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Original Research

Thoracic Outlet Syndrome in Major League Baseball Pitchers

Return to Sport and Performance Metrics After Rib Resection

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Background: Thoracic outlet syndrome (TOS) is a rare injury that affects Major League Baseball (MLB) pitchers and is often corrected with surgical resection of the first rib. There are limited return-to-play (RTP) data for this surgery in MLB pitchers.

Hypothesis: It was hypothesized that MLB pitchers who undergo first rib resection for TOS will show (1) a high rate of RTP, (2) no difference in postoperative career length compared with controls, (3) no difference in pre- and postoperative performance, and (4) no difference in postoperative performance compared with controls.

Study Design: Cohort study; Level of evidence, 3.

Methods: This retrospective cohort study evaluated MLB pitchers with neurogenic or vascular TOS who underwent rib resection surgery between January 1, 2001, and December 31, 2019. Players were identified through public injury reports from press releases, the MLB website, MLB team injury reports, and blogs. A demographics- and performance-matched control group was generated for comparison. Each player in the control group was given an index year that corresponded to the surgery year of the case group. Performance data included innings pitched (IP), games played (GP), earned run average (ERA), complete GP, shutouts, saves, hits, runs, home runs (HR), walks, strikeouts (K), walks plus hits per IP (WHIP), and earned runs (ER).

Results: We identified 26 MLB pitchers who underwent rib resection for neurogenic or vascular TOS; 21 players (81%) had a successful RTP. Pitchers were 30 ± 3.6 years old at the time of surgery and had played 6.2 ± 3.5 seasons before undergoing surgery. Average postoperative career length was 3.1 ± 2.0 seasons, with an average time from surgery to RTP being 10 ± 4.7 months. Pitchers who RTP showed no significant differences in performance metrics compared with controls. Players pitch 0.94 ($P < .05$) more IP/GP in the season directly following RTP compared with the season before surgical intervention.

Conclusion: MLB pitchers undergoing rib resection for TOS demonstrated (1) high RTP rates following rib resection, (2) no difference in postoperative career length compared with controls, (3) improvement in postoperative performance, and (4) no difference in postoperative performance compared with controls.

Keywords: thoracic outlet syndrome; Major League Baseball; pitcher; return to sport

Thoracic outlet syndrome (TOS) is a condition that arises from compression of the neurovascular structures in the cervicobrachial region as they pass through the thoracic outlet, defined as the space between the first thoracic vertebra, first rib, and manubrium of the sternum. The thoracic outlet is divided into 3 areas, which include the scalene triangle above the clavicle, the costoclavicular space between the clavicle and first rib, and the pectoralis minor space below the clavicle.[7] The neurovascular bundle consists of 3 structures that are subject to mechanical compression, which include the subclavian artery, the subclavian vein, and the brachial plexus, corresponding to arterial, venous, and neurogenic TOS, respectively.[7,11,23,26] The neurovascular bundle passes from the scalene triangle into the costoclavicular space and then exits through the pectoralis minor space.[7]

Compression of the neurovascular bundle in the thoracic outlet can occur via several adjacent structures, including the clavicle, first rib, and scalene muscles, or by a variety of other anomalies including fascial bands and cervical ribs.[5,7] Repetitive, high-intensity overhead exercise exerts pressure on these structures, placing high-performance

The Orthopaedic Journal of Sports Medicine, 10(4), 23259671221079835
DOI: 10.1177/23259671221079835
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athletes, including baseball pitchers, at increased risk for developing TOS.[5,6,15,28,36,40] Although the clinical presentation of TOS varies, common symptoms include a combination of upper extremity pain, weakness, numbness, edema, pallor, and/or paresthesia.[23,26] Neurogenic TOS is more common than vascular TOS and generally presents with pain, numbness, paresthesia, and weakness of the affected extremity.[23] Although less common, vascular TOS has potentially more serious complications than neurogenic TOS. The arterial subtype of vascular TOS can lead to intimal damage of the subclavian artery with eventual aneurysm formation and limb threatening ischemia. Similar intimal damage can occur in the venous subtype and lead to thromboembolic events.[23]

