

Association of Parsonage–Turner syndrome with COVID-19 infection and vaccination: a systematic review

Muhammad Zain Ameer¹ , Ata Ul Haiy¹,
Muhammad Hassan Bajwa¹, Huzaifa Abeer¹,
Biah Mustafa¹, Fatima Ameer²,
Zunaira Amjad³ and Aqeeb Ur Rehman¹

Abstract

Objectives: The exact etiology of Parsonage–Turner syndrome is unknown, but it is known to be preceded by infection, vaccination, or surgical intervention. In this review, we describe associations of Parsonage–Turner syndrome with COVID-19 infection and vaccination.

Methods: A systematic literature search was conducted using PubMed/MEDLINE, ScienceDirect, and Google Scholar. Microsoft Excel was used for data extraction and statistical analysis. The quality of case reports and case series was assessed using the Joanna Briggs Institute Critical Appraisal Tool.

Results: We selected 44 case reports and 10 case series, including 68 patients (32 post-vaccination and 36 with post-COVID-19 infection Parsonage–Turner syndrome). Middle-aged males were predominantly affected in both groups. The most frequently administered vaccine was Comirnaty (Pfizer) (53%). The mean latency was 11.7 days in the post-vaccination group and 20.3 days in the post-infection group. The most affected nerves in both groups were the axillary, suprascapular, and musculocutaneous nerves; and 78.1% and 38.9% of patients showed partial amelioration of their symptoms in the post-vaccination and post-infection groups, respectively.

Conclusion: Post-vaccination Parsonage–Turner syndrome presents earlier than post-infection disease. Pain and sensorimotor deficits of the upper limb are common in both situations. Complete or partial recovery occurs in most cases.

³Department of Medicine, Services Institute of Medical Sciences, Lahore, Pakistan

Corresponding author:

Muhammad Zain Ameer, MBBS, King Edward Medical University, Neela Gumbad, Anarkali, Lahore 54000, Pakistan.

Email: zainameer32@gmail.com

¹Department of Medicine, King Edward Medical University, Lahore, Pakistan

²Department of Medicine, Mayo Hospital, King Edward Medical University, Lahore, Pakistan



Keywords

Brachial neuritis, COVID-19 infection, COVID-19 vaccination, neuralgic amyotrophy, Parsonage–Turner syndrome, pain, sensorimotor deficit

Date received: 28 December 2022; accepted: 14 June 2023

Introduction

Parsonage–Turner syndrome (PTS) is a lesser-known neurologic condition that was first described by Parsonage and Turner¹ in 1948. It has been reported in the literature many times since then under different names, including amyotrophic neuralgia,² brachial neuritis,³ and acute brachial neuropathy.⁴ PTS commonly affects adult men and typically presents unilaterally, with sudden onset of severe shoulder pain followed by motor weakness and sometimes patchy sensory deficit of the upper limb.⁵ Many atypical presentations, including diaphragm and lower limb defects, have been reported in addition to the characteristic shoulder girdle defects.^{6,7} The exact etiology is currently unknown, but the onset of the disease is preceded by upper respiratory tract viral infection, vaccination, or surgery. Genetic determinants may also affect the threshold for the development of disease.^{8,9} Magnetic resonance imaging (MRI) and electromyographic and nerve conduction studies are helpful in confirming the diagnosis. The prognosis of most cases is excellent, with complete recovery.⁵

Coronavirus disease (COVID)-19 was declared to be a pandemic in January 2020 by the World Health Organization (WHO) and >630 million cases had been reported by November 2022.¹⁰ In early 2021, a robust vaccination drive, using a number of mRNA-based and vector-based vaccines, was launched worldwide to curb the pandemic, and >4.97 billion people had been fully vaccinated by November 2022.¹⁰ Two processes, viral infection and

vaccination, the principal suspected triggers of PTS, were present during the period of the pandemic. In July 2020, Siepmann *et al.*¹¹ reported the first case of PTS in a patient with confirmed COVID-19. The rapidly increasing literature regarding the topic merits a systematic review to explore the possible triggers, pathophysiology, clinical presentation, and the outcomes of this association to familiarize clinicians with this disease as a possible sequela of COVID-19 infection or vaccination and to provide a foundation for further work aimed at increasing knowledge of the potential complications of COVID-19.

Methods

This article is fully compliant with the PRISMA (Preferred Reporting Items for Systematic Reviews) 2020 statement.¹² The review was registered with the international prospective register of systematic reviews PROSPERO (registration number: CRD 42022372719). Institutional ethics approval was not required for this retrospective data analysis. The authors ensured that consent had been obtained from the patients for the original publication of their cases.

Search strategy

A systematic literature search was conducted up to 1 November 2022 of the following four databases: PubMed/MEDLINE, Cochrane, ScienceDirect, and Google Scholar. The search string consisted of a combination of the following keywords and MeSH terms: “COVID-19” [MeSH], “Covid*”,

“SARS-CoV-2”, “COVID Vaccination” [MeSH], “Vaccination”, “Vaccine”, “Parsonage–Turner syndrome”, “Brachial plexopathy”, “Neuralgic amyotrophy”, “Amyotrophic neuralgia”, and “Brachial plexus neuritis” [MeSH].

The complete search string used in each database is provided in the supplementary files. No filters regarding time, study design, language, or country of publication were used in the retrieval of the relevant publications.

Eligibility criteria

Inclusion criteria. All articles that described PTS, confirmed by electrodiagnostic or radiological studies, in association with COVID-19 infection or vaccination, were included.

Exclusion criteria. Articles describing patients in whom a diagnosis of PTS was not confirmed by electrodiagnostic or radiological studies, or in which a diagnosis was not associated with COVID-19 infection or vaccination, were excluded.

Study selection

Relevant articles were selected and screened according to the PRISMA flowchart presented in Figure 1. The records identified through a preliminary search were downloaded into Mendeley (Elsevier, Amsterdam, Netherlands) and duplicates were removed. Two authors (MZA and FA) independently performed the screening and identified case reports, case series, abstracts, and letters to the editor reporting cases of PTS in association with COVID-19. The bibliographies of these articles were also screened to identify any omitted cases.

Data extraction

Data were extracted and collated in the form of two tables, one summarizing the

demographics, clinical features, imaging, electrodiagnostic investigations, and outcomes of COVID-19-associated PTS (Table 1); and the other for summarizing the same parameters for COVID vaccination-associated PTS (Table 2). Continuous variables are presented as means $\pm$ standard deviations and categorical variables are presented as absolute values and percentages. Microsoft Excel (Redmond, WA, USA) was used for the data extraction and statistical analysis. Datasets were compared using the unpaired *t*-test and chi-square test, as appropriate. Articles in languages other than English were translated using Google Translate (translate.google.com). The references were added using Zotero (zotero.org).

Quality assessment

The quality of the case reports and case series was assessed using the Joanna Briggs Institute Critical Appraisal Tool.¹³ Three authors (MHB, AUH, and HA) first independently scored each article and then decided on a score for each. The scores are provided in the supplementary files.

Results

The search of the four databases identified 449 articles, of which 48 were excluded because of duplication, 341 were not relevant, 3 were not eligible, and the full text of 3 could not be retrieved. The remaining 54 articles, comprising 44 case reports and 10 case series, were included in the final quantitative synthesis.^{11,14–66} The systematic review of these articles included individual data from 68 patients, who were categorized according to whether the likely trigger was COVID-19 infection or vaccination. The demographics and clinical characteristics of the patients are summarized in Table 1 and Table 2. A comparison of the findings in the two groups is shown in Table 3.

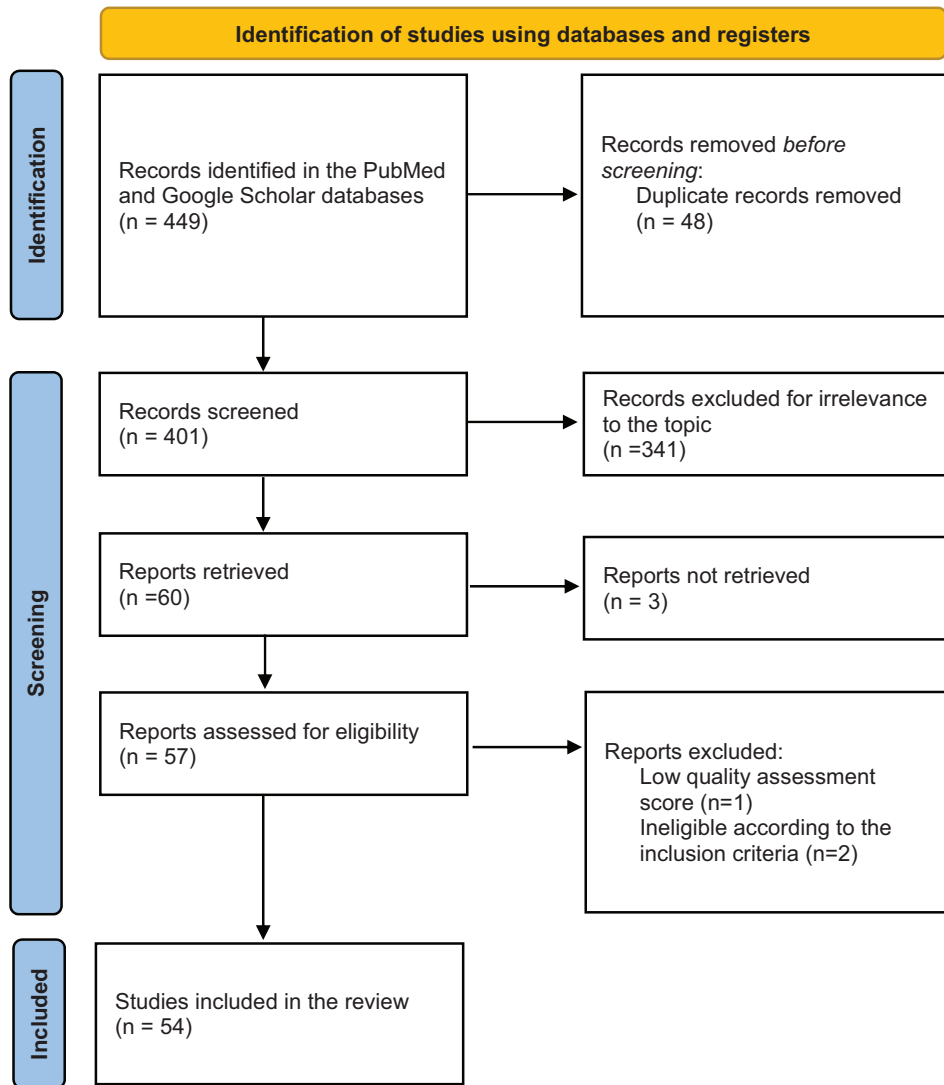


Figure 1. PRISMA flow diagram for study selection.

