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ORIGINAL ARTICLE

Surgical Management of Neurogenic Thoracic Outlet Syndrome: A Systematic Review and Meta-analysis

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ABSTRACT

Background: The thoracic outlet is the passage from the supraclavicular fossa to the axilla, connecting the first rib and the clavicle.**Aim:** To evaluate the clinical and radiological results of neurogenic thoracic outlet syndrome following surgical intervention**. Patients and Methods:** We conducted a search for possibly suitable titles in many electronic databases, including MEDLINE (via PubMed), SCOPUS, EMBASE,and Google Scholar, utilizing relevant keywords. The utilized keywords comprised: Transaxillary resection - Thoracic outlet syndrome - Posterior approach - Supraclavicular approach - Thoracic outlet decompression - compression neuropathy- brachial plexus- anterior scalene muscle- Treatment strategy.

Results: The rate of success (determined as excellent, good, or fair results) for supraclavicular 1st rib excision with scalenectomy (SAFRE), trans axillary 1st rib resection (TAFRR), and rib-sparing scalenectomy (RSS) were 93.2%, 87.9 percent and 97.4 percent respectively (TAFRR vs. SAFRE, P-value <.05; SAFRE verses. RSS, P >.05; RSS vs. TAFRR, P-value<.05. The following surgery DASH scores for each group were as follows: 23.6 (ninety-five percent confidence interval, 18.0, 29.2) for SAFRE, 27.9 (ninety-five percent confidence interval, 14.8, 41.1) for TAFRR, and 13.4 (−9.6, 36.5) for RSS. SAFRE and TAFRR had an overall postoperative CBSQ score of 30.4 (ninety-five percent confidence interval, 7.8, 53.0) and 32.4 (ninety-five percent confidence interval, 23.3, 41.5), respectively. There were statistically insignificant variances in postoperative CBSQ and DASH scores among the groups (P-value>.05).

Conclusions: Rib-Sparing Scalenectomy (RSS) has the highest success rate for treating nTOS, with superior outcomes compared to First Rib Resection (FRR), with TAFRR showing better improvement.

Key words: Thoracic;RSS; SAFRE.

INTRODUCATION

Thoracic outlet syndrome (TOS) is a diverse collection of conditions that are distinguished by the damage and/or compression of to the neurovascular structures at the thoracic outlet, which is the passage from the thorax into the neck. One or more anatomic structures of the upper thoracic outlets (the subclavian artery, the brachial plexus, and/or the subclavian vein) might be involved. Compression and injury to these structures are the result of a diverse array of causes [1].

The thoracic outlet is the portion of the body that extends from the supraclavicular fossa to the axilla, passing among the 1st rib and the clavicle. A classic distinction is made between venous thoracic outlet syndrome (vTOS), arterial thoracic outlet syndrome (aTOS) and neurogenic thoracic outlet syndrome

(nTOS). The percentage of neurogenic thoracic outlet syndrome was eighty-two percent in major patients' series from the United States of America, for instance, in a prospective analysis of outpatient patients at the University of South Florida.[٢].

The percentage of cases who had operations for thoracic outlet syndrome ranged from eighty-two to eighty-five percent, and the cases whose thoracic outlet syndrome were diagnosed as neurogenic thoracic outlet syndrome using the uniform standards established by the Society for Vascular Surgery. The percentage of female cases diagnosed with neurogenic thoracic outlet syndrome increased from fifty-nine percent to ninety-five percent over the course of the study. A difficulty in terms of methodology is presented by the precise determination of the occurrence and prevalence of neurogenic thoracic outlet syndrome. [٣].

The aim of this investigation was to evaluate the radiological and clinical results of neurogenic thoracic outlet syndrome following an operation.