Given these nonspecific manifestations, diagnostic studies such as chest radiographs, electromyography, angiography, and anterior scalene lidocaine blocks are often necessary to diagnose TOS.[2,23,24] The first line of treatment for TOS is generally conservative, with activity modifications and physical therapy. When TOS is refractory to nonoperative measures, the standard surgical treatment is resection of the first rib. Rib resection has proven to be safe, technically feasible, and portends long-term relief of symptoms.[23,31,34]

After an injury, high-level athletes are often at increased pressure to quickly return to play (RTP) at peak levels of physical performance. Surgical intervention, postoperative recovery, secondary injury, reinjury and psychological readiness can all significantly affect athletic performance.[5,38,39] RTP rates and perioperative performance metrics among Major League Baseball (MLB) pitchers are well documented for ulnar collateral ligament reconstruction,[4,9,12,21] labrum repair,[4,14,33] and rotator cuff repair,[4] but are limited for first rib resection.[35] Thus, the objective of this study was to determine the RTP rate in MLB pitchers who undergo first rib resection for the treatment of TOS, and to assess the effect of surgery on perioperative performance metrics.

The purposes of this study were to determine (1) the RTP rate of MLB pitchers after rib resection for TOS, (2) postoperative career length compared with player-matched controls without rib resection for TOS, (3) pre- and postoperative performance, and (4) postoperative performance compared with player-matched controls without rib resection for TOS. We hypothesized that MLB pitchers who undergo first rib resection for a diagnosis of neurogenic or vascular TOS will show (1) a high rate of RTP, (2) no significant difference in postoperative career length compared with controls, (3) no significant difference in pre- and postoperative performance, and (4) no significant difference in postoperative performance compared with matched controls.

METHODS

This was a retrospective cohort study that evaluated MLB pitchers with a diagnosis of neurogenic or vascular TOS who underwent rib resection and decompression surgery between January 1, 2001, and December 31, 2019. The players were identified manually through publicly available injury reports from press releases, reports from the MLB website (https://www.mlb.com/news), MLB team injury reports, player profiles and biographies, and blogs (https://blogs.fangraphs.com/). Several published studies have employed this method of data collection.[§] Because all patient information is publicly available, this study was determined to be exempt from institutional review board approval.

All players identified were included in the RTP analysis. A player was determined to RTP if he pitched in any MLB game after surgery during the study period. A player did not RTP if he did not pitch in any MLB game after surgery. Inclusion criteria included players who (1) pitched for at least 1 season in the MLB before surgery, (2) had a diagnosis of neurogenic or vascular TOS on their pitching side, and (3) underwent rib resection for treatment. Exclusion criteria included players who (1) underwent surgery before completing their first MLB season or (2) played a position other than pitcher during the study period. Players were also excluded if their surgery occurred within 18 months of the end of the study period because this was determined to be too short of an opportunity to RTP. Players were included if they met inclusion criteria that was verified by at least 3 of the sources listed above. Information from all sources was compared for accuracy. Players were excluded if there was any discrepancy in either the diagnosis or procedure or if it was not verifiable by at least 3 independent sources (Figure 1).

Demographic data collected included player height, weight, body mass index (BMI), pitching position at the time of surgery, handedness, age at time of surgery, date of surgery, date of final game before surgery, and game of first game back from surgery. Cases were classified as either neurogenic or vascular TOS. This was determined by the sources stating the diagnosis directly or inferred based on the players presenting symptoms, with numbness and paresthesia corresponding to neurogenic TOS

[§]References 1, 3, 12, 13, 16, 18–20, 25, 29, 30.

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Final revision submitted November 11, 2021; accepted November 30, 2021.