The mean age of the 32 patients who developed PTS after vaccination was 50.6 ± 15.3 years, and 25 (78%) were male. Most patients ($n=17$, 53%) had received Comirnaty (Pfizer, New York, NY, USA). The mean interval between vaccination and the onset of symptoms was 11.7 days. The patients presented with the following symptoms: pain ($n=29$, 90.6%), motor weakness ($n=15$, 46.9%), and

sensorimotor deficits ($n=17$, 53.1%). The symptoms were unilateral in 30 (93.8%) and bilateral in 2 (6.3%) patients. The axillary nerve was affected in 11 (34.4%) patients. Thirty patients (83.3%) had MRI findings and 32 patients (88.9%) had electrodiagnostic findings suggestive of PTS. Twelve (37.5%) patients were treated with physiotherapy and 11 (34.4%) with steroids or pregabalin. Twenty-nine (93.5%)

Table 1. Demographics and clinical characteristics of patients with COVID-associated Parsonage–Turner syndrome

Patient no.	Authors, Year	Age, Sex	Potential risk factors	Latency Period (Days)	Presentation and laterality	Physical examination findings	Electrodiagnostic findings (EMG/NCS)	Radiologic findings	Treatment(s)	Outcome
1	Siepmann T et al. 2020 ¹¹	52, M	Infection	14	Right-sided pain, weakness, numbness	Weakness of the right FDP, FPL, abductor pollicis, and OP muscles; hyperesthesia of the median nerve skin distribution.	EMG: low MUAP of APB and OP muscles. Absent MUAP in FPL.	MRI: edema and inflammatory contrast enhancement of the right distal median nerve.	Prednisone	No improvement after 2 weeks
2	Alvarado M et al. 2021 ¹⁴	38, M	Infection, prone	5	Bilateral pain, weakness, paresthesia	Atrophy of the deltoid, supraspinatus, and infraspinatus muscles; and right scapular winging.	EMG: Signs of denervation in the trapezius, deltoid, and serratus anterior.	Shoulder MRI: edema of the bellies of both infraspinatus muscles and tendinosis of both supraspinatus muscles.	NSAIDs, opioids, prednisolone	Improvement
3	Alvarez A et al. 2021 ¹⁵	46, F	Infection, prone	18	Left-sided pain, weakness, numbness	Atrophy of the left shoulder muscles, tenderness of subacromial region, weakness of left shoulder abduction and extension (MRC 4/5).	EMG: Signs of denervation in the left deltoid and biceps. NCS: Mild left median neuropathy at the wrist.	Shoulder MRI: moderate tendinosis of the subcapularis, supraspinatus, infraspinatus, and the long head of the biceps tendon. Moderate edema of the deltoid, teres major, teres minor, and latissimus dorsi.	NSAIDs	Complete recovery after 3 months
4	Ansari B et al. 2022 ¹⁶	54, M	Infection	17	Left-sided pain, weakness, numbness	Proximal left upper limb muscle weakness. Weakness in the elevation, abduction, and external rotation of the left shoulder. Absent biceps reflex.	EMG: Spontaneous activity in the left biceps, deltoid, supraspinatus, and rhomboid muscles. NCS: Radial and median SNAPs reduced.	Cervical and brachial plexus MRI: slight C3–C4 disc herniation.	Prednisolone	Complete recovery after 2 months
5	Cheung VYT et al. 2022 ¹⁷	55, M	Infection, family history	21	Right-sided pain, numbness, weakness	No muscle wasting, scar, rash, or trophic changes.	Normal	Brachial plexus MRI: mild T2 hyperintensity at the right brachial plexus.	Pregabalin	Partial improvement after 3 months
6	Coll C et al. 2021 ¹⁸	63, M	Infection, prone	70	Right-sided pain, weakness, paresthesia	Active and passive limitation of shoulder movements; atrophy of the upper trapezius muscle and supra-infra-spinous fossae.	EMG: Denervation signs in the upper and lower trapezius muscles	Brachial plexus MRI: atrophy and fatty infiltration on T1 sequence and high signal intensity on STIR sequence of right trapezius, consistent with semi-recent denervation in the distal territory of CN XI.	n/r	n/r

(continued)

Table 1. Continued.

Patient no.	Authors, Year	Age, Sex	Potential risk factors	Latency Period (Days)	Presentation and laterality	Physical examination findings	Electrodiagnostic findings (EMG/NCS)	Radiologic findings	Treatment(s)	Outcome
7	Coll C et al. 2021 ¹⁸	74, M	Infection, proning	42	Left-sided pain, weakness	Atrophy of the upper trapezius muscle and supra, infra-spinous fossae; weakness and a mild winged scapula in a lateral position.	EMG: Denervation signs in the upper and lower trapezius muscles.	Brachial plexus MRI: atrophy and fatty infiltration on T1 sequence and high signal intensity on STIR sequence of right trapezius, consistent with semi-recent denervation in the distal territory of CN XI.	n/r	n/r
8	De Penille CV et al. 2021 ¹⁹	46, F	Infection, mechanical ventilation	18	Pain, sensorimotor defect	Atrophy of the deltoid; proximal motor deficit (deltoid 3/5, biceps 2/5, brachioradial 3/5, interosseous 4/5); hypoaesthesia of the first two fingers of the hand.	NCS: Upper trunk involvement.	Plexus MRI: inflammatory and non-mechanical lesion.	n/r	Improvement
9	Díaz C et al. 2021 ²⁰	36, M	Infection	14	Right-sided pain, weakness	Atrophy of the supraspinatus and infraspinatus fossa, deltoids, and biceps; lower force in anterior elevation, abduction, external rotation (MRC 2/5), and internal rotation (3/5).	EMG: Positive sharp waves and fibrillation in the deltoids, biceps, supraspinatus, and rhomboids. NCS: right upper brachial plexopathy.	Shoulder MRI: supraspinatus and infraspinatus intramuscular hyperintensity in T2-weighted sequence.	Pregabalin, physiotherapy	Symptoms resolved after 6 months
10	Doğan Y et al. 2022 ²¹	27, M	Infection	7	Right-sided pain, weakness, hyperaesthesia	Limited right elbow extension; weakness in shoulder abduction, elbow flexion/extension, wrist extension, and finger abduction in the right upper limb.	EMG: Insufficient electrical activity in the first dorsal interosseous, FCU, and FPL muscles.	USG: painful sonopalpation of the median nerve in the arm, without any brachial plexus abnormalities.	Pregabalin	Improvement after 3 weeks
11	Fortanier E et al. 2022 ²²	45, F	Infection	10	Right-sided pain, weakness	Weakness of shoulder abduction and elbow flexion (MRC 3/5). Impaired reflexes.	EMG: Acute denervation without spontaneous activity in the biceps brachii and deltoid muscles.	Plexus MRI: persistent hyperintense signal involving the right C6 root and the superior truncus of the brachial plexus.	None received	Complete disappearance of symptoms after 3 months.
12	Fortanier E et al. 2022 ²²	21, M	Infection	10	Right-sided pain, weakness	Right scapular winging	EMG: Right serratus anterior muscle neurogenic recruitment pattern. NCS: Long thoracic nerve: lower CMAP	Plexus MRI: hyperintense signal involving the right long thoracic nerve within the scalenus medius muscle.	Prednisone	Partial improvement after 3 months

(continued)

Table 1. Continued.

Patient no.	Authors, Year	Age, Sex	Potential risk factors	Latency Period (Days)	Presentation and laterality	Physical examination findings	Electrodiagnostic findings (EMG/NCs)	Radiologic findings	Treatment(s)	Outcome
13	Galvez LA et al. 2022 ²³	66, F	Infection, mechanical ventilation	4	Right-sided pain, paresthesia	Monoplegia, hyporeflexia	Abnormal muscle recruitment in all limb segments.	n/r	Opioids, gabapentin, physiotherapy	Complete recovery
14	Gee Jin NG et al. 2022 ²⁴	34, M	Infection, vaccination	1	Left-sided pain, weakness, and numbness	Diminished left biceps reflex, weakness of the left shoulder, elbow, wrist, and finger movements (MRC 3/5).	n/r	Plexus MRI: stronger signal along the course of the distal trunks and divisions of the left brachial plexus. Coronal T1 sequence shows partial effacement of the intervening fat planes between the nerves, indicating inflammation in all the trunks, divisions, and cords of the brachial plexus.	Conservative	Improvement after 13 days
15	Ismail II et al. 2021 ²⁵	32, M	Infection	7	Bilateral pain, weakness, numbness	Left scapular winging. Minimal atrophy on both sides; sensorimotor deficit	NCs: Lower CMAP of the musculocutaneous, axillary, and suprascapular nerves on both sides, and of the long thoracic and anterior interosseous nerves on the left side.	Plexus MRI: hyperintense T2-weighted signal of the supra- and infraspinatus muscles, indicating intramuscular edema.	Steroids (discontinued), IVIG	No improvement after 8 weeks
16	Cacciavillani M et al. 2021 ²⁶	52, M	Infection	12	Left-sided pain, numbness	Purely sensory deficit.	NCs: Lower SNAP of the left lateral antebrachial cutaneous nerve.	Normal	Acetaminophen	Partial improvement after 6 weeks
17	Mitry MA et al. 2020 ²⁷	17, F	Infection	Few weeks	Left sided pain, weakness	Dyspnea, functional weakness.	n/r	MRI left shoulder: uniform increase in T2 signal of the supraspinatus, infraspinatus, teres minor, teres major, and trapezius muscles.	Steroids	n/r
18	Pivaral CE et al. 2022 ²⁸	44, M	Infection, family history	n/r	Left-sided pain, burning sensation	Atrophy of the deltoid, supraspinatus, and scapular muscles.	NCs: Postganglionic SNAPs of the left brachial plexus affected at the level of the trunk.	n/r	NSAIDs, opioids, gabapentin	Complete recovery after 56 days
19	Pivaral CE et al. 2022 ²⁸	45, F	Infection, family history	n/r	Left-sided pain, burning sensation	Atrophy of the deltoid, supraspinatus, and scapular muscles.	NCs: Postganglionic SNAPs of the left brachial plexus affected at the level of the trunk.	n/r	NSAIDs, opioids, gabapentin	Complete recovery after 51 days

(continued)

Table 1. Continued.