METHODS

This investigation is a systematic review and meta-analysis has been performed in Orthopedic Surgery Department, Zagazig University Hospitals. We conducted a search for possibly qualifying titles and abstracts in several electronic databases, including MEDLINE (via PubMed), Google Scholar, SCOPUS, and EMBASE, utilizing relevant keywords. The utilized keywords comprised: Transaxillary resection - Thoracic outlet syndrome - Posterior approach - Supraclavicular approach - Thoracic outlet decompression - compression neuropathy- brachial plexus- anterior scalene muscle- Treatment strategy

Inclusion criteria: All case reports, case series, and clinical studies presented as full-text articles regarding the operative care of neurogenic thoracic outlet syndrome in the English literature. All levels of evidence have been involved.

Exclusion criteria: The exclusion criteria were duplicates, inaccessible, unrelated, biomechanical research, full texts (abstract-only papers), reports involving cases under eighteen years of age, venous thoracic outlet syndrome, non-English literature, and arterial thoracic outlet syndrome.

Data extraction

The following is a structured extraction excel file that we entitled data collecting from the full texts that were included: Involving general information such as type of publication , title, origin country , author, and characteristics of research (such as the, randomization techniques, design, quality assessment or possibility of objectives of the study ,bias, etc.), characteristics of the participants (such as age, sex, mechanism of injury, the number of patients, related injuries, neurological deficits, etc.), management and intervention modalities, complications of an operation, monitoring time, and results, and so on.

Assessment of quality: It utilized checklists, which have a preference above quality scores, to assess the methodological quality of the research.

Data analysis: Both a forest plot and a funnel plot are what are used to represent the findings of the data analysis.

Administrative design: The protocol for the research was presented to the Institutional Review Board (IRB) of Zagazig University for assessment and validation.

RESULTS

A total of 10 studies have been selected for the current analysis, including a total of 1729 patient. The publication year ranged from 2012 to 2021. Sample sizes vary across the studies, ranging from 15 to 473 patients, reflecting a broad spectrum of research in different medical domains. Some studies include bilateral assessments, indicated by the mention of sides, while others focus on unilateral evaluations. Mean age was 36.9, the diverse age distributions highlight the heterogeneity among the study populations, underscoring the importance of considering age factors in the interpretation of the respective study outcomes. Baseline characteristics of involved investigation are demonstrated in (Table 1).

There was a total of ten investigations that were examined, and five of them described supraclavicular first rib excision with scalenectomy (812 cases), three described trans axillary first rib resection (478 cases), and two described rib-sparing scalenectomy (720 cases). Regarding the investigations that were incorporated, there were four retrospective series, six prospective series, and not a single randomized controlled trial. In order to determine the potential for bias in retrospective research, the National Institutes of Health Quality Assessment Tool for Case Series Studies has been utilized through the assessment process. Accordingly, all of these had "good "quality. When contrasted with prospective research, this did not serve to infer that the quality of these retrospective investigations was particularly good. When comparing different research and groups, age and follow-up time were shown to be different(Table2). The results for each group in the postoperative DASH assessment were as follows: twenty-three

(ninety-five percent confidence interval, 18.0, 29.2) for the SAFRE, 27.9(ninety-five percent confidence interval, 14.8, 41.1) for the trans axillary first rib resection, and 13.4 (−9.6, 36.5) for the rib-sparing scalenectomy. An overall CBSQ score of 30.4 (ninety-five percent confidence interval, 7.8, 53.0) was obtained for SAFRE, while the score for trans axillary 1st rib resection was 32.4 ninety-five percent confidence interval, 23.3, 41.5). There was statistically insignificant variance between the groups in terms of postoperative DASH and CBSQ scores (P-value greater than 05) (Table 3).

The success rates for SAFRE, trans axillary 1st rib resection, and RSS were 93.2 percent, 87.9 percent, and 97.4percent, respectively. These success rates were characterized as excellent, good, or fair findings. They were statistically significant (supraclavicular 1st rib excision with scalenectomy vs trans axillary first rib resection, P-value less than .05; supraclavicular first rib excision with scalenectomy versus rib-sparing scalenectomy, P-value greater than .05; trans axillary first rib resection versus rib-sparing scalenectomy, P\.05) (Figure 2).

