair between the ipsilateral and contralateral sides were significantly different, the absolute difference in rate is small and may not be clinically significant. Finally, previous trauma or pathology outside of the shoulder arthroscopy was unable to be determined through the database. Therefore, we were unable to determine whether injury exists to the operative arm that would lead to greater likelihood of developing CTS compared with the nonsurgical arm.

This study demonstrated a significantly higher incidence of operative side CTS within 1 year following arthroscopic rotator cuff repair and labral repairs. Arthroscopic RCR was also associated with significantly increased risk of requiring operative side carpal tunnel injections and carpal tunnel release. Additionally, the postoperative development of CTS was more likely in women, older patients, and those with increased comorbidities. As such, it is vital that surgeons be aware of this association and evaluate and discuss these potential complications with each patient based on additional comorbidities and demographics.

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