Patient no.	Authors, Year	Age, Sex	Potential risk factors	Latency Period (Days)	Presentation and laterality	Physical examination findings	Electrodiagnostic findings (EMG/NCS)	Radiologic findings	Treatment(s)	Outcome
20	Torres L et al. 2022 ²⁹	48, F	Infection	n/r	Left-sided pain, weakness, burning sensation	n/r	NCS: Acute motor sensory axonal neuropathy and left brachial neuritis.	MRI: High signal intensity in trunks, divisions, chords, and terminal branches of the left brachial plexus, suggesting neuritis. High signal intensity in the supraspinatus muscle, owing to edema/denervation.	n/r	n/r
21	Torres L et al. 2022 ²⁹	69, M	Infection	n/r	Sensorimotor deficit	n/r	NCS: Sensorimotor polyneuropathy.	MRI: Consistent with the diagnosis.	n/r	n/r
22	Torres L et al. 2022 ²⁹	78, F	Infection, prone	n/r	Bilateral pain, weakness	n/r	EMG/NCS: Consistent with the diagnosis.	MRI: high signal intensity in the trunks, divisions, chords, and terminal branches of the left brachial plexus, suggesting neuritis.	n/r	n/r
23	Viatgé T et al. 2021 ³⁰	20, M	Infection, prone	24	Left-sided weakness, numbness	Anyotrophic changes, left diaphragmatic paresis.	NCS: Chronic and active neurogenic abnormalities of the C5 and C6 territories, without sensory conduction abnormalities.	MRI: edematous hypersignal (STIR) in the supraspinatus, infraspinatus, deltoid, rhomboid, and small left pectoral muscles; STIR hypersignal on the path of the nerve bundles from the left C5.	Physiotherapy	n/r
24	Voss TG et al. 2022 ³¹	61, M	Infection	n/r	Left-sided pain, weakness, numbness	Weakness with forward flexion, external rotation.	EMG: Reduction in recruitment in the infraspinatus, deltoid, and, to a lesser extent, the biceps brachii, with associated fibrillation.	MRI: Mild edema within the deltoid and supraspinatus muscle bellies.	Physiotherapy	Partial improvement after 12 months
25	Han CY et al. 2020 ³²	52, M	Infection, mechanical ventilation	4	Left-sided pain, weakness, numbness	Absent tone in the left hand, wrist, and elbow. Pin and thermal sensations absent on the left forearm and hand, tactile allodynia.	EMG: Signs of denervation in the left triceps, brachioradialis, ECR, EDC, and EI. NCS: Left-sided median, ulnar, radial, musculocutaneous, and medial antebrachial cutaneous responses absent.	MRI Plexus: T2 hyperintensity and thickening of the entire brachial plexus, without contrast enhancement.	Physiotherapy, gabapentin, opioid, and acetaminophen	Minor improvement after 3 months

(continued)

Table 1. Continued.

Patient no.	Authors, Year	Age, Sex	Potential risk factors	Latency Period (Days)	Presentation and laterality	Physical examination findings	Electrodiagnostic findings (EMG/NCS)	Radiologic findings	Treatment(s)	Outcome
26	Zazzara MB et al. 2022 ¹³³	47, F	Infection	60	Left-sided pain, numbness	Dysesthesias. Muscle strength normal.	NCS: Low SNAP left medial and lateral antebrachial cutaneous nerves.	MRI: T2 hyperintensity and thickening of the left upper trunk. Some confluent lymph nodes with irregular borders were identified in the left suprachavicular fossa	Steroids, duloxetine, and gabapentin	Significant improvement after 2 months
27	Cabona C et al. 2021 ¹³⁴	46, M	Infection, mechanical ventilation	13	Left-sided pain, weakness	Atrophy and weakness of the biceps (MRC 4/5).	EMG: Denervation signs in the left brachial biceps muscle.	MRI: increase in the fascicular diameter and characteristic multifocal damage of the MCN.	Steroids	Complete recovery after 1 month
28	Mano T et al. 2022 ¹³⁵	80, M	Infection, prone	14	Bilateral weakness, right sided numbness	Bilateral weakness of muscles.	EMG: Less recruitment in the left deltoid, triceps, ED, and both biceps. NCS: Low SNAP in the left radial and both median nerves.	MRI: excluded radiculopathy, neuritis.	Physiotherapy	Improved after 83 days
29	Diprose WK et al. 2021 ¹³⁶	55, F	Infection, prone	12	Bilateral weakness, numbness	Bilateral weakness of shoulder abduction and external rotation, mild weakness of finger abduction, and numbness over the distribution of the axillary nerves bilaterally.	EMG: Denervation of the deltoid muscles bilaterally, right-sided infraspinatus, supraspinatus, and ulnar-innervated intrinsic hand muscles. NCS: Distal median neuropathy.	MRI: T1 hyperintense signal within the supraspinatus, infraspinatus, and deltoid muscles bilaterally.	n/r	n/r
30	Sneag DB et al. 2021 ¹³⁷	55, M	Infection, mechanical ventilation	49	Left-sided pain, weakness, numbness	n/r	NCS: Sensorimotor abnormalities in the left median, ulnar, axillary, musculocutaneous, and suprascapular nerve distributions.	T2 weighted MRI plexus: prominent signal hyperintensity of nerves throughout the left brachial plexus. Axial T2-weighted Dixon water image through the proximal arm demonstrated a denervation edema pattern of the biceps muscle and signal hyperintensity of the median, ulnar, musculocutaneous, and radial nerves.	Gabapentin	No improvement after 3 months

(continued)

Table 1. Continued.

Patient no.	Authors, Year	Age, Sex	Potential risk factors	Latency Period (Days)	Presentation and laterality	Physical examination findings	Electrodiagnostic findings (EMG/NCS)	Radiologic findings	Treatment(s)	Outcome
31	Sánchez-Soblechero A et al. 2020 ³⁸	69, M	Infection, prone	8	Right-sided weakness, numbness	Weakness of humeral rotation, shoulder abduction (MRC 1/5), and elbow flexion (4/5); lower sensation, poorer reflexes.	EMG: Signs of denervation in the right supraspinatus, deltoid, and biceps brachii muscles. NCS: Lower SNAP amplitudes of the right median sensory branch to the first finger and right lateral antebrachial cutaneous nerves.	n/r	n/r	Slight improvement after 1 month
32	Waheed W et al. 2023 ³⁹	56, M	Infection	28	Right-sided pain, weakness; dyspnea	Wasting of the right brachialis	n/r	Axial T2-weighted MRI: denervation edema of the brachialis but sparing of the biceps muscles. Enlargement just proximal to a severe intrinsic constriction of the brachialis fascicular bundle of the musculocutaneous nerve.	n/r	n/r
33	Alves M et al. 2021 ⁴⁰	24, F	Infection	60	Bilateral dysesthesia, weakness	n/r	NCS: Sensitive conduction speed in the wrist: 50 m/sec (right); 55 m/sec (left). Sensitive latency: 2.8 (right) and 2.6 (left). Amplitude: 17 (right) and 24 (left). EMG: Denervation of the trapezius and serratus anterior muscles.	MRI: Increase in signal in Proton Density with Fat Suppression in both median nerves.	Benfotiamine	Improvement
34	Saade F et al. 2022 ⁴¹	22, M	Infection	21	Right-sided pain, weakness	Limited shoulder abduction (MRC 4/5), visible atrophy of the trapezius muscle. Winged scapula.	EMG: Denervation of the trapezius and serratus anterior muscles.	MRI: Intramuscular edema of the serratus anterior and trapezius muscles, consistent with denervation.	Steroids, physiotherapy	Partial improvement after 6 months
35	Omar I et al. 2021 ⁴²	21, M	Infection, prone	5	Bilateral pain, weakness, numbness	Upper extremity weakness, including right wrist drop.	EMG: Moderate left shoulder infraspinatus and deltoid muscle dysfunction. NCS: Distal right radial neuropathy.	Left shoulder MRI: Diffuse infraspinatus and supraspinatus muscle edema; and anterior and lateral deltoid head diffuse muscle edema.	Physiotherapy	Improvement

(continued)

Table 1. Continued.

Patient no.	Authors, Year	Age, Sex	Potential risk factors	Latency Period (Days)	Presentation and laterality	Physical examination findings	Electrodiagnostic findings (EMG/NCS)	Radiologic findings	Treatment(s)	Outcome
36	Omar I et al. 2021 ⁴²	61, M	Infection, proning	n/r	Left-sided weakness	Weakness of elbow flexion and shoulder adduction (MRC 1/5), elbow extension (4/5), and wrist flexion and extension (3/5).	Upper trunk brachial plexopathy, active deltoid muscle denervation, and mild ulnar sensory neuropathy.	MRI: No clear findings of impingement; STIR imaging demonstrated symmetric muscle and fascial edema and enhancement of the supraspinatus, infraspinatus, and teres minor muscles. The left musculocutaneous nerve and biceps brachii muscle were diffusely edematous and enhancing.	Physiotherapy	Improvement

F, female; M, male; n/r, not reported; EMG, electromyography; NCS, nerve conduction studies; MUAP, motor unit action potential; SNAP, sensory nerve action potential; MRC, Medical Research Council muscle power scale; STIR, short tau inversion recovery; MRI, magnetic resonance imaging; USG, ultrasonography; NSAIDs, non-steroidal anti-inflammatory drugs; APB, abductor pollicis brevis; ECR, extensor carpi radialis; ED, extensor digitorum; EDC, extensor digitorum communis; EI, extensor indicis; FCU, flexor carpi ulnaris; FPL, flexor pollicis longus; OP, opponens pollicis.

