

MR neurography in Parsonage-Turner syndrome

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Abstract

Background and Aims: Parsonage Turner Syndrome is a well known clinical entity. Several excellent articles have succinctly described Magnetic Resonance Imaging (MRI) findings in PTS. However, these articles have inferred neural involvement in PTS based on the patterns of denervation of muscles in the shoulder region. The aim of this study is to directly visualize the distribution and extent of abnormality in MR Neurography (MRN) of the brachial plexus in known cases of brachial plexus neuritis or Parsonage-Turner Syndrome (PTS). **Methods:** 15 patients who were diagnosed with PTS based on clinical and electrophysiological findings participated in the study. MRN of the brachial plexus was done in a 1.5T system using a combination of T1W (T1-weighted), T2W (T2-weighted) fat-saturated, STIR (Short Tau Inversion Recovery), 3D STIR SPACE (Sampling Perfection with Application Optimized Contrasts) and 3D T2W SPACE sequences. Findings were recorded and assessed. **Results:** The age range of our patients was 7-65 years (mean 37.87 years). Most of the patients had unilateral symptoms. All patients had weakness in shoulder abduction. Other common associated complaints included pain in the shoulder/neck/arm and preceding fever. MRN revealed the percentage of involvement of roots, trunks, cords and terminal branches was 53.3%, 46.7%, 40% and 13.3% respectively. Evidence of muscle denervation in the form of edema, fatty infiltration and atrophy was noted in 8 (53.3%) patients. **Conclusion:** Most of the patients in this study had unilateral involvement on MRN. The roots were the commonest site of involvement followed by the trunks, cords and terminal branches. C5 was the most commonly involved root.

Key words: Brachial plexus; MR Neurography; magnetic resonance imaging; neuritis; parsonage-turner syndrome

Introduction

A localized neuritis of the shoulder girdle was first described by Spillane in 1943.^[1] Subsequently, in 1948, Parsonage and Turner elaborated upon the "Shoulder-Girdle syndrome" or "Neuralgic Amyotrophy", in which there was pain and flaccid paralysis of the shoulder musculature.^[2] Since then, this condition continues to be referred to as Parsonage-Turner Syndrome (PTS) although it is also called acute idiopathic brachial plexus neuritis.

Several excellent articles have succinctly described Magnetic Resonance Imaging (MRI) findings in PTS.^[3,4] However, these articles have inferred neural involvement in PTS based on the patterns of denervation of muscles in the shoulder region. Luigetti *et al.* in their paper have described Magnetic Resonance Neurography (MRN) findings in the brachial plexus in a series of 8 patients with PTS and have found it

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Cite this article as: Upadhyaya V, Upadhyaya DN, Bansal R, Pandey T, Pandey AK. MR neurography in Parsonage-Turner syndrome. Indian J Radiol Imaging 2019;29:264-70.

Received: 20-Jul-2019
Accepted: 04-Sep-2019

Revision: 01-Sep-2019
Published: 30-Oct-2019

Access this article online

Quick Response Code:



Website:
www.ijri.org

DOI:
10.4103/ijri.IJRI_269_19

to be useful in confirming the clinical diagnosis as well as in ruling out other probable causes.^[5] Hence, the authors decided to carry out a study which focuses on the pattern of involvement of various components of the plexus in PTS by imaging the plexus directly by MRN.

Methods

This was a single institution prospective study carried out from January 2016 to January 2018. Approval of the Institutional Ethics Committee was obtained for the study.

All patients with a clinical and electrophysiological diagnosis of PTS presenting to the Department of Radiology for an MRN examination of the brachial plexus were included in the study. These patients had already undergone an MRI of the cervical spine/shoulder and lesions such as large cervical disc herniations, rotator cuff tear or tendinopathy, labral tear with paralabral cystic lesion, mass lesions or shoulder impingement had been excluded. These patients had no history of trauma, neoplasm or radiation exposure. The MRN images of the brachial plexus were evaluated by two experienced radiologists, both with more than 14 years of experience in reading MR scans. Both the radiologists were blinded to the diagnosis and identity of the patients. The findings were tabulated in an Excel sheet for analysis later on.