Mean difference was as follows: rib-sparing scalenectomy 42.98 (95% CI31.97,54.0), first rib scalenectomy with excision 21.76 (ninety-five percent confidence interval, 17.06, 26.46), trans axillary first rib resection: 26.8 (ninety-five percent confidence interval, 18.87, 34.73). It was determined was a statistically significant distinction has been observed among the groups (P-value less than .05). The SMD between investigations was used to generate the ninety-five percent prediction interval, which has been determined to be between 0.2 and 3.2. In each individual research, the black squares reflect the average scores, and the error bars represent the ninety-five percent confidence interval for the variance among the groups. Both the pooled mean variance and the confidence interval of ninety-five percent for this difference are represented by the diamond. (Figure 3)

We conducted an initial search of several databases, which resulted in the discovery of 2009 reports. Out of those reports, the endnote software deemed 252 to be duplicates and hence excluded them. After reviewing the remaining 1757 publications based on their titles and abstracts, it was discovered that 1675 other studies had been excluded for a variety of reasons. Following 107 examines were eliminated from the meta-analysis due to full-text screening, we eventually decided to include Ten additional reports (Figure 1).

Table 1: Study and Patient's characteristics

NO.	Study ID	Study design	NO. of participants	side	Age	
					mean	Range
1	Caputo et al. (4)	Retrospective study	185 patients	254 sides 70 Bi=140 114 uni	40	19 - 80
2	Al Hashel et al. (5)	Prospective study	136 patients	147 sides	34	18-57
3	Ohman et al. (6)	prospective observational cohort study	409 patients	-	36	17-73
4	Gelabert et al. (7)	Prospective study	46 patients	-	-	19-68
5	Balderman et al. (8)	prospective observational cohort study	259 patients	-	32.2	17-55
6	Johnson et al. (9)	Retrospective study	165 patients	175 sides	38	15-64

NO.	Study ID	Study design	NO. of participants	side	Age	
					mean	Range
7	Dua el al. (10)	Prospective study	15 patients	-	44	29-64
8	Lie et al et al. (11)	Retrospective study	24 patients	-	38	23-54
9	Hawng et al. (12)	Retrospective study	17 patients	-	35	15-54
10	Guarrderma et al.,2021	- Prospective study	473 patients	-	35	18-55

Table 2: Demographics Depend on Surgical Approach

Surgical Approach	NO. of participants	Age			Proportion of woman			Follow-up (months)		
		mean	SD	Range	mean	SD	Range	mean	SD	Range
(SCFRR) supraclavicular FRR with scalenectomy	812	34.6	5.1	17.3-40.6	77%	6%	54-84%	15.2	17.8	3-44.4
(TAFRR) transaxillary first rib resection with scalenectomy.	478	40.5	2	35-41.8	79%	2.8 %	77-84%	28.3	9.2	15-44.7
RSS	720	33.0	3.2	29-53	76%	4.3 %	71-100%	14.5	13.6	4.5-102

Table 3: Summary of Preoperative and cases Reported results Measures following surgery.

Approach	Outcome	Timeline	# of articles included	Patients (N)	Score (CI)
SCFRR	(DASH) Disabilities of Arm, Shoulder and Hand	Preoperative	9	763	45.6 (ninety-five percent confident interval, 38.9, 52.4)
		Combined postoperative	9	771	23.6 (ninety-five percent confident, 18.0, 29.2)
	(CBSQ) Cervical Brachial Symptom Questionnaire	Preoperative	3	309	70.3 (ninety-five percent confident, 62.8, 77.8)
		Combined	2	219	30.4 (ninety-five