Table 2. Demographics and clinical characteristics of patients with COVID vaccination-associated Parsonage–Turner syndrome

No.	Author, Year	Age, Sex	Potential risk factors	Vaccine, doses given	Latency Period (Days)	Presentation and laterality	Physical exam findings	Electrodiagnostic findings (EMG/NCS)	Radiologic findings	Treatment(s)	Outcome
1	Amjad MA et al. 2022 ⁴³	78, M	Vaccination	Pfizer, 2	21	Bilateral weakness	Weakness in right hand grip and wrist flexion (MRC 3/5).	EMG: low motor unit recruitment in the bilateral first dorsal interosseous and right deltoid, biceps, and triceps muscles. NCS: Bilaterally low median, ulnar SNAP amplitudes and slow conduction.	MRI Cervical Spine: No signs of demyelination, fracture, deformity, traumatic subluxation, or compressive myelopathy.	Prednisone	Slight improvement
2	Balloy G et al. 2021 ⁴⁴	63, M	Vaccination	AstraZeneca, 1	21	Ipsilateral pain, weakness	Atrophy in infraspinatus fossa, scapular winging; left shoulder abduction (MRC 1/5) and left arm external rotation weakness.	Denervation in supraspinatus, infraspinatus, left upper trapezius, and serratus anterior.	MRI Shoulder: STIR hypersignal in the left supraspinatus and infraspinatus muscles indicating muscle edema.	Physiotherapy	Improvement
3	Cursem VG et al. 2022 ⁴⁵	46, M	Vaccination	Pfizer, 2	3	Ipsilateral pain, weakness	Atrophy of the serratus anterior, scapular winging.	EMG: Low MUAP in right serratus anterior. NCS: Low amplitude and slow conduction in right long thoracic nerve.	MRI: Normal.	Physiotherapy	Improvement
4	Bernheimer JH et al. 2022 ⁴⁶	42, F	Vaccination	Moderna, 2	21	Ipsilateral pain, paresthesia, weakness	Diminished grip, fasciculations on left upper extremity; weakness of internal rotation, external rotation, and abduction of the left shoulder (MRC 4/5).	EMG/NCS: revealed evidence of a subacute left upper trunk brachial plexopathy.	Shoulder MRI: Normal.	Prednisone, gabapentin	Considerable improvement after 2 months
5	Crespo Burillo JA et al. 2021 ⁴⁷	38, M	Vaccination	AstraZeneca	4	Left-sided pain, functional weakness; dyspnea after 40 days	Functional weakness. No motor or sensory deficits.	EMG: Fibrillations and positive waves in the affected muscles. NCS: Low amplitude in axillary, musculocutaneous, median, and radial nerves.	MRI Shoulder: Left subacromial tendinopathy. CT Chest: Left diaphragm paralysis.	IV methyl prednisone, followed by oral prednisone	Resolved after 2 weeks
6	Chua M et al. 2022 ⁴⁸	64, M	Vaccination	Moderna, 2	14	Ipsilateral pain, weakness, paresthesia	Less strength in the left finger extensors (MRC 4/5), particularly in the left fourth and fifth digits, and the thenar eminence. Impaired sensation.	EMG: Less recruitment in left EI and FDP to digit IV; greater spontaneous activity in the left first dorsal interosseus. NCS: Left ulnar SNAP: borderline low; left ulnar abductor digiti minimi CMAP: borderline low.	MRI Left brachial plexus: High STIR, T2W signal medial left scalene muscles along the inferior brachial plexus, consistent with inflammatory changes and intramuscular edema.	Prednisone	Near complete resolution after 4 months

(continued)

Table 2. Continued.

No.	Author, Year	Age, Sex	Potential risk factors	Vaccine, doses given	Latency Period (Days)	Presentation and laterality	Physical exam findings	Electrodiagnostic findings (EMG/NCs)	Radiologic findings	Treatment(s)	Outcome
7	Civardi C et al. 2022 ⁴⁹	50, F	Vaccination	Pfizer, 1	11	Bilateral pain, weakness, numbness	Weakness in the right biceps brachii (MRC 3/5), diminished sensation of light touch throughout the right C5 dermatome.	EMG: Fibrillations and positive sharp waves in the right biceps brachii. Absent voluntary recruitment pattern. NCS: Left lateral antebrachial cutaneous sensory nerve SNAP absent; musculocutaneous nerve CMAP absent.	MRI: Normal.	Prednisolone, pregabalin	Improvement
8	Ferguson D et al. 2022 ⁵⁰	56, M	Vaccination, previous COVID infection	Unspecified, 2	1	Ipsilateral pain, weakness	Left deltoid atrophy, limited abduction, and external rotation.	EMG/NCs: left-sided brachial plexopathy involving the upper, middle, and lower trunks. Normal.	MRI Left shoulder: Edematous signal in proximal and infraspinatus muscles MRI: Patchy edema and enhancement of the right brachial plexus and scalene muscles, suggestive of subacute denervation.	n/r	n/r
9	Koh JS et al. 2021 ⁵¹	50, M	Vaccination	Pfizer, 1	25	Ipsilateral pain, weakness, numbness	n/r	Normal.	MRI: Patchy edema and enhancement of the right brachial plexus and scalene muscles, suggestive of subacute denervation.	Corticosteroids	Improvement after 7 weeks
10	Koh JS et al. 2021 ⁵¹	44, M	Vaccination	Pfizer, 2	4	Contralateral pain, numbness, weakness	n/r	EMG/NCs: Predominant lower trunk involvement of the brachial plexus.	MRI: mild edema and enhancement of the right posterior scalene muscle, suggestive of subacute denervation.	None	Significant improvement after 8 weeks
11	Koh JS et al. 2021 ⁵¹	58, M	Vaccination	Moderna, 2	7	Ipsilateral pain, weakness, numbness	n/r	EMG/NCs: Predominant lower trunk involvement of the brachial plexus.	MRI: Lower trunk involvement of the brachial plexus.	Corticosteroids	Improvement after 5 weeks
12	Kang J, Cho J 2022 ⁵²	83, M	Vaccination	AstraZeneca, 2	7	Right sided pain, numbness	PFTs: Restrictive pattern.	NCS: Low CMAP in the right axillary and musculocutaneous nerves. EMG/NCs showed signs compatible with right lower trunk brachial plexopathy.	CXR: Elevation of the right hemidiaphragm after vaccination. MRI: Normal.	Analgesics	Significant improvement after 8 months
13	Leemans W et al. 2022 ⁵³	57, M	Vaccination	Pfizer, 2	28	Right-sided pain, weakness, numbness	Weakness (MRC 4/5) of right finger flexion, finger abduction, thumb abduction and adduction, and hypoesthesia of the medial antebrachial cutaneous nerve territory.			Corticosteroids	Improvement
14	Krisztina L et al. 2022 ⁵⁴	40, F	Vaccination	Pfizer, 2	28	Pain on right side, pain and weakness on left side	Shoulder swelling on both sides.	Substantial axon loss in the left axillary nerve.	MRI shoulder: fluid accumulation on both sides next to the supraspinatus tendon, behind and below the acromion, and next to the tendon of the long head of the biceps.	NSAIDs, physiotherapy, steroids	Improvement

(continued)

Table 2. Continued.

No.	Author, Year	Age, Sex	Potential risk factors	Vaccine, doses given	Latency Period (Days)	Presentation and laterality	Physical exam findings	Electrodiagnostic findings (EMG/NCs)	Radiologic findings	Treatment(s)	Outcome
15	Mahajan S et al. 2021 ⁵⁵	50, M	Vaccination	Pfizer, 2	7	Ipsilateral pain, weakness	Weakness of left finger extension and left-hand grip (MRC 3/5).	EMG: Left first dorsal interosseous, FCU, ADM, ED, and EI muscles. MUAP: low.	MRI: Normal.	Corticosteroids	Significant amelioration of pain and slight amelioration of hand weakness.
16	Lakkireddy, M et al. 2022 ⁵⁶	21, M	Vaccination	Covishield, 2	7	Contralateral pain, paresthesia, weakness	Atrophy of deltoid, supraspinatus, and infraspinatus muscles; hyperalgesia over the axillary nerve territory.	NCs: Axillary and musculocutaneous nerves showed low CMAP. EMG/NCs: Neurogenic tracing of right deltoid muscle.	Neurogram of upper brachial plexus showed intact nerves. T1 sagittal MRI: normal supraspinatus, infraspinatus, and subscapularis muscle bulk.	Physiotherapy	Improvement
17	Mejri I et al. 2022 ⁵⁷	50, M	Vaccination, previous COVID infection	Pfizer, 2	15	Ipsilateral pain, numbness, weakness	Hypoesthesia, paresis of the right upper limb with weakness in shoulder abduction and extension (MRC 4/5); right deltoid atrophy.	EMG/NCs: Neurogenic tracing of right deltoid muscle.	MRI: Normal.	Corticosteroids, analgesics, physiotherapy	Improvement
18	Öncel A, et al. 2022 ⁵⁸	56, M	Vaccination	Pfizer, 2	1	Ipsilateral pain, weakness	Swelling, redness, warmth at deltoid area. Shoulder flexion, abduction, and extension were 2/5, elbow flexion 4/5.	EMG: Deltoid, biceps, brachioradialis: positive sharp waves, fibrillation, greater insertional activity, low MUA, recruitment low. NCs: Axillary, musculocutaneous CMAP: low amplitude.	Brachial plexus MRI: STIR sequence high intensity over roots C5–C6.	NSAIDs, physiotherapy	Significant improvement after 3 months
19	Pilgram L, et al. 2021 ⁵⁹	M	Vaccination	Unspecified, 1	10	Left-sided pain, weakness	4/5 in left shoulder abduction and 3/5 external rotation strength, along with scapular dyskinesis and left infraspinous fossa atrophy.	EMG: Infraspinatus, supraspinatus: abnormal spontaneous activity, polyphasic units. FPL: polyphasic units. NCs: suprascapular and anterior interosseous neuropathy.	n/r	n/r	Improvement after 2 months (pain resolved, weakness persisted)
20	Queler SC, et al. 2022 ⁶⁰	59, M	Vaccination, Lyme disease	Pfizer, 1	0.5	Contralateral pain, weakness, numbness	Weakness in wrist flexion and forearm pronation (MRC 4/5).	EMG: Denervation and no motor unit recruitment in the supraspinatus, infraspinatus, left upper trapezius, or serratus anterior. NCs: Abnormal.	Axial T2-weighted MRI: denervation edema pattern of the pronator teres and flexor carpi radialis muscles. Abnormal signal hyperintensity and hourglass-like constrictions of the fascicular bundle of the median nerve.	Prednisone	Pain resolved; greater weakness after 3 months

(continued)

Table 2. Continued.