Imaging technique

All the patients were imaged in a 1.5T scanner (Magnetom Essenza, Siemens, Erlangen, Germany). The patients were scanned in the supine position with arms by their sides. Both the cervical and body coils were used. The scan area extended from C3-T3 level. A combination of two-dimensional (2D) and three-dimensional (3D) sequences was used. In the axial plane, T1W (T1-weighted) and T2W (T2-weighted) fat saturated sequences were acquired. In the coronal plane, T1W and 3D STIR (Short Tau Inversion Recovery) SPACE (Sampling Perfection with Application Optimized Contrasts) were obtained. The 3D STIR SPACE sequence was focused on the affected side of the plexus. In the sagittal plane, sequences acquired included STIR on the affected side and 3D T2 SPACE, which was focused on the cervical spine and was used to evaluate

the intra-dural roots [Table 1]. No intravenous contrast was given to the patients.

Image interpretation

The entire brachial plexus was evaluated starting from the roots till the terminal branches, namely axillary, radial, musculocutaneous, median and ulnar nerves. Roots included both intra-spinal and extra-spinal nerves.

Nerves which appeared round or oval with well defined, smooth margins with size similar to adjacent arteries and maintained perineural fat planes were interpreted as normal. They showed signal intensity similar to muscle in T1W images, similar to slightly hyperintense in T2W images and hyperintense in STIR images.^[6-9]

Abnormal findings suggestive of neuritis included nerve thickening with hyperintense signal in T2W and STIR images. Hyperintense signal in the innervated muscle in T2W and STIR images compared to adjacent normal muscles was taken to be suggestive of acute denervation. Linear hyperintense foci in the muscle in T1W images with decrease in muscle bulk was interpreted as fatty infiltration and atrophy, when compared to other normal muscles.^[3]

Results

The age range of our patients was 7-65 years with a mean of 37.87 years. There were 11 males and 4 females in the study. The ratio of right to left side involvement was 4:3 and one patient had bilateral involvement. The duration of the patient's symptoms varied from 0.25 to 6 months with a mean of 2.28 months [Table 2]. All the patients complained of weakness in shoulder abduction. This was preceded by pain in the involved shoulder, arm or neck in eleven cases. The weakness appeared after fever in six patients. There was associated tingling in one patient and complains of diminished sensation in the arm in another. One patient gave history of skin rashes along with the fever one and half months back, following which he developed shoulder and elbow weakness. The skin rash had been diagnosed as Varicella infection at the time. Relevant past history included a history of cholecystectomy in one patient one month back and history of severe gastroenteritis half month back in

Table 1: MR Neurography Protocol

Sequence	FOV (mm)	Slice Thickness (mm)	Slice Gap (mm)	TR (msec)	TE (msec)	Acquisition Duration (min)	Voxel Size (mm)
Axial T1W	190 × 320	3.0	0.9	597	15	3:59	1.2 × 1.0 × 3.0
Axial T2W FS	188 × 320	3.0	0.9	3860	102	3:15	1.3 × 1.0 × 3.0
Coronal T1W	263 × 350	3.0	0.6	460	12	3:18	1.1 × 0.8 × 3.0
Coronal 3D STIR SPACE	300 × 300	1.2	-	3800	207	7:38	1.3 × 1.2 × 1.2
Sagittal STIR (Affected Side)	240 × 240	3.0	0.3	5210	19	6:52	1.2 × 0.9 × 3.0
Sagittal 3D T2W SPACE	250 × 250	0.75	-	1500	226	6:51	0.8 × 0.8 × 0.8

FOV=Field Of View, TR=Repetition Time, TE=Time of Echo, T1W=T1-Weighted, T2W=T2-Weighted, FS=Fat Saturated, STIR=Short Tau Inversion Recovery, SPACE=Sampling Perfection with Application optimized Contrasts by using varying flip angle Evolutions

another, for which he had been hospitalized. There was no history of trauma or excessive physical activity in any of the patients. No family history of the same condition was noted [Table 3].

Analysis of the MRN findings showed that the roots were involved in 8 (53.3%) patients, trunks in 7 (46.7%) patients, cords in 6 (40%) patients and terminal branches in 2 (13.3%) patients. The involved plexus showed hyperintense signal with or without mild thickening in T2W fat saturated images and STIR SPACE images [Figures 1-4]. Therefore, roots were the most common and terminal branches were the least common site of involvement. There was single level involvement in 8 patients. Involvement at two levels was seen in 6 patients and at three levels in only one patient [Table 4].

Among roots, C5 was involved the most often and T1 was not involved in any case. There was involvement of one root in 5 patients, 2 roots in 2 patients and 3 or more roots in only one patient [Table 5]. Among the trunks, upper trunk was most often involved in 7 patients, while the other two trunks were both involved in 4 patients each [Table 6]. The lateral cord was most frequently involved in 6 patients while the posterior and medial cords were involved in 4 and 2 patients, respectively. The terminal branch seen to be involved in our series was the axillary nerve in 2 cases [Table 7].