One or more of the authors has declared the following potential conflict of interest or source of funding: H.A.G. has received hospitality payments from W.L. Gore. K.J.J. has received speaking fees from Arthrex and Linvatec and consulting fees and honoraria from Joint Restoration Foundation. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was waived by the University of California, Los Angeles (reference No. 21-001925).

Figure 1. Flowchart of player inclusion in the study. MLB, Major League Baseball; TOS, thoracic outlet syndrome.

and thromboembolism and swelling corresponding to vascular TOS.

Pre- and postoperative performance metrics were collected from publicly available internet databases (https://www.baseball-reference.com/ and https://stathead.com/). For each pitcher, all regular season games were included in the analysis. At the time of the study, the 2020 season was ongoing and was therefore not included. No performance data from the 2020 season were included in analysis. Players who were able to RTP were included in the performance analysis, and only data from regular-season MLB games were included. Performance data included the following: innings pitched (IP), games played (GP), earned run average (ERA), complete games (CG) played, shutouts, saves, hits, runs, home runs (HR), walks, strikeouts (K), walks plus hits per IP (WHIP), and earned runs (ER). These metrics were collected as mean values for each player over the course of his pre- and postoperative career. Performance metrics were divided by GP and IP in order to control for variation in playing time per season. This same analysis was performed for the single season directly preceding surgery and the first full season after achieving RTP. If a player underwent surgery in the middle of a season, only the data from that same season leading up to surgery were used as the presurgery metrics.

TABLE 1
Demographic Differences Between Case and Control Groups[a]

Characteristic	Cases (n=21)	Controls (=21)	P
Age at surgery/index year, y	30 ± 3.9	30 ± 3.9	.82
BMI, kg/m^2	27 ± 1.5	27 ± 2.7	.45
Seasons played before surgery/index	6.4 ± 3.8	6.4 ± 3.8	>.99
Age at MLB debut, y	23 ± 1.5	23 ± 1.4	.72
Handedness (%)			
Right	17 (80%)	17 (80%)	> .99
Left	4 (19%)	4 (19%)	> .99
Pitching position (%)			
Starters	16 (76%)	16 (76%)	> .99
Relievers	5 (24%)	5 (24%)	> .99

[a]Data are reported as mean ± SD or n (%). BMI, body mass index; MLB, Major League Baseball.

A player-matched control group was made for comparison of performance metrics. Controls were matched based on demographic parameters, including BMI, seasons played in the MLB, age at MLB debut, handedness, and pitching position (Table 1). Controls were also matched to cases based on preoperative performance, with groups showing no significant difference. Each control player was given an index year that was equivalent to the year of surgery for the case group to compare preoperative and postoperative performance data. For instance, if a pitcher had surgery 4 years after his MLB debut, the control player's index year was placed 4 years after his debut.

Players who successfully RTP were compared with those who did not RTP using chi-square, Fisher exact test, and paired-samples t test as appropriate. These analyses were also performed to compare venous and neurogenic TOS demographics. Binary logistic regression was performed to identify predictors of successful RTP. Pre- and postoperative metrics were compared between the case and control groups using a 2-tailed paired-samples Student t test. This technique was also used to compare pre- with postoperative metrics within each group (cases or controls). Positive difference values corresponded to improvements in performance after the surgery/index year and negative values corresponded to declines in performance after the surgery/index year. Linear regression was performed to determine the change in number of rib resections performed over the study time period. A Kaplan-Meier survivorship curve with MLB retirement as the endpoint was constructed postoperatively for cases and postindex for controls. The log-rank test was performed to determine differences in career survival after surgery/index. Statistical significance was defined as a $P < .05$.

RESULTS

This study identified 26 players with diagnosed TOS who underwent rib resection surgery. Of these 26 cases, 4 (15%)

Figure 2. Number of publicly reported rib resections performed per year of the study period (n = 26).