Approach	Outcome	Timeline	# of articles included	Patients (N)	Score (CI)
		postoperative			percent confident, 7.8, 53.0)
	(VAS) Visual Analogue Scale	Preoperative	3	238	5.4 (ninety-five percent confident, 4.1, 6.6)
		Combined postoperative	3	238	2.4 (ninety-five percent confident, 0.8, 3.9)
TAFRR	(DASH) Disabilities of Arm, Shoulder and Hand	Preoperative	2	323	56.8 (ninety-five percent confident, 49.0, 64.8)
		Combined postoperative	2	76	27.9 (ninety-five percent confident, 14.8, 41.1)
	(CBSQ) Cervical Brachial Symptom Questionnaire	Preoperative	-	-	-
		Combined postoperative	2	114	32.4 (ninety-five percent confident, 23.3, 41.5)
	(VAS) Visual Analogue Scale	Preoperative	2	73	7.5 (ninety-five percent confident, 7.1, 8.0)
		Combined postoperative	2	73	2.3 (ninety-five percent confident, 0.1, 4.5)
RSS	(DASH) Disabilities of Arm, Shoulder and Hand	Preoperative	2	458	58.3 (ninety-five percent confident, 48.5, 68.1)
		Combined postoperative	2	458	13.4 (ninety-five percent confident, −9.6, 36.5)

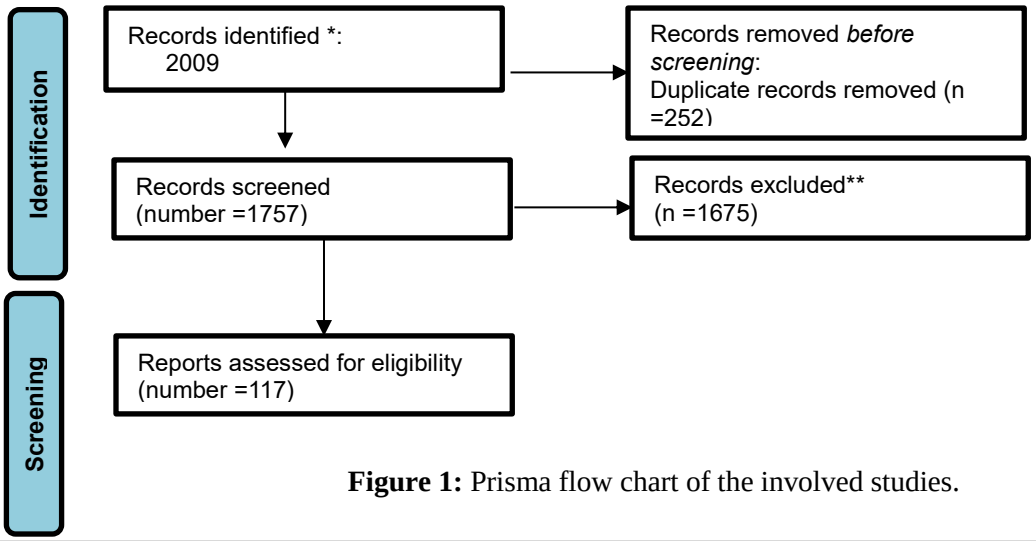

Figure 1: Prisma flow chart of the involved studies.