Evidence of muscle denervation in the form of edema, fatty infiltration and atrophy was noted in 8 (53.3%) patients [Figures 5 and 6]. 5 of these 8 patients (62.5%) showed muscle involvement in the form of edema. The

affected muscles showed hyperintense signal in T2W fat saturated and STIR SPACE images. In the other 3 cases (37.5%), the affected muscles showed evidence of fatty infiltration and atrophy. Here, they showed decreased bulk with interspersed hyperintense signal in T1W images. The muscle most often involved in our study was the supraspinatus followed by the infraspinatus [Table 8].

Table 2: Demographics

Age (in years)	
Range	7-65
Mean	37.87
Sex	
Male	11
Female	4
Laterality	
Right	8
Left	6
Bilateral	1
R: L Ratio	4:3
Duration (in months)	
Range	0.25-6
Mean	2.28

Table 3: Clinical findings

Fever	6	
Pain	11	
Tingling/Decreased Sensation	2	
Rash	1	
Weakness	15	
	Weakness at Shoulder	12
	Shoulder/Elbow	1
	Shoulder/Elbow/Wrist	2
History of Past Illness	3	
	Cholecystectomy	1
	Gastroenteritis	1
	Varicella	1

Table 4: MRN findings

Roots	8	
Trunks	7	
Cords	6	
Terminal Nerves	2	
One Level	8	
	Root	5
	Trunk	2
	Cord	1
	Terminal Nerve	0
Two Levels	6	
	Root and Trunk	2
	Trunk and Cord	2
	Cord and Terminal Nerve	2
Three Levels	1	
Root/Trunk/Cord		

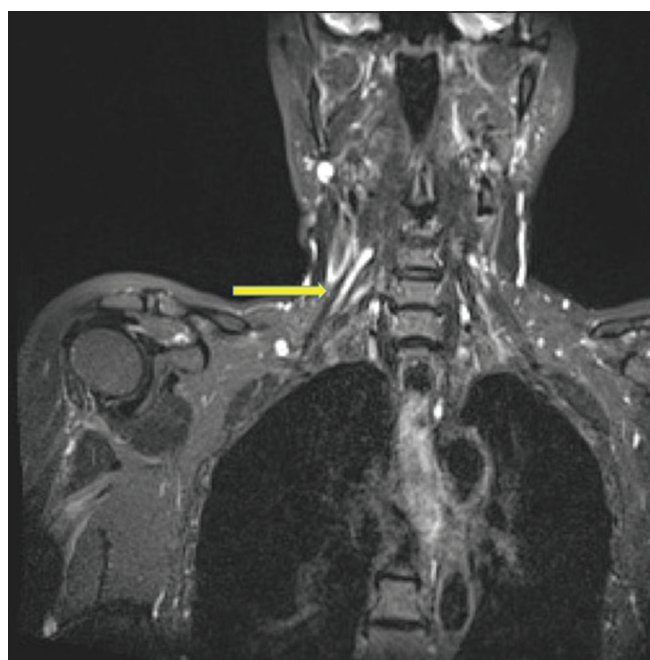


Figure 1: Coronal 3D STIR SPACE image in a patient with PTS showing hyperintense signal in the right C5 and C6 spinal nerves (Yellow Arrow)

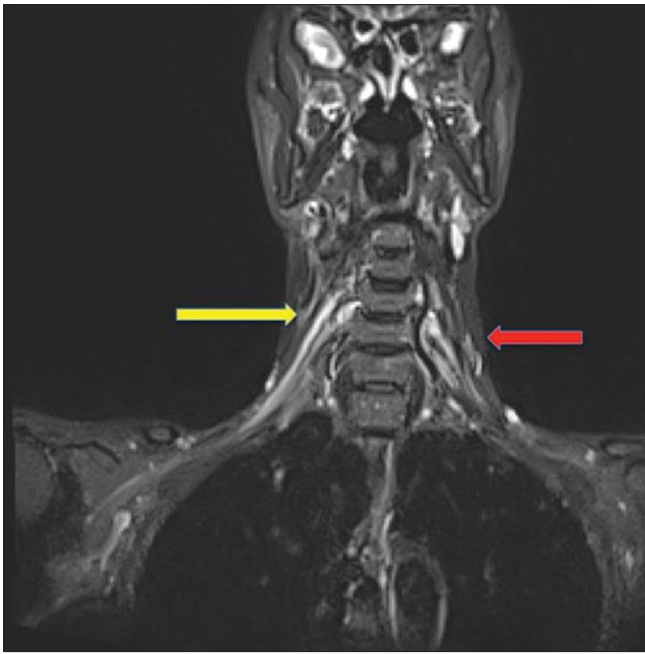


Figure 2: Coronal 3D STIR SPACE image showing hyperintense signal in the right C5 spinal nerve and upper trunk (Yellow Arrow). The left plexus is also involved with hyperintense signal in left C6 and C7 spinal nerves (Red Arrow)

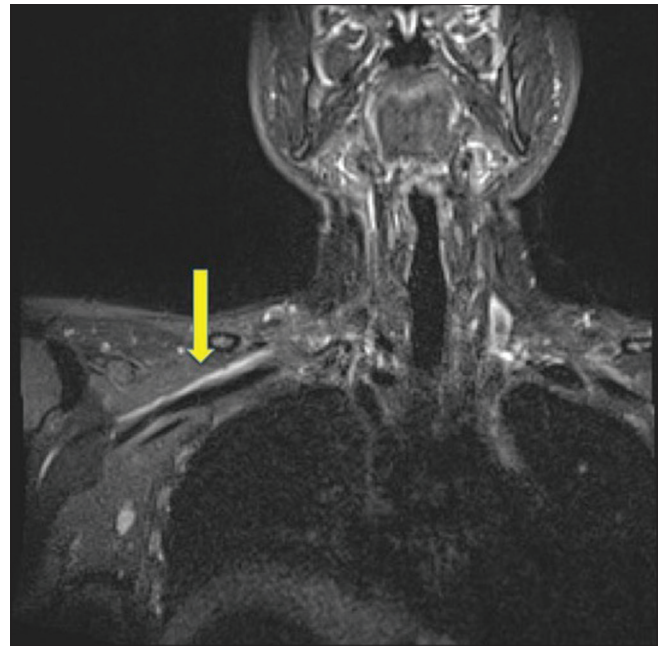


Figure 3: Coronal 3D STIR SPACE image shows hyperintense signal in the right lateral cord (Yellow Arrow)

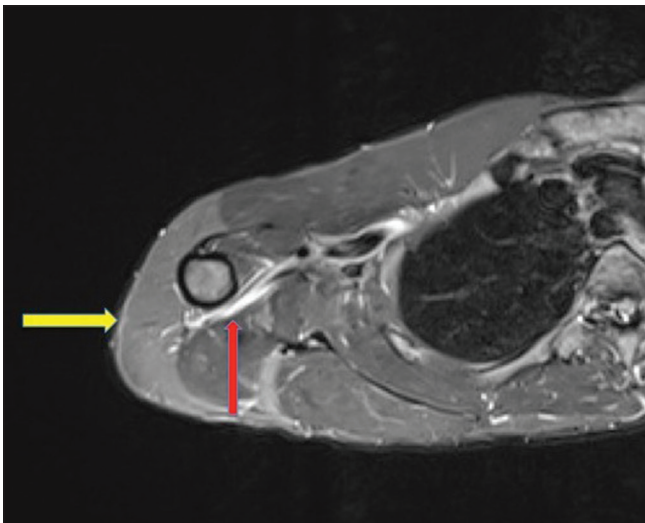


Figure 4: Axial T2W fat saturated image shows hyperintense signal in the right axillary nerve (Red Arrow) and edema in the deltoid muscle (Yellow Arrow)

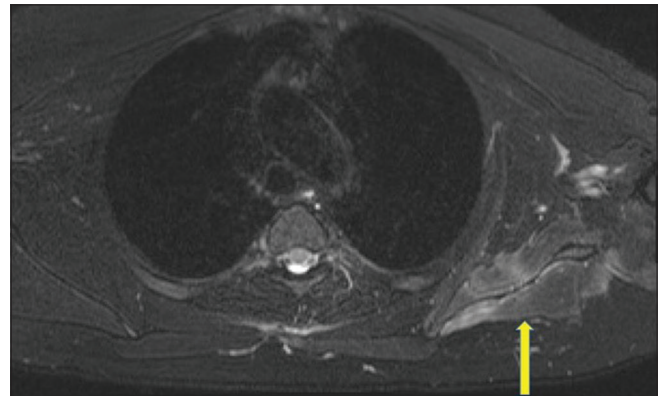


Figure 5: Axial T2W fat saturated image showing edema in the left infraspinatus and subscapularis muscles (Yellow Arrow). The supraspinatus was also involved, not shown here

Discussion

PTS is a painful condition which produces symptoms that can be confused for other causes such as rotator cuff pathology or cervical radiculopathy. Delay in diagnosis and appropriate treatment can prolong the agony of these patients. However, diagnosis is facilitated by using a combination of history, examination findings, electrodiagnostic tests and imaging. Here, MRN has an extremely important role to play as it can beautifully visualize the entire brachial plexus extending from the

roots till the terminal branches. It can also assess the condition of the muscles innervated by the brachial plexus. Today, it is considered the imaging modality of choice to evaluate both traumatic and non-traumatic pathologies of the peripheral nerves including the brachial plexus.^[10-17]

PTS is commoner in men than in women, occurring in a ratio of 2:1. It is seen in people of all age groups and median age of onset is forty years. About 70% of patients have unilateral involvement, while about 30% show bilateral asymmetric pattern of involvement. In about 25% of patients, the condition appears to recur in the first year itself.^[18,19] Our study has a small sample size and the results cannot be compared to studies comprising a large number of patients. However, we too had a wide age range varying from 7-65 years with mean age of 37.87 years. We

Table 5: Root involvement on MRN

C5	7	
C6	3	
C7	2	
C8	1	
T1	0	
One Root Involvement	5	
	C5	4
	C7	1
Two Roots Involvement	2	
	C5/C6	2
Three or more Roots	1	
	C5/C6/C7/C8	1

Table 6: Trunk involvement on MRN

Upper	7	
Middle	4	
Lower	4	
One Trunk Involvement	3	
	Upper Trunk	3
Two Trunks Involvement	0	
All Three Trunks	4	

Table 7: Cord and nerve involvement on MRN

Lateral Cord	6	
Posterior Cord	4	
Medial Cord	2	
One Cord Involved	2	
	Lateral Cord	2
Two Cords Involvement	2	
	Lateral and Posterior Cord	2
All Three Cords Involvement	2	
Terminal Nerve Involvement	2	
	Axillary Nerve	2

Table 8: MRI findings in muscles

Total	8	
Edema	5	
	Supraspinatus	4
	Infraspinatus	2
	Subscapularis	2
	Deltoid	1
	Pectoralis Major	1
Atrophy	3	
	Supraspinatus	3
	Infraspinatus	3
	Subscapularis	1
	Deltoid	1
	Pectoralis Major	0

had 11 males and 4 female patients in our study. Only one of our patients had bilateral symptoms, while the majority presented with unilateral involvement.

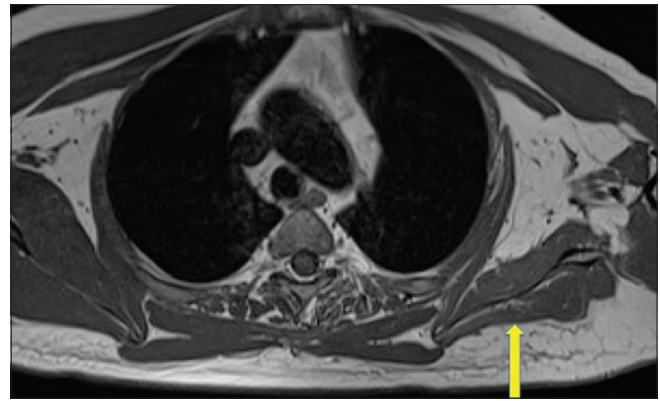


Figure 6: Axial T1W image showing atrophy in the left infraspinatus and subscapularis muscles (Yellow Arrow)

Most patients with PTS present with an attack of continuous, severe pain extending from the shoulder or neck to the arm. Some others have pain extending from the scapular region to the arm or chest wall and in few others, it maybe localized to the medial arm, hand or axilla. This attack of pain is followed by muscle weakness mostly within the first day or first week while in others it can occur in the second week or even later. Subsequently, muscle atrophy occurs within 2-5 weeks. Associated sensory symptoms such as hypaesthesia, paraesthesia or a combination of the two are seen in over 75% patients.^[18] In our study, all the patients had shoulder weakness and most of the times, in about 75% cases (73.34%), the weakness was preceded by the pain. However, only two of our patients complained of sensory symptoms in the form of tingling and diminished sensation in the arm.

History of fever was elicited in 6 of our patients prior to the attack. One of the patients had a skin rash along with the fever which was diagnosed as Varicella infection one and half months back. There was history of cholecystectomy in one patient one month back. Another patient had severe gastroenteritis half a month back, following which he had been hospitalized. This association with antecedent factors has been noted in landmark studies by Spillane, Parsonage-Turner and van Alfen.^[1,2,18] Infection is the most common of such factors and patients were either in the acute or convalescent phase of different infections. Other factors include surgery, childbirth, vaccination, stress or trauma elsewhere.^[1,2,18] Interaction between various mechanical and environmental factors is postulated to be responsible for attacks of PTS. This includes stress on the upper plexus by routine movements on a daily basis which slowly damages the blood-nerve barrier along with factors such as infections, surgery or childbirth which provoke the immune system.^[19] Genetic susceptibility is also considered a cause in patients with repeated attacks.^[20]

MRN is the imaging modality of choice to evaluate the peripheral nerves due to its excellent soft tissue contrast. In

PTS, findings can be seen in the brachial plexus itself and/or the muscles innervated by the plexus. The affected nerves of the plexus appear thickened and show hyperintense signal in T2W and STIR images. The most commonly involved areas of the brachial plexus are the suprascapular nerve, upper trunk, axillary nerve and long thoracic nerve. Sometimes however, the plexus may appear normal. This may be due to the fact that the patient has only mild neuritis so it cannot be detected by imaging or because the patient has been imaged too early when findings have not yet set-in or too late when the inflammation has subsided.^[17,21-26] The affected muscles can show edema in the acute phase in which case they appear hyperintense in T2W images with maintained architecture.^[17] Although edema can occur as early as within 2 days in an experimental set-up, it usually takes about 2 weeks to appear in an MR scan.^[4,27] In the subacute and chronic phase, there is fatty infiltration and atrophy of the affected muscles. The fatty infiltration produces linear hyperintense signal in T1W images in affected muscles. With atrophy, there is a decrease in the bulk of affected muscles.^[3,28]

In our study, similar findings were seen in MRN images in affected nerves and muscles. The roots and trunks were involved more than the cords and terminal branches. Findings at the level of roots were seen in 8 patients, trunks in 7 patients, cords in 6 patients and terminal branches in 2 patients. If the distribution of in the roots, trunks, cords and terminal branches was separately analyzed, the C5 root, upper trunk, lateral cord and axillary nerve were involved most often. Associated findings in muscles were edema in 5 patients while 3 patients showed fatty infiltration and atrophy. Among the muscles, the supraspinatus and infraspinatus were involved most often. Other muscles involved included subscapularis, deltoid and pectoralis major.

There are few limitations of this study. Firstly, all the patients included in it were already diagnosed with PTS based on clinical and electrophysiological findings. Secondly, our sample size was small and we don't know if these findings hold for a larger number of patients. Thirdly, follow-up imaging was not a part of the study. If done, it can yield information about the persistence or disappearance of signal abnormalities in nerves and muscles which can be correlated with the patient's symptoms.

The advantage of MR imaging is that not only does it show findings which, along with clinical and electrophysiological correlation, suggest the diagnosis of brachial plexitis, but, it is also able to rule out so many other conditions which may be considered by the clinician as the cause of the patient's symptoms. These include a tear in the rotator cuff, impingement, labral tear, calcific tendinosis, adhesive capsulitis and cervical disc herniations.^[29] It is also important to remember that if only MRN findings in the brachial

plexus are considered, PTS may appear similar to chronic inflammatory demyelinating polyneuropathy (CIDP) or multifocal motor neuropathy (MMN). Here, the nerves of the plexus also appear thickened with hyperintense signal in T2W images.^[5,25] However, when the patient's clinical profile is reviewed along with MR imaging and electrophysiological findings, the diagnosis of PTS can be reached with ease.

A significant number of patients with PTS have persistent pain and weakness on follow-up as found by van Alfen and Engelen.^[18] Therefore it is extremely important to timely diagnose this condition and manage it appropriately in the early phase to avoid long-term morbidity.

Conclusion

This article describes the spectrum of findings on MRN in patients with PTS. Most of the patients in this study had unilateral involvement on MRN. The roots were the commonest site of involvement followed by the trunks, cords and terminal branches. Among the roots, C5 was the most commonly involved root. Associated changes in muscle were most often seen in the supraspinatus and infraspinatus.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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