Figure 3. Kaplan-Meier plot for career survival after surgery/index year for cases and controls. MLB, Major League Baseball.

had a vascular etiology, and the remaining 22 (85%) were neurogenic. Pitchers played 6.2 ± 3.5 (mean ± SD) seasons before undergoing surgery, with a total professional career length of 8.7 ± 4.0 seasons. Player's age and BMI at the time of surgery was 30 ± 3.6 years and 27 ± 1.6 kg/m^2, respectively. Five players were actively pitching in the MLB at the time of the study. Linear regression showed that the incidence of publicly reported rib resections per year increased over the course of the study period ($R = 0.73$, $R^2 = 0.53$, $P < .05$) (Figure 2).

Overall, 21 (81%) players were able to RTP in the MLB during the study period and 17 (65%) returned to play for more than 1 season postoperatively. Professional career length after surgery was 3.1 ± 2.0 seasons, with the average time from surgery to RTP being 10 ± 4.7 months (Figure 3). The RTP rate for neurogenic and vascular TOS were 82% and 75%, respectively, but this was not a significant difference ($P = .75$). Binary logistic regression showed that BMI, age at debut, seasons played before surgery, pitching position, age at surgery, and TOS variant were not significant predictors for ability to RTP. Log rank test showed no significant difference in career survival between cases and controls after surgery or index year ($P = .43$). When comparing players who did and did not successfully RTP, handedness, pitching position, TOS etiology, age at time of surgery, BMI, and age at MLB debut did not differ significantly (Table 2). The non-RTP cohort showed a significantly higher percentage of relievers compared with the RTP cohort ($P < .05$) (Table 2). The venous and neurogenic TOS cohorts did not differ in terms of time to RTP, BMI, age at MLB debut, seasons played before surgery, seasons

TABLE 2
Demographic Comparison Between Players Who Did and Did Not RTP[a]

Variable	RTP (n = 21)	Did Not RTP (n = 5)	*P*
Age at time of surgery, y	30 ± 3.9	30 ± 2.2	.89
BMI, kg/m^2	27 ± 1.5	26 ± 2.2	.26
Seasons played before surgery	6.4 ± 3.7	5.2 ± 2.5	.51
Age at MLB debut, y	23 ± 1.5	24 ± 1.8	.47
Handedness			
Right	17 (80%)	3 (60%)	.32
Left	4 (19%)	2 (40%)	.32
Pitching position			
Starters	16 (76%)	1 (20%)	**.02**
Relievers	5 (24%)	4 (80%)	**.02**
TOS variant			
Neurogenic	18 (86%)	4 (80%)	.75
Venous	3 (14%)	1 (20%)	.75

[a]Data are reported as mean ± SD or n (%). Bolded *P* values indicate statistically significant difference between groups ($P < .05$). BMI, body mass index; MLB, Major League Baseball; TOS, thoracic outlet syndrome.

TABLE 3
Difference in Career Performance Before and After Surgery/Index Year for Cases and Controls[a]

	Cases, Before vs After Surgery		Controls, Before vs After Index	
Metric	Difference ± SD	*P*	Difference ± SD	*P*
IP/GP	0.51 ± 1.5	.14	0.57 ± 0.82	**.01**
IP/season	24 ± 56	.07	22.5 ± 56.8	.08
GP/season	4.8 ± 11	.06	2.2 ± 13.6	.46
ERA	-0.57 ± 1.8	.16	-0.96 ± 1.9	**.03**
CG/GP	0.014 ± 0.031	.05	0.017 ± 0.027	**.01**
Shutouts/GP	0.0045 ± 0.019	.28	0.0057 ± 0.016	.13
Saves/GP	0.0098 ± 0.023	.07	-0.005 ± 0.025	.37
Hits/IP	-0.076 ± 0.22	.12	-0.072 ± 0.24	.19
Runs/IP	-0.074 ± 0.20	.10	-0.098 ± 0.2	**.03**
HR/IP	-0.050 ± 0.082	**.01**	-0.049 ± 0.065	**.01**
Walks/IP	-0.036 ± 0.098	.10	-0.0015 ± 0.14	.96
K/IP	0.0031 ± 0.13	.91	0.075 ± 0.22	.13
WHIP	-0.11 ± 0.27	.07	-0.074 ± 0.29	.26
ER/IP	-0.063 ± 0.20	.16	-0.11 ± 0.21	**.03**

[a]Bolded *P* values indicate statistically significant differences ($P < .05$). CG, complete games; ER, earned runs; ERA, earned run average; GP, games played; HR, home runs; IP, innings pitched; K, strikeouts; WHIP walks plus hits per IP.