No.	Author, Year	Age, Sex	Potential risk factors	Vaccine, doses given	Latency Period (Days)	Presentation and laterality	Physical exam findings	Electrodiagnostic findings (EMG/NCs)	Radiologic findings	Treatment(s)	Outcome
21	Queler SC, et al. 2022 ⁶⁰	44, M	Vaccination	Moderna, 2	18	Ipsilateral pain, weakness, numbness	Weakness in left shoulder abduction (MRC 2/5) and external rotation (3/5). Diminished sensation of pinprick in the radial nerve distribution.	EMG: Denervation and poor motor unit recruitment in the infraspinatus muscle. NCs: Mild slowing of the left median and radial sensory responses.	T2-weighted MRI: signal hyperintensity and multiple focal hourglass-like constrictions of the suprascapular nerve with accompanying denervation edema pattern of the supraspinatus and infraspinatus muscles.	Gabapentin, physiotherapy	Improvement after 3 months
22	Diaz-Segarra N, et al. 2021 ⁶¹	35, F	Vaccination, previous COVID infection	Pfizer	9	Contralateral weakness, numbness	Low anti-gravity strength of the deltoid, supraspinatus, biceps brachii, triceps brachii, ECR, ED, EI, FDS, and FDP. Winging of scapula; low sensation.	Axonal and demyelinating brachial plexopathy, primarily involving the upper trunk.	Cervical spine CT: mild degenerative changes without foraminal narrowing.	Prednisone	Improvement after 1 week
23	Sharma A, et al. 2022 ⁶²	34, M	Vaccination	Covishield	1	Left-sided pain, weakness	Loss of shoulder contour. Weakness of the rotator cuff muscles.	Active denervation changes in the left triceps, biceps, deltoid, supraspinatus, rhomboids, and serratus anterior, suggestive of the involvement of the left brachial plexus.	MRI: Normal	Steroids	Gradual improvement
24	Shields LBE et al. 2022 ⁶³	36, F	Vaccination	Pfizer, 1	7	Ipsilateral pain, weakness	Weakness of right deltoid, biceps, and infraspinatus.	EMG: Fibrillation, positive sharp waves in the deltoid.	MRI: Normal.	Prednisone, gabapentin, physiotherapy	Improvement after 3 months
25	Shields LBE et al. 2022 ⁶³	74, M	Vaccination	Pfizer, 2	14	Ipsilateral pain, weakness	Weakness of flexion of the left thumb at the inter-phalangeal joint.	EMG: Low MUAP in the affected muscles	n/r	Physiotherapy	Improvement after 4 months
26	Shields LBE et al. 2022 ⁶³	50, M	Vaccination	Moderna, 2	5	Ipsilateral pain, weakness, numbness	Weakness of the right deltoid, biceps, brachioradialis, triceps, and infraspinatus; low pinprick sensation in right upper arm.	EMG: Fibrillation, PSWs, and fewer motor units in the right deltoid, biceps, brachioradialis, and triceps.	n/r	Methylprednisolone, physiotherapy	Improvement after 4 months
27	Shields LBE et al. 2022 ⁶³	53, M	Vaccination	Pfizer, 1	14	Ipsilateral pain, paresthesia, weakness	Weakness of the left triceps, extensor digitorum communis, first digital interosseous, abductor digiti minimi, and abductor pollicis brevis.	EMG: PSWs and less motor unit recruitment in the FDI and ADM; less motor unit recruitment in the EPL, EDC, APB, and triceps.	n/r	Prednisone, gabapentin	No improvement after 3.5 months

(continued)

Table 2. Continued.

No.	Author, Year	Age, Sex	Potential risk factors	Vaccine, doses given	Latency Period (Days)	Presentation and laterality	Physical exam findings	Electrodiagnostic findings (EMG/NCS)	Radiologic findings	Treatment(s)	Outcome
28	Shields LBE et al. 2022 ⁶³	84, M	Vaccination	Pfizer, 2	56	Contralateral pain, weakness	Weakness of extension of the left digits at the metacarpophalangeal joints.	EMG: No CMAP over EI or EDC; fibrillation and PSWs of the EDC and EPL.	n/r	None	Significant improvement after 3 months
29	Shields LBE et al. 2022 ⁶³	46, M	Vaccination	Moderna, 2	6	Ipsilateral pain, weakness	Weakness of extension of the left digits, weak shoulder abduction.	EMG: Less motor unit recruitment and greater polyphasic units in the left deltoid, triceps, EDC, and EI.	n/r	Steroids	Improvement
30	Vitturi BK et al. 2021 ⁶⁴	51, M	Vaccination	AstraZeneca, 1	4	Left-sided pain, numbness, weakness	Atrophy of the proximal muscles of the left upper limb; paresis of the left deltoid, biceps brachii, triceps brachii, and infraspinatus muscles.	EMG: Mild-to-moderate peripheral neurological damage, with signs of reinnervation of the deltoid, biceps brachii, triceps brachii, infraspinatus, EPL, EPB, and first interosseous muscles. NCS: Low amplitude of the left axillary nerve action potential.	n/r	NSAIDs, pregabalin, physiotherapy	Improvement after 5 months
31	Kim SI, et al. 2021 ⁶⁵	45, F	Vaccination	AstraZeneca	2	Ipsilateral pain, weakness, and numbness	Low strength against resistance of the left leg (MRC 4/5); less sensation.	EMG: Less motor unit recruitment in the left leg muscles. Axonal and demyelinating lumbosacral plexopathy (L2–L4). NCS: Low amplitude and prolonged latency in the left lateral femoral cutaneous and left saphenous SNAPs; low amplitude of the left femoral CMAP.	T2-weighted contrast-enhanced lumbar MRI: high intensities in the left femoral and obturator nerves. T2-weighted thigh MRI: greater signal intensity with atrophic changes in the vastus medialis, rectus femoris, and vastus lateralis muscles.	Prednisolone	Slight improvement
32	Lee SM, et al. 2022 ⁶⁶	21, M	Vaccination	Pfizer, 2	2	Ipsilateral burning sensation and weakness	Wrist and finger drop; weakness in arm extension and flexion.	NCS: Low left radial CMAP and SNAP.	Brachial plexus MRI: multiple enlarged benign lymph nodes (LNs) along the neck (level IV). USG: An enlarged LN compressing the radial nerve was discovered.	Methylprednisolone, physiotherapy	Complete recovery

F; female; M; male; n/r; not reported; EMG, electromyography; NCS, nerve conduction studies; MUAP, motor unit action potential; SNAP, sensory nerve action potential; MRC, Medical Research Council muscle power scale; MRI, magnetic resonance imaging; STIR, short tau inversion recovery; USG, ultrasonography; CXR, chest X-ray; NSAIDs, non-steroidal anti-inflammatory drugs; ADM, abductor digiti minimi; APB, abductor pollicis brevis; ECR, extensor carpi radialis; ED, extensor digitorum; EI, extensor indicis; EPL, extensor pollicis longus; FCU, flexor carpi ulnaris; FDP, flexor digitorum profundus; FDS, flexor digitorum superficialis.

Table 3. Comparison of findings in patients with COVID-associated and COVID vaccination-associated Parsonage–Turner syndrome

Parameter	After COVID vaccination	After COVID infection	p-value
No. of cases reported	32	36	
Age (mean $\pm$ SD), years	50.9 $\pm$ 15.3	47.5 $\pm$ 17.2	0.7067
Male: Female ratio	4:1	2:1	0.2627
Vaccination received before symptoms developed			
Pfizer	17 (53.1%)		
AstraZeneca	5 (15.6%)		
Moderna	6 (18.8%)		
Covishield	2 (6.25%)		
Unspecified	2 (6.25%)		
No. of doses received			
1	8 (25%)		
2	20 (62.5%)		
Unspecified	4 (12.5%)		
Time to onset of symptoms (mean), days	11.67	20.3	0.0321
Laterality of symptoms			
Unilateral	30 (93.8%): Ipsilateral (78.3%), Contralateral (21.7%)	28 (77.8%)	0.6288
Bilateral	2 (6.25%)	8 (22.2%)	
Presentation			
Pain	29 (90.6%)	29 (80.6%)	—
Pure motor	15 (46.9%)	10 (27.8%)	0.1438
Sensorimotor	17 (53.1%)	24 (66.7%)	
Pure sensory	None	2 (5.6%)	
Muscle group affected			
Proximal	15 (46.8%)	22 (61.1%)	0.1132
Distal	10 (31.2%)	4 (11.4%)	
Both	5 (15.6%)	8 (22.2%)	
Nerves affected			
Axillary	11 (34.4%)	9 (25%)	—
Musculocutaneous	8 (25%)	9 (25%)	
Suprascapular	8 (25%)	9 (25%)	
Radial	7 (21.9%)	5 (13.9%)	
Median	5 (15.6%)	7 (19.4%)	
Ulnar	3 (9.4%)	4 (11.1%)	
Long thoracic	3 (9.4%)	2 (5.6%)	
Antebrachial cutaneous	6 (18.8%)	1 (2.1%)	
Spinal accessory	3 (9.4%)	0 (0%)	
Anterior and posterior interosseous	3 (9.4%)	1 (2.1%)	
Phrenic	2 (6.3%)	2 (4.2%)	
Lumbosacral plexus	1 (3.1%)	1 (2.1%)	
Brachial plexus trunk involvement			
Upper	17 (53.1%)	18 (50%)	0.0059
Lower	11 (34.4%)	1 (2.8%)	

(continued)

Table 3. Continued.