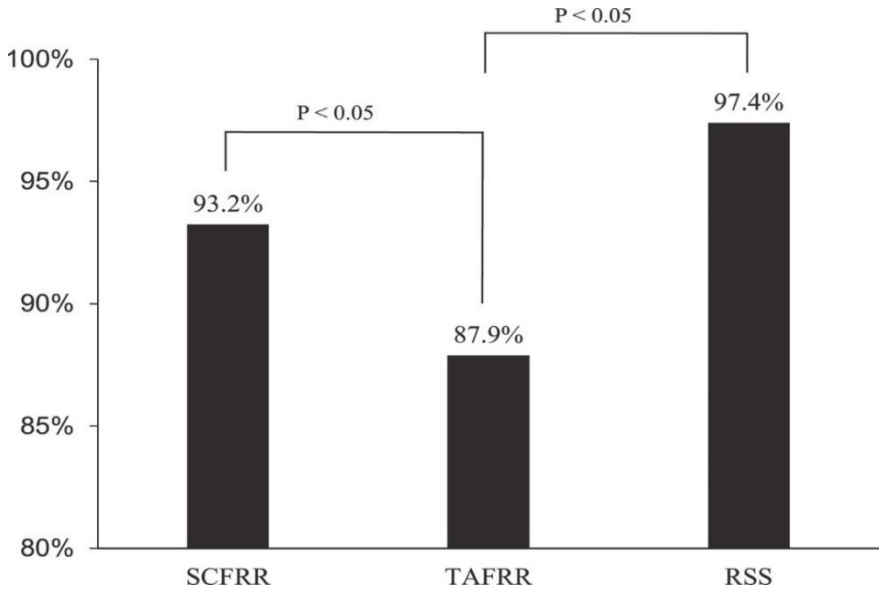

Figure 2: Derkash score-based Success Rate. Trans axillary first rib resection with scalenectomy and supraclavicular first rib resection with scalenectomy is both common surgical procedures.