TABLE 4
Difference in Performance 1 Year Before Surgery/Index Year Compared With the First Full Season After RTP/Index Year for Cases and Controls[a]

	Cases, 1 y Before vs Season After RTP		Controls, 1 y Before vs Season After Index	
Metric	Difference ± SD	*P*	Difference ± SD	*P*
IP/GP	0.94 ± 1.5	**.01**	-0.055 ± 1.1	.81
IP/season	10 ± 70	.49	7.7 ± 58	.55
GP/season	3.2 ± 18	.42	2.8 ± 13.8	.37
ERA	0.057 ± 2.8	.93	-0.39 ± 1.7	.31
CG/GP	0.015 ± 0.058	.26	-0.0044 ± 0.031	.53
Shutouts/GP	0.0033 ± 0.027	.59	0.00035 ± 0.015	.92
Saves/GP	0.0081 ± 0.045	.42	-0.00009 ± 0.037	.99
Hits/IP	0.01 ± 0.35	.89	0.014 ± 0.27	.82
Runs/IP	0.027 ± 0.31	.69	-0.033 ± 0.19	.43
HR/IP	-0.041 ± 0.112	.13	-0.04 ± 0.066	**.01**
Walks/IP	-0.047 ± 0.20	.30	0.038 ± 0.16	.28
K/IP	0.026 ± 0.18	.51	0.046 ± 0.26	.42
WHIP	-0.037 ± 0.35	.63	0.054 ± 0.22	.27
ER/IP	0.0089 ± 0.32	.90	-0.045 ± 0.2	.31

[a]Bolded *P* values indicate statistically significant differences ($P < .05$). CG, complete games; ER, earned runs; ERA, earned run average; GP, games played; HR, home runs; IP, innings pitched; K, strikeouts; WHIP walks plus hits per IP.

played after surgery, total career length, and time to RTP. The vascular TOS cohort underwent surgery at a younger age compared with the neurogenic cohort (26 ± 1.3 vs 30 ± 3.5 years; $P < .05$).

Comparison of all pre- to postoperative performance across all seasons showed that within the case group, pitchers pitched 0.045 ± 0.082 ($P < .05$) fewer HR/IP over their postoperative career, and within the control group, pitchers pitched 0.57 ± 0.82 more IP/GP and 0.02 ± 0.027 CG/GP ($P < .05$); the control group also showed decreases of 0.098 ± 0.20 runs/IP, 0.049 ± 0.065 HR/IP, 0.11 ± 0.21 ER/IP, and 0.96 ± 1.9 ERA ($P < .05$) (Table 3). When the season directly preceding surgery was compared with the first full season after RTP for the case group, there was an increase of 0.94 ± 1.5 ($P < .05$) IP/GP (Table 4). When the season directly preceding the index year was compared with the season directly following the index year for the control group, there was a decrease of 0.04 ± 0.066 ($P < .05$) HR/IP (Table 4). No other performance metrics were significantly different between pre- and postoperative values. There were no significant differences between cases and controls in career performance, both before surgery/index year and after surgery/index year (Table 5).