Parameter	After COVID vaccination	After COVID infection	p-value
Middle	2 (6.3%)	2 (5.6%)	
Pan plexopathy	1 (3.1%)	7 (19.4%)	
Outside brachial plexus	3 (9.4%)	7 (19.4%)	
Treatment given			
Steroids	11 (34.4%)	9 (25%)	–
Pregabalin	11 (34.4%)	6 (16.7%)	
Physiotherapy	12 (37.5%)	9 (25%)	
NSAIDs	4 (12.5%)	4 (11.1%)	
Gabapentin	4 (12.5%)	5 (13.9%)	
None	5 (15.6%)	1 (2.8%)	
Outcome			
Complete recovery	4 (12.5%)	8 (22.2%)	0.6483
Partial recovery	25 (78.1%)	14 (38.9%)	
Poor recovery	2 (6.3%)	5 (13.9%)	
Not reported	1 (3.1%)	9 (25%)	

Data are n (%), unless otherwise stated. Data were analyzed using the chi-square test or Student's t-test, as appropriate.

patients for whom outcomes were reported had achieved complete or partial recovery at follow-up.

The mean age of the 36 patients who developed PTS after COVID-19 infection was 47.5 ± 17.1 years, and 25 (69.4%) were male. Eleven of these patients (30.6%) had undergone prone ventilation. The mean interval between the onset of infection and the onset of symptoms was 20.3 days. The patients presented with pain (n=29, 80.6%), motor weakness (n=10, 27.8%), sensorimotor deficits (n=24, 66.7%), and/or pure sensory deficits (n=2, 5.6%). Twenty-eight (77.8%) patients had unilateral symptoms and 8 (22.2%) had bilateral symptoms. The suprascapular, musculocutaneous, and axillary nerves were affected in nine (25%) patients each. Proximal weakness was reported in 22 patients (61.1%) and distal weakness in 4 (11.4%). Seventeen patients (53%) had MRI findings and 31 patients (96.8%) had electrodiagnostic findings suggestive of PTS. Nine (25%) patients were treated with steroids and nine (25%) patients with physiotherapy. Twenty-two

(81.5%) patients for whom outcomes were reported had achieved complete or partial recovery at follow-up.

Discussion

PTS is a rare neurological phenomenon that was first described by Parsonage and Turner in 1948.¹ Although its exact etiology is unknown, according to recent studies, viral infection and immunization are the most common risk factors.⁵ The development of this rare disease has been associated with a number of etiologies, including hepatitis E,⁶⁷ cytomegalovirus,⁶⁸ varicella zoster virus,⁶⁹ and *Borrelia burgdorferi*⁷⁰ infections. PTS has also been shown to be associated with immunization, with clinical evidence suggesting that vaccinations against influenza,⁷¹ typhoid,⁷² human papillomavirus,⁷³ and DPT⁷⁴ in children are possible etiologic factors. Because cases of PTS have been increasingly reported following COVID-19 vaccination, Kim *et al.*⁷⁵ performed a study using disproportionality analysis, and concluded that the risk of neuralgic amyotrophy associated

with COVID-19 vaccines does not exceed that associated with influenza vaccines. However, this weak association is still crucial in the context of both vaccination hesitancy among the general population and other COVID-19 vaccination-related neuropathic symptoms and syndromes.⁷⁶

During the COVID-19 pandemic, cases of PTS were reported after both vaccination and infection. In this review, we have summarized the findings associated with 32 cases that developed following vaccination and 36 that developed following infection. Under both circumstances, middle-aged men were the most commonly affected group. The characteristics of the two etiologic groups were similar, except that the mean latency period for PTS following COVID-19 infection was almost double that following vaccination ($p=0.0321$). Vaccinated patients also showed a higher prevalence of the involvement of the lower trunk of the brachial plexus than patients who had COVID-19 infection ($p=0.0059$).

The majority of patients in the post-vaccination group had received the Comirnaty vaccine, followed by Spikevax (Moderna) and the AstraZeneca vaccine/Vaxzevria (Astra Zeneca, Cambridge, UK). While the exact pathogenesis of vaccination-associated PTS remains unclear, molecular mimicry and bystander activation of immune-mediated mechanisms affecting the brachial plexus are the likely culprits in certain individuals who are susceptible to the condition.⁶ The delay in the onset of symptoms following the administration of vaccines, calculated to be a mean of 11.7 days in the present review, is consistent with this pathogenetic mechanism. This latency period is similar to the time required to achieve a maximal immune response following vaccine administration.⁷⁷ In view of the above findings, it can be theorized that mRNA vaccines are more likely to be associated with the subsequent development of PTS, and this

hypothesis has been previously been tested and confirmed by Kim *et al.*⁷⁵ This finding is especially important in the context of the COVID-19 pandemic, during which clinicians should have a high index of suspicion of PTS in patients who present with compatible symptoms who have received Comirnaty in the recent past. It is noteworthy that, in the present review, we found that most (78.3%) patients experienced symptoms of PTS ipsilateral to the injection site, which suggests that the pathogenesis may involve the local spread of the inoculum. We also found that most patients who developed PTS following vaccination were treated with corticosteroids and non-steroidal anti-inflammatory drugs, and most showed partial or complete recovery within a year. This finding is indicative of a pathogenetic mechanism involving inflammation in such cases.

It is also important to discuss the pathogenesis of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)-induced PTS. SARS-CoV-2 binds to angiotensin-converting enzyme-2 receptors in various tissues, including the lungs, olfactory epithelium, intestinal epithelium, and endothelial cells in the kidneys and blood vessels. This accounts for the multi-organ defects associated with “long COVID”. SARS-CoV-2 also elicits an aberrant immune response, causing an overproduction of proinflammatory cytokines.⁷⁸ Both these models are supported by the findings of edema in patients by MRI, indicative of inflammation in the nerves and muscles involved.

Cheung *et al.*¹⁷ reported a case of PTS following COVID-19 infection in a 55-year-old man, who presented with pain that extended from his neck and right interscapular region to his shoulder and along his arm and forearm; a weak hand grip, and disturbed sleep. His sister had also developed similar neuropathic symptoms. Pivaral *et al.*²⁸ also reported two

post-infection cases of PTS in two siblings. The clinical presentations of the two siblings were similar, and nerve conduction studies demonstrated abnormal postganglionic sensory nerve action potentials in the left brachial plexus at the level of the trunk. This suggests that genetics may be involved in the etiology of post-infection PTS. Kuhlenbäumer *et al.*⁹ have identified three mutations in the gene encoding septin 9 (*SEPT9*) in six families with hereditary neuralgic amyotrophy (HNA) that are linked to chromosome 17q25. PTS is a more common, sporadic form of painful brachial plexus neuropathy that is clinically indistinguishable from HNA, and the genes involved may be closely linked to or even at the same locus. However, this possibility must be evaluated in future studies.

Of the 36 patients who had been diagnosed with COVID-19 prior to the development of PTS, 11 had received prone ventilation as part of their treatment. Prone positioning improves the distribution of blood flow and ameliorate the ventilation-perfusion mismatch, in addition to helping with the drainage of secretions, and hence is used as an adjunct in patients requiring mechanical ventilation.⁷⁹ Surgical interventions involving over-abduction of the arms in a prone position can damage the brachial plexus,⁸⁰ possibly by causing injury to the blood-nerve barrier of the brachial plexus.⁸¹ Although there is mounting evidence that PTS also develops following surgical procedures that involve little-to-no traction or compression injury of the brachial plexus,⁸² mechanical trauma during the ventilation of patients with COVID-19 must be considered when investigating the etiology of post-infection PTS.

Given that the exact etiology of PTS is not known, and some of the patients had concomitant factors that could have contributed to its development in various ways, it is critical to consider the possible interplay between multiple risk factors.

However, we believe that the well-known neuropathic potential of SARS-CoV-2 is consistent with such an association. Andalib *et al.*⁸³ studied nerve pain and skeletal muscle injury, Guillain-Barré syndrome, cranial polyneuritis, and neuromuscular junction disorders as peripheral nervous system manifestations in patients with COVID-19. We believe that PTS can be added to this list of the possible neurologic manifestations of COVID-19. Similarly, SARS-CoV-2 vaccination has been reported to be associated with neuropathic side effects. In their study, Safavi *et al.*⁷⁶ reported new neuropathic symptoms that developed within the first month following SARS-CoV-2 vaccination, including paresthesia, a burning sensation, numbness, and autonomic symptoms.

Although most of the reported patients presented with similar symptoms, some atypical clinical findings were also observed. Kang and Cho⁵² reported a case of PTS that followed COVID-19 vaccination that was characterized by a restrictive pattern on pulmonary function testing. Kim *et al.*⁶⁵ also reported a case of post-vaccination PTS that featured lower extremity involvement, instead of the more typical upper extremity involvement; and lumbosacral plexopathy (L2–L4) that was confirmed by electromyography. There have been previous reports of lumbosacral plexus involvement, but this is commonly associated with an underlying medical illness.⁸⁴

The clinical presentations of patients in the present study are comparable to those reported in earlier studies of PTS. Van Alfen *et al.*⁶ analyzed 246 cases and concluded that most patients are middle-aged men (mean age, 41.3 years) who initially present with pain, followed by unilateral weakness of the upper limbs. The upper trunk of the brachial plexus is most frequently involved, and most patients show partial recovery, with some residual symptoms.