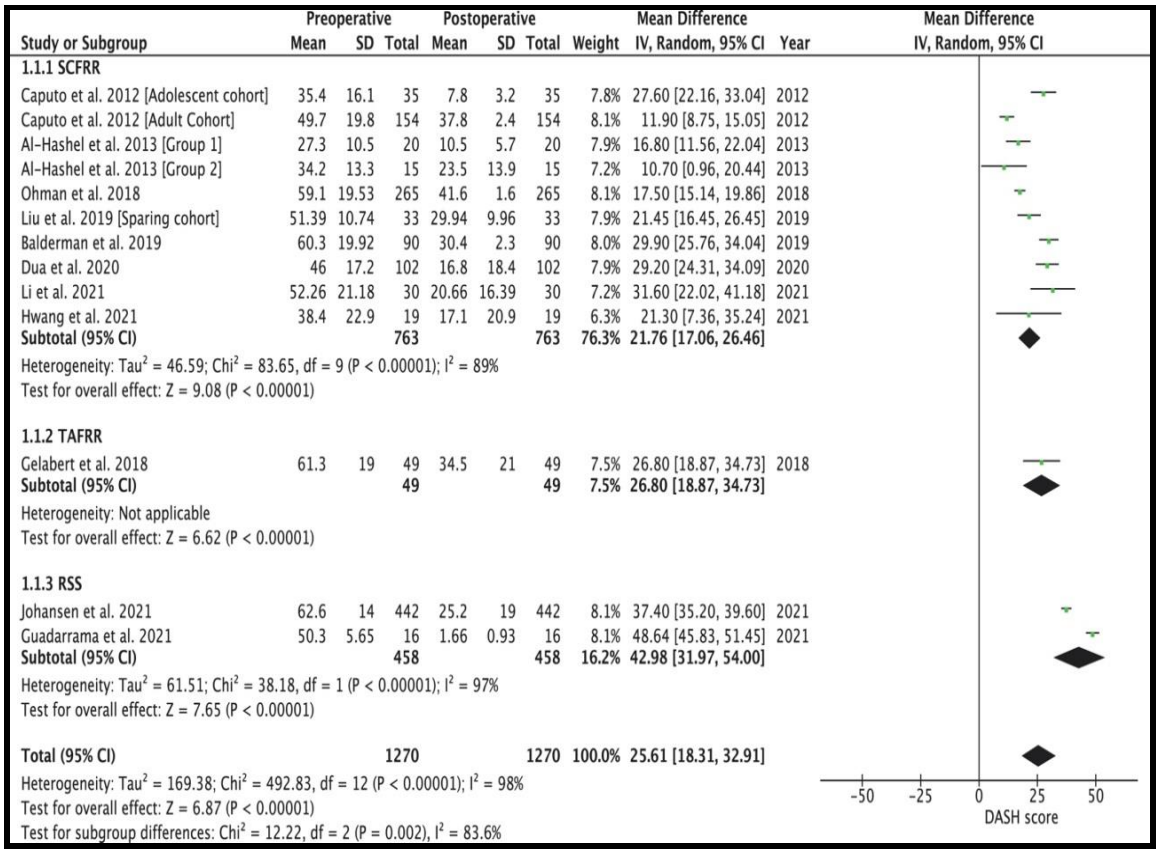

Figure 3: A forest plot illustrating the alteration in DASH score from preoperative to following surgery, as well as the interval variation (mean variance).

DISCUSSION

The most prevalent subtype of thoracic outlet syndrome is known as neurogenic thoracic outlet syndrome, which accounts for more than ninety percent of the case who have been diagnosed with the disturbance. The prevalence of neurogenic thoracic outlet syndrome has been observed to range anywhere from three cases per thousand persons to three cases per hundred thousand persons. Trauma and repetitive motion are among the triggering causes [١٣].

Our study shows that a total of 10 investigations have been selected for the current analysis, including a total of 1729 patient. The publication year ranged from 2012 to 2021. Sample sizes vary across the studies, ranging from 15 to 473 patients, reflecting a broad spectrum of research in different medical domains. Some studies include bilateral assessments, indicated by the mention of sides, while others focus on unilateral evaluations. Mean age was 36.9, the diverse age distributions highlight the heterogeneity among the study populations, underscoring the importance of considering age factors in the interpretation of the respective study outcomes.

According to the findings of our research, out of the ten papers that were examined, five of them described SAFRE (812 cases), three described TAFRR (478 cases), and two described RSS (720 cases). With regard to the investigations that have been incorporated, there were four retrospective series, six prospective series, and not a single randomized controlled trial. In order to determine the potential for bias in retrospective research, the National Institutes of Health Quality Assessment Tool for Case Series Studies has been utilized through the evaluation process. Therefore, each and every one of these have "good" qualities. It was not implied that these retrospective investigations were of superior quality in comparison to prospective research. There were differences in age and follow-up period across investigations and between groups.

Despite the fact that many investigations involve adolescents and the elderly, the exact distribution of ages frequently wasn't documented. Consequently, we were unable to perform a meta-analysis that separated the results according to age groups, which would have been able to explain some of the heterogeneity that we observed in our findings. According to the findings of this meta-analysis and systematic review, the weighted averages for age were 34.6 years for supraclavicular first rib excision with scalenectomy, 40.5 years for TAFRR, and thirty-three years for rib-sparing scalenectomy, respectively. It would be logical to assume that the elderly patient population in TAFRR contributed to the greater preoperative and following surgery Disabilities of the Arm, Shoulder and Hand scores.

According to the findings of Caputo et al. [4], the outcomes of supraclavicular first rib excision with scalenectomy were more positive for adolescents with an average age of 17.3 years than they were for adults with an average age of forty years.

The findings of our research indicate that the following surgery disabilities of the arm, shoulder and hand scores for each group were as follows: the SAFRE scores were 23.6 (ninety-five percent confidence interval [CI], 18.0, 29.2), the TAFRR scores were 27.9 (ninety-five percent confidence interval, 14.8, 41.1), and the RSS scores were 13.4 (−9.6, 36.5). For supraclavicular first rib excision with scalenectomy, the overall following surgery Cervical Brachial Symptom Questionnaire score was 30.4 (ninety-five percent confidence interval, 7.8, 53.0), while for TAFRR, the score was 32.4 (ninety-five percent confidence interval, 23.3, 41.5). There was statistically insignificant variance between the groups in terms of postoperative DASH and CBSQ scores (P >.05). Success rates (which is defined as excellent, good, or fair results) for SAFRE, TAFRR, and RSS were 93.2 percent, 87.9 percent, and 97.4 percent respectively (supraclavicular 1st rib excision with scalenectomy vs. trans axillary 1st rib resection, P.05; SAFRE vs. rib-sparing scalenectomy, P -value greater ran .05; TAFRR vs. Rib-Sparing Scalenectomy, p-value less than .05.