TABLE 5
Difference in Career Performance Before and After Surgery/Index Between Cases and Controls[a]

	Cases vs Controls, Before Surgery/Index		Cases vs Controls, After Surgery/Index	
Metric	Difference ± SD	*P*	Difference ± SD	*P*
IP/GP	-0.45 ± 1.4	.15	-0.4 ± 1.5	.23
IP/season	-6.1 ± 33.9	.42	-7.3 ± 50.8	.52
GP/season	1.4 ± 10.3	.54	-1.1 ± 13.8	.71
ERA	-0.16 ± 0.83	.38	-0.55 ± 2.3	.28
CG/GP	-0.002 ± 0.046	.85	0.00061 ± 0.027	.92
Shutouts/GP	0.00024 ± 0.023	.65	0.0035 ± 0.013	.22
Saves/GP	0.009 ± 0.022	.08	-0.0058 ± 0.013	.22
Hits/IP	-0.0025 ± 0.15	.94	0.0012 ± 0.28	.99
Runs/IP	-0.016 ± 0.098	.48	-0.04 ± 0.25	.47
HR/IP	-0.0086 ± 0.04	.34	-0.0082 ± 0.098	.71
Walks/IP	0.00096 ± 0.085	.96	0.036 ± 0.14	.24
K/IP	-0.015 ± 0.15	.65	0.057 ± 0.3	.40
WHIP	-0.001 ± 0.17	.98	0.037 ± 0.36	.64
ER/IP	-0.018 ± 0.092	.38	-0.061 ± 0.25	.28

[a]CG, complete games; ER, earned runs; ERA, earned run average; GP, games played; HR, home runs; IP, innings pitched; K, strikeouts; WHIP walks plus hits per IP.

DISCUSSION

We found that MLB pitchers undergoing rib resection for TOS showed RTP rates of 81%. Pitchers saw an immediate increase in the number of IP per game in the season after RTP. The findings of this study suggest that players undergoing rib resection for TOS can expect to RTP at a high rate, at the same performance level or better as compared with before undergoing rib resection surgery.

TOS is a progressive injury, presumed to be at its most severe just before a player undergoes surgery. This can lead to limited playing time secondary to pain and dysfunction. On average, athletes with neurogenic TOS exhibit

symptoms for 11 months before surgical evaluation while venous TOS presents more acutely with a mean time of 1.6 months.[5] This suggests that the single season before surgery may reflect a pitcher's performance while experiencing the symptoms of TOS. This study compared the season directly before surgery to the first full season after RTP and found that they pitched an average of 0.94 more innings per game after undergoing surgery. This study included performance data from the same season leading up to surgery, which could bias the results toward poorer presurgery performance because players were likely symptomatic from TOS symptoms. The increase in IP per game after surgery should be interpreted with this in mind. This difference was not seen in the control group, suggesting that players with TOS benefited from surgery and were able to pitch for longer as a result. This is consistent with the literature, as most athletes who undergo rib resection for TOS report a resolution of symptoms.[32] No other performance metrics showed significant differences in the case group, so rib resection does not appear to have any negative effect on performance. For players who experience limitations in playing time due to symptoms of TOS, these findings suggest that rib resection may allow pitchers to pitch more without any significant performance consequences.

The results of this study demonstrate that MLB pitchers who undergo rib resection for TOS can expect high RTP rates, comparable with the more commonly performed ulnar collateral ligament (UCL) reconstruction rates of 79% to 100%.[9,12] Furthermore, our findings show that pitchers generally return quickly from surgery and most play the following season, with an average RTP time of only 10 months from the time of surgery. One study of rib resection for TOS in competitive athletes documented a mean recovery rate of 4.4 months,[5] with another study reporting 50% of their athletes returning within 6 months and the remainder returning within 12 months.[32] This is in stark contrast to the 20-month average recovery period following UCL reconstruction.[9] The faster recovery for TOS rib resection is likely due to the fact that the symptoms are caused by compression of the native structures of the upper extremity as opposed to any traumatic ruptures or tears, allowing for rapid resolution of symptoms following decompression. Because no reconstruction is involved, there is no need to allow for any bone-tendon or bone-ligament healing, as is the case for many orthopaedic surgeries performed in this population. In the event that surgery becomes the only course of action to relieve a pitcher's symptoms, knowing the time to RTP can help inform surgical and roster planning.

Although the high RTP rates are encouraging, rib resection for TOS was a career-ending surgery for nearly 20% of players. This study did not identify any significant risk factors for being unable to RTP following rib resection, though the cohort of players who did not RTP was composed of a significantly higher percentage of relievers. Compared with starting pitchers, relievers pitch for less innings in a game, but also tend to pitch harder while in play. In addition, they tend to have less recovery time between games than starters. There is debate over which type of pitcher is more susceptible to overuse injuries such as UCL tears.[8,10,22] Given how rare TOS is among MLB pitchers, extra attention to detail must be taken in documenting each player's recovery process so that risk factors for inferior outcomes following surgical intervention may be identified.

Gutman et al[17] recently published RTP data on MLB pitchers following treatment for TOS. They found a lower RTP of 74% compared with the 81% found in the present study. In addition, they found a higher percentage of pitchers with vascular TOS. A possible explanation for this is that they included players with all surgical management for TOS, whereas this study included only those undergoing rib resections. Many cases of vascular TOS are treated with thrombolysis and embolectomy without decompression surgery.[37] Players treated solely with this method were excluded from this study and could explain our lower number of vascular cases. Athletes treated solely with thrombolysis or embolectomy without decompression surgery may be at increased risk of recurrence.[27] The present study excluded pitchers treated by these methods and thus could explain our higher RTP rate. Thompson et al[35] found a 77% RTP rate for MLB pitchers with neurogenic TOS undergoing rib resection, closer to the 82% RTP rate for neurogenic TOS reported here. For athletes, physicians, and trainers, this study provides the most up-to-date RTP data on pitchers undergoing rib resection surgery for neurogenic or venous TOS. In addition, this study is the first to include a player-matched control group for MLB pitchers undergoing rib resection for TOS.

This study has several limitations. Despite being the largest study examining rib resection for TOS in MLB pitchers, we are still limited by a small sample size due to how rare TOS is among MLB pitchers. A post hoc power analysis performed for the differences in player performance showed that this study was underpowered across the majority of metrics. Thus, there is opportunity for type 2 error, and there may be significant differences that this study was unable to detect. In addition, this study was underpowered to determine significant differences between neurogenic and vascular TOS due to the limited number of vascular cases. The lack of significant findings in this study should be interpreted with this in mind. The presurgery performance metrics for the case group included the season of surgery, which could bias the results toward inferior performance due to players being symptomatic from TOS. In addition, this could have led to selection of a control group of lower caliber performance compared with the case group when healthy. The use of publicly available data accessed via the internet introduces the possibility of selection bias in our study cohort. Indeed, our study indicates that the publicly reported incidence of rib resection in MLB pitchers has been rising over time. It is difficult to discern whether this represents a true increase in the number of operations being performed or an increase in reporting due to a growing internet presence of athletes, reporters, and baseball clubs over the course of the study. This study was not able to identify all nonoperative diagnoses of TOS, so we are unable to inform on what proportion of players receive surgery and how it compares with nonoperative management. We were also unable to determine how long each player

experienced symptoms and whether they had predisposing factors such as presence of a cervical rib. In addition, the performance analysis only included players who were able to RTP, biasing the results to those with successful surgery and better performance. This study also only used MLB athletes, and it is unknown whether these results are generalizable to other pitchers at the minor league or collegiate level.

TOS remains a rare condition in MLB pitchers. With more players electing to undergo rib resection, more information about its implications for career survival and performance has become available. The results of this study should dispel some of the uncertainty regarding this procedure and provide data to aid in informed decision-making concerning the optimal treatment path for those pitching at the highest professional level.

CONCLUSION

MLB pitchers undergoing rib resection for TOS demonstrated high RTP rates following rib resection, no difference in postoperative career length compared with controls, improvement in postoperative performance, and no difference in postoperative performance compared with controls.

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