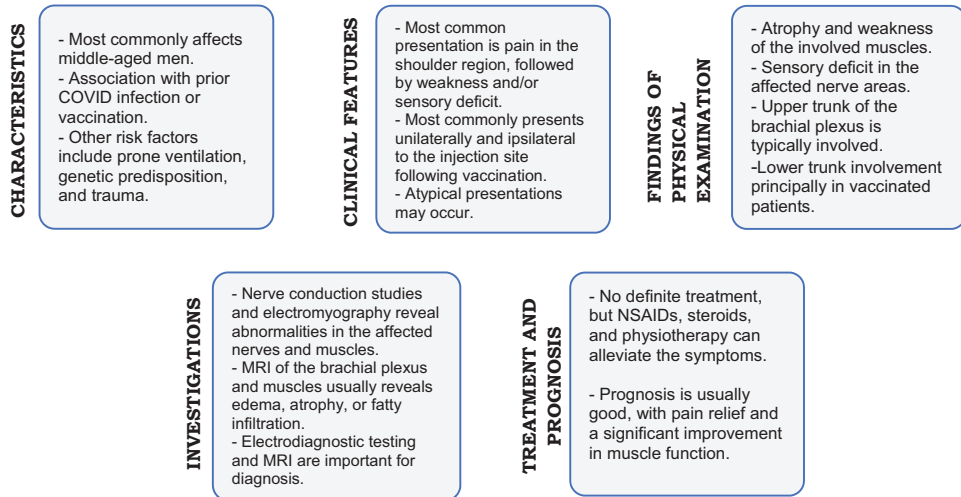


Figure 2. Summary of Parsonage–Turner syndrome associated with COVID vaccination or infection MRI, magnetic resonance imaging; NSAIDs, non-steroidal anti-inflammatory drugs

To the best of our knowledge, this is the first systematic review of all the evidence available regarding the incidence of PTS in association with COVID-19 infection or vaccination (Figure 2). An awareness of such an association may aid in the early diagnosis, reduction of morbidity, and a better prognosis for patients with PTS.

The authors would also like to acknowledge a few limitations in the reporting of their findings. Owing to the rarity of the disease and its association with COVID-19, some cases of post-vaccination or post-infection PTS may have been misdiagnosed or missed completely. This issue of unreported cases brings into question the generalizability of the present findings to the general population. Moreover, there was also an inherent heterogeneity in the results, owing to inter-individual variations in the reported patients and subjectivity in reporting of the cases by the physicians. However, given the rigorous methodology used for literature searching and data extraction, we believe that we have provided a comprehensive overview of all the available literature regarding the clinical and pathophysiological aspects of PTS.

Conclusions

The incidence of PTS has increased considerably during the rollout of the COVID-19 vaccines. Post-vaccination PTS presents earlier and involves the upper or lower trunks of brachial plexus, in contrast to the post-infection disease, which presents later and principally involves the upper trunk. A presentation of pain, followed by proximal weakness, and sensory deficits in the upper limb following COVID infection or vaccination, should arouse clinical suspicion of PTS. A diagnosis can be confirmed by either electrodiagnostic studies or MRI. Complete or partial recovery has been reported for most patients, irrespective of the etiology.

Author Contributions

MZA and AUR conceived the study. AUH and FA established the search strategy. MZA and FA retrieved the articles and screened them for relevance. AUH and ZA assisted with full text screening. MHB, AUH and HA performed the quality assessment of the selected articles. Data were extracted by AUH, MHB, and HA. FA and ZA proofread the extracted data. MZA

and BM performed the statistical analysis. AUH and BM wrote the article. AUR critically revised the article. All the authors read and approved the final version of the article.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ORCID iD

Muhammad Zain Ameer  <https://orcid.org/0000-0001-7388-364X>

References

1. Parsonage MJ and Turner JW. Neuralgic amyotrophy; the shoulder-girdle syndrome. *Lancet* 1948; 251: 973–978.
2. Martínez-Salio A, Porta-Etessam J, Berbel A, et al. Amyotrophic neuralgia: review of 37 cases. *Rev Neurol* 1998; 27: 823–826. In Spanish.
3. Al Khalili Y, Jain S, Lam JC, et al. Brachial Neuritis. in *StatPearls* (StatPearls Publishing, 2022).
4. Tsairis P, Dyck PJ and Mulder DW. Natural history of brachial plexus neuropathy: report on 99 patients. *Arch Neurol* 1972; 27: 109–117.
5. Feinberg JH and Radecki J. Parsonage-Turner Syndrome. *HSS J* 2010; 6: 199–205.
6. Van Alfen N and Van Engelen BG. The clinical spectrum of neuralgic amyotrophy in 246 cases. *Brain* 2006; 129: 438–450.
7. England JD and Sumner AJ. Neuralgic amyotrophy: an increasingly diverse entity. *Muscle Nerve* 1987; 10: 60–68.
8. Husson M, Goizet C, Rivera S, et al. Hereditary neuralgic amyotrophy: a paediatric and familial presentation of Parsonage-Turner syndrome. *Arch Pediatr Organe Off Soc Francaise Pediatr* 2004; 11: 1336–1338. In French.
9. Kühlenbäumer G, Hannibal MC, Nelis E, et al. Mutations in SEPT9 cause hereditary neuralgic amyotrophy. *Nat Genet* 2005; 37: 1044–1046.
10. WHO Coronavirus (COVID-19) Dashboard. <https://covid19.who.int>.
11. Siepmann T, Kitzler HH, Lueck C, et al. Neuralgic amyotrophy following infection with SARS-CoV-2. *Muscle Nerve* 2020; 62: E68–E70.
12. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Int J Surg* 2021; 88: 105906.
13. Moola S, Munn Z, Tufanaru C, et al. Chapter 7: Systematic reviews of etiology and risk – JBI Manual for Evidence Synthesis – JBI Global Wiki. <https://doi.org/10.46658/JBIMES-20-08>.
14. Alvarado M, Lin-Miao Y and Carrillo-Arolas M. Parsonage-Turner syndrome post-infection by SARS-CoV-2: a case report. *Neurol Engl Ed* 2021; 36: 568–571.
15. Alvarez A, Amirianfar E, Mason MC, et al. Extended neuralgic amyotrophy syndrome in a confirmed COVID-19 patient after intensive care unit and inpatient rehabilitation stay. *Am J Phys Med Rehabil* 2021; 100: 733–736.
16. Ansari B, Eishi Oskouei A and Moeinzadeh F. Parsonage-Turner syndrome following COVID-19 infection: a rare and unique case. *Adv Biomed Res* 2022; 11: 7.
17. Cheung VY, Tsui FP and Cheng JM. Pain management for painful brachial neuritis after COVID-19: a case report. *Hong Kong Med J* 2022; 28: 178–180.
18. Coll C, Tessier M, Vandendries C, et al. Neuralgic amyotrophy and COVID-19 infection: 2 cases of spinal accessory nerve palsy. *Joint Bone Spine* 2021; 88: 105196.
19. De Pémile CV, Vandendries C, Bruel C, et al. Syndrome de Parsonage–Turner (plexopathie inflammatoire) secondaire à une infection par le SARS-CoV2. *Rev Neurol (Paris)* 2021; 177: S75. In French.
20. Díaz C, Contreras JJ, Muñoz M, et al. Parsonage-Turner syndrome association with SARS-CoV-2 infection. *JSES Rev Rep Tech* 2021; 1: 252–256.
21. Doğan Y, Kara M, Doğan KÇ, et al. Neuralgic amyotrophy associated with

- COVID-19 infection: the broken bough. *Korean J Pain* 2022; 35: 233–235.
22. Fortanier E, Le Corroller T, Hocquart M, et al. Shoulder palsy following SARS-CoV-2 infection: two cases of typical Parsonage–Turner syndrome. *Eur J Neurol* 2022; 29: 2548–2550.
 23. Arce Gálvez L, Benavides Ramirez A and Mancera Alzate JM. Dolor y rehabilitación en síndrome de Parsonage-Tuner por SARS-CoV2: a propósito de un caso. *Rev Soc Esp Dolor* 2022. In Spanish.
 24. Ng GJ, Chiew YR, Kong Y, et al. Neuralgic amyotrophy in COVID-19 infection and after vaccination. *Ann Acad Med Singapore* 2022; 51: 376–377.
 25. Ismail II, Abdelnabi EA, Al-Hashel JY, et al. Neuralgic amyotrophy associated with COVID-19 infection: a case report and review of the literature. *Neurol Sci* 2021; 42: 2161–2165.
 26. Cacciavillani M, Salvalaggio A and Briani C. Pure sensory neuralgic amyotrophy in COVID-19 infection. *Muscle Nerve* 2021; 63: E7–E8.
 27. Mitry MA, Collins LK, Kazam JJ, et al. Parsonage–Turner syndrome associated with SARS-CoV2 (COVID-19) infection. *Clin Imaging* 2021; 72: 8–10.
 28. Pivaral CC, Sánchez AR, Rodríguez ND, et al. Parsonage Turner syndrome associated with COVID-19: about 2 family cases. *Neurologia (Engl Ed)* 2023; 38: 57–58.
 29. Torres L, Massignan Â, Gheno R, et al. Acquired peripheral nerve injury findings in critically ill COVID-19 patients. *J Belg Soc Radiol* 2022; 106: 26.
 30. Viatgé T, Noel-Savina E, Prévot G, et al. Syndrome de Parsonage–Turner compliquant une infection sévère à SARS-CoV-2. *Rev Mal Respir* 2021; 38: 853–858. In French.
 31. Voss TG and Stewart CM. Parsonage–Turner syndrome after COVID-19 infection. *JSES Rev Rep Tech* 2022; 2: 182–185.
 32. Han CY, Tarr AM, Gewirtz AN, et al. Brachial plexopathy as a complication of COVID-19. *BMJ Case Rep CP* 2021; 14: e237459.
 33. Zazzara MB, Modoni A, Bizzarro A, et al. COVID-19 atypical Parsonage–Turner syndrome: a case report. *BMC Neurol* 2022; 22: 96.
 34. Cabona C, Zaottini F, Pistoia F, et al. Isolated musculocutaneous nerve involvement in COVID-19 related neuralgic amyotrophy. Comment on: ‘Neuralgic amyotrophy and COVID-19 infection: 2 cases of spinal accessory nerve palsy’ by Coll et al. *Joint Bone Spine* 2021; 88: 105196. *Joint Bone Spine* 2021; 88: 105238.
 35. Mano T and Fujimura S. Brachial plexus injury and musculocutaneous nerve palsy during prone positioning in a patient with COVID-19. *Cureus* 2022; 14: e24931.
 36. Diprose WK, Bainbridge L, Frith RW, et al. Bilateral upper limb neuropathies after prone ventilation for COVID-19 pneumonia. *Neurol Clin Pract* 2021; 11: e211–e213.
 37. Sneag DB, Geannette C, Queler S, et al. Long-segment nonfocal peripheral neuropathies after COVID-19 infection: a case report of magnetic resonance neurography findings. *HSS J* 2022; 18: 156–160.
 38. Sánchez-Soblechero A, García CA, Sáez Ansotegui A, et al. Upper trunk brachial plexopathy as a consequence of prone positioning due to SARS-CoV-2 acute respiratory distress syndrome. *Muscle Nerve* 2020; 62: E76–E78.
 39. Waheed W and Sneag D. Parsonage–Turner syndrome: fascicular involvement and focal constriction. *J Clin Neuromuscul Dis* 2022; 23: 227–228.
 40. De Pinho Teixeira Alves M and Nóbrega JPG. Median nerve neuritis after infection by the SARS-CoV-2 virus. *Clin Surg* 2021; 6: 3306.
 41. Saade F, Bouteille C, Quemener-Tanguy A, et al. Parsonage–Turner syndrome and SARS-CoV-2 infection: a case report. *Hand Surg Rehabil* 2022; 42: 90–92.
 42. Omar I and Garg, A. Magnetic resonance neurography findings in three critically ill COVID-19 patients with new onset of extremity peripheral neuropathy. *Pol J Radiol* 2021; 86: 394–400.
 43. Amjad MA, Hamid Z, Patel Y, et al. COVID-19 vaccine-induced Parsonage–Turner syndrome: a case report and literature review. *Cureus* 2022; 14: e25493.