These results are associated with those that were published by Yin et al. [14], who conducted a meta-analysis utilizing cases' subjective evaluations of the relief of symptom following operation for neurogenic thoracic outlet syndrome. In comparison to supraclavicular 1st rib excision had scalenectomy and trans axillary 1st rib resection, the cases reported success rates of eighty-five percent, seventy-seven percent and seventy-six percent respectively for rib-sparing scalenectomy. Compared to supraclavicular first rib excision with scalenectomy and trans axillary 1st rib resection, the complete relief rates for rib-sparing scalenectomy were sixty-one percent, fifty-seven percent and fifty-three percent respectively. Rib-sparing scalenectomy was the most superior procedure. A statistically insignificant variance has been observed among the categories. It is possible that the greater rate of success indicates that the subjective improvement of symptoms, as

perceived by cases, might be behind the real improvement, as evaluated using PROM. Furthermore, they discovered that Transaxillary 1st rib resection and supraclavicular 1st rib excision with scalenectomy had greater complication rates compared to Rib-Sparing Scalenectomy (25.96percent, 22.56percent, and 12.6percent, respectively).

The success of operation carried out with various approaches was calculated utilizing a conventional random-effect meta-analysis in our results in contrast. Therefore, the results from both investigations are complementary, and the total analysis suggests that rib-sparing scalenectomy is sufficient for managing neurogenic thoracic outlet syndrome without the additional morbidity that is correlated with first rib resection.

In addition, our meta-analysis demonstrated that supraclavicular first rib excision with scalenectomy had better results in comparison to trans axillary first rib resection when evaluated by Derkash ratings and postoperative complication rate. This was the case for cases who were having first rib resection. On the other hand, alterations in Disabilities of the Arm, Shoulder and Hand and Visual Analogue Scale (VAS) ratings were significantly improved for trans axillary 1st rib resection in comparison to supraclavicular first rib excision with scalenectomy.

Our findings are consistent with a retrospective review conducted by Aboul Hos et al. [15], which demonstrated that supraclavicular first rib excision with scalenectomy and trans axillary first rib resection resulted in similar results for cases with neurogenic thoracic outlet syndrome. Traditionally, transaxillary 1st rib resection has been utilized to enhance the appearance and adequately expose the target anatomical structures (i.e., the anterior aspect of the 1st rib).

The supraclavicular first rib excision with scalenectomy has been recommended by a greater number of previous research. This is due to the fact that it allows for direct visibility the brachial plexus and of the thoracic outlet. Urschel & Razzuk, [١٦]; Scali et al. [١٧].

Conclusions

This meta-analysis and systematic review provide significant insights into the clinical and radiological outcomes after surgical intervention for nTOS. Our data indicates that although the differences in following surgery DASH and CBSQ scores among surgical methods were statistically insignificant, the rates of success differed, with Rib-Sparing Scalenectomy (RSS) exhibiting the greatest rate of success relative to other techniques. Rib-Sparing Scalenectomy has been developed as an adequate method for managing nTOS, potentially providing a successful therapy with less morbidity relative to first rib resection. Among the FRR methodologies, supraclavicular first rib resection (SAFRE) exhibited superior results compared to trans-axillary FRR (TAFRR), especially for Derkash scores and complications following surgery. Nonetheless, TAFRR demonstrated superior enhancement in VAS and DASH ratings relative to SAFRE.

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Conflict of interest

The authors declare that they have no conflicts of interest with respect to authorship or publication of this article

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Citation

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