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Magnetic resonance imaging of traumatic brachial plexus injuries

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Abstract

Purpose: The aim of this study is to evaluate role of MRI in diagnosing brachial plexus injuries, to evaluate site of injury and to differentiate pre and post ganglionic injury in all age group patients who have history of trauma.

Patients and methods: This study include 22 patients (18 male and 4 female) with history of trauma due to fall from height, road traffic accident, impact of heavy objects on shoulder or sports injuries who underwent Magnetic Resonance Imaging of the brachial plexus.

Results: In our study, 22 patients with history of trauma and suspicious involvement of brachial plexus were subjected to MRI of the affected side of brachial plexus after initial clinical examination. Out of 22 patients, 59.09 % was postganglionic neuropraxic injury and 40.91 % was preganglionic and root avulsion. The most common component involved in brachial plexus injuries was roots in 68.18% (15 patients) of cases followed by trunks in 63.63% (14 patients) of cases. The most common nerve root segment involved was C6 and C7 in 73.33% (11 patients) of cases followed by C5 in 40.00% (6 patients) of cases. The most common level involved in pseudo meningocele formation was C6-C7 in 88.88% (8 patients) of cases. Multiple segment of root and trunk injury is more common than single segment.

Conclusion: Because of exquisite soft tissue contrast resolution, non-invasive nature and multiplanar capabilities of MR imaging make it especially valuable for the detection and assessment of brachial plexus injuries.

Keywords: Magnetic resonance imaging, brachial plexus injuries, trauma, root, trunk, pseudo meningocele.

1. Introduction

Nowadays, there is upward trend in the number of cases presenting with neurological symptoms in trauma and emergency department. High chances of distraction for the attending physician when head injuries are seen in the unconscious patient, where complete neurological evaluation is limited. On the other hand, in conscious the evaluation of neurological signs and symptoms is much challenging where proper diagnosis is vital before any appropriate treatment is started.

The most common cause of brachial plexopathies are motorcycle accidents. It results from severe traction force exerted on the upper limb, resulting in complete or partial motor paralysis. Evaluation of brachial plexus is daunting task for both clinician and radiologists due to complex anatomy and altered soft tissue morphology in trauma setting.

The clinical differentiation of brachial plexopathy from other spine-related abnormalities often poses a considerable diagnostic challenge, and electrodiagnostic tests are difficult to perform due to the deep location of the plexus, often leading to indeterminate results.

Magnetic resonance imaging (MRI) is the modality of choice for evaluating and assessing the brachial plexus injuries because of multiplanar and better soft tissue resolution and also helps in localizing and assessing the severity of damage.

1.1 Brachial plexus anatomy^[1]: The brachial plexus is formed from the ventral rami of the C5 to T1 spinal nerves and further simplified into roots, trunks, divisions, cords and terminal branches. The MR imaging anatomy can be made simple by searching at particular location. The roots are located in interscalene triangle, trunks at lateral border of middle scalene muscle, divisions in retro clavicular space, cord and terminal branches in retro pectoralis space. On sagittal images, the C8 and T1 are below the proximal part of first rib.

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Trunks are formed just lateral to the scalene triangle. Divisions are located where the brachial plexus cross the clavicle. Cords are positioned around the axillary artery. On coronal images, the T1 nerve root can be identified as a horizontal linear structure surrounded by fat close to lung

apex. T1WI clearly delineates the anatomy of the brachial plexus and T2WI demonstrates neural or peri-neural signal abnormalities. T2 fat suppressed or STIR images are better for evaluation of traumatic brachial plexus injuries.