44. Balloy G, Magot A, Fayet G, et al. COVID-19: a putative trigger for neuralgic amyotrophy. *Rev Neurol (Paris)* 2022; 178: 157–158.
45. Cutsem GV and Bolyn S. Isolated long thoracic nerve palsy following COVID-19 vaccine: a case report. 2023. <https://www.researchsquare.com/article/rs-1888467/v1>.
46. Bernheimer JH and Gasbarro G. Parsonage Turner syndrome following vaccination with mRNA-1273 SARS-CoV-2 vaccine. *J Clin Neuromuscul Dis* 2022; 23: 229–230.
47. Crespo Burillo JA, Lorienté Martínez C, García Arguedas C, et al. Neuralgia amiotrófica secundaria a vacuna contra COVID-19 Vaxzevria (AstraZeneca). *Neurología* 2021; 36: 571–572. In Spanish.
48. Chua MMJ, Hayes MT and Cosgrove R. Parsonage-Turner syndrome following COVID-19 vaccination and review of the literature. *Surg Neurol Int* 2022; 13: 152.
49. Civardi C, Delconte C, Pisano F, et al. Isolated musculocutaneous involvement in neuralgic amyotrophy associated with SARS-CoV2 vaccination. *Neurol Sci* 2022; 43: 3515–3517.
50. Ferguson D, Yasuda T and Selod O. Parsonage Turner syndrome following COVID19 vaccination in a cancer patient: a case report. 2022. UNTHSC Scholar Abstract.
51. Koh JS, Goh Y, Tan BY, et al. Neuralgic amyotrophy following COVID-19 mRNA vaccination. *QJM* 2021; 114: 503–505.
52. Kang J and Cho JY. Diaphragmatic dysfunction due to neuralgic amyotrophy after SARS-CoV-2 vaccination: a case report. *J Korean Med Sci* 2022; 37: e283.
53. Leemans W, Antonis S, De Vooght W, et al. Neuromuscular complications after COVID-19 vaccination: a series of eight patients. *Acta Neurol Belg* 2022; 122: 753–761.
54. Krisztina L, Eva C and Bela F. Bilateral Parsonage-Turner syndrome after COVID-19 vaccination: a case report and review of the literature. *Orv Hetil* 2022; 163: 1055–1060.
55. Mahajan S, Zhang F, Mahajan A, et al. Parsonage Turner syndrome after COVID-19 vaccination. *Muscle Nerve* 2021; 64: E3–E4.
56. Lakkireddy M, Sathu S, Kumar R, et al. Parsonage-Turner syndrome following Covishield (AstraZeneca ChAdOx1 nCoV-19) vaccination: a case report. *Cureus* 2022; 14: e27867.
57. Mejri I, Ben Hmida L, Bedoui I, et al. Parsonage–Turner syndrome of the brachial plexus secondary to COVID-19 vaccine: a case report. *Clin Case Rep* 2022; 10: e6483.
58. Öncel A and Coşkun E. Parsonage-Turner syndrome after SARS-CoV-2 vaccination: a case report. *ADM* 2022; 10: 250.
59. Pilgram L. Parsonage-Turner syndrome after COVID-19 vaccination: a case report. *PMR Meeting Abstracts* <https://pmrjabstracts.org/abstract/parsonage-turner-syndrome-after-covid-19-vaccination-a-case-report/>.
60. Queler SC, Towbin AJ, Milani C, et al. Parsonage-Turner syndrome following COVID-19 vaccination: MR neurography. *Radiology* 2022; 302: 84–87.
61. Diaz-Segarra N, Edmond A, Gilbert C, et al. Painless idiopathic neuralgic amyotrophy after COVID-19 vaccination: a case report. *PMR* 2022; 14: 889–891.
62. Sharma A and Gupta A. A rare case of brachial plexus neuropraxia after COVID-19 vaccination. *Cureus* 2022; 14: e21244.
63. Shields LBE, Iyer VG, Zhang YP, et al. Parsonage-Turner syndrome following COVID-19 vaccination: clinical and electromyographic findings in 6 patients. *Case Rep Neurol* 2022; 14: 58–67.
64. Vitturi BK, Grandis M, Beltramini S, et al. Parsonage–Turner syndrome following coronavirus disease 2019 immunization with ChAdOx1-S vaccine: a case report and review of the literature. *J Med Case Reports* 2021; 15: 589.
65. Kim SI, Seok HY, Yi J, et al. Leg paralysis after AstraZeneca COVID-19 vaccination diagnosed as neuralgic amyotrophy of the lumbosacral plexus: a case report. *J Int Med Res* 2021; 49: 3000605211056783.
66. Lee SM, Hong JY, Kim SY, et al. Ipsilateral radial neuropathy after COVID-19 mRNA vaccination in an immunocompetent young man. *Yonsei Med J* 2022; 63: 966–970.
67. Garofoli R, Zauderer J, Seror P, et al. Neuralgic amyotrophy and hepatitis E infection: 6 prospective case reports. *RMD Open* 2020; 6: e001401.

68. Mastroianni A and Mauro MV. Parsonage-Turner syndrome and cytomegalovirus disease. *Clin Neuropathol* 2022; 41: 135–144.
69. Chebbi W, Kessomtini W, Kacem HH, et al. Syndrome de Parsonage-Turner après une infection à virus varicelle-zona. *Presse Méd* 2015; 44: 569–571. In French.
70. Wendling D, Sevrin P, Bouchaud-Chabot A, et al. Parsonage–Turner syndrome revealing Lyme borreliosis. *Joint Bone Spine* 2009; 76: 202–204.
71. Shaikh MF, Baqai TJ and Tahir H. Acute brachial neuritis following influenza vaccination. *BMJ Case Rep* 2012; 2012: bcr2012007673.
72. Kim JG, Kim SY, Oh HS, et al. Parsonage-Turner syndrome following typhoid vaccination. *Yonsei Med J* 2021; 62: 868–871.
73. Debeer Ph, De Munter P, Bruyninckx F, et al. Brachial plexus neuritis following HPV vaccination. *Vaccine* 2008; 26: 4417–4419.
74. Hamati-Haddad A and Fenichel GM. Brachial neuritis following routine childhood immunization for diphtheria, tetanus, and pertussis (DTP): report of two cases and review of the literature. *Pediatrics* 1997; 99: 602–603.
75. Kim JE, Park J, Min, YG, et al. Associations of neuralgic amyotrophy with COVID-19 vaccination: disproportionality analysis using the World Health Organization Pharmacovigilance Database. *Muscle Nerve* 2022; 66:766–770.
76. Safavi F, Gustafson L, Walitt B, et al. Neuropathic symptoms with SARS-CoV-2 vaccination. *medRxiv* 2022; 2022.05.16.22274439. Preprint at <https://doi.org/10.1101/2022.05.16.22274439>.
77. Addo IY, Dadzie FA, Okeke SR, et al. Duration of immunity following full vaccination against SARS-CoV-2: a systematic review. *Arch Public Health* 2022; 80: 200.
78. Cevik M, Kuppalli K, Kindrachuk J, et al. Virology, transmission, and pathogenesis of SARS-CoV-2. *BMJ* 2020; 371: m3862.
79. Gandhi KD, Sharma M, Taweedsdt PT, et al. Role of proning and positive end-expiratory pressure in COVID-19. *World J Crit Care Med* 2021; 10: 183–193.
80. Goettler CE, Pryor JP and Reilly PM. Brachial plexopathy after prone positioning. *Crit Care* 2002; 6: 540–542.
81. Van Eijk JJ, Groothuis JT and Van Alfen N. Neuralgic amyotrophy: An update on diagnosis, pathophysiology, and treatment. *Muscle Nerve* 2016; 53: 337–350.
82. Malamut RI, Marques W, England JD, et al. Postsurgical idiopathic brachial neuritis. *Muscle Nerve* 1994; 17: 320–324.
83. Andalib S, Biller J, Di Napoli M, et al. Peripheral nervous system manifestations associated with COVID-19. *Curr Neurol Neurosci Rep* 2021; 21: 9.
84. Sander JE and Sharp FR. Lumbosacral plexus neuritis. *Neurology* 1981; 31: 470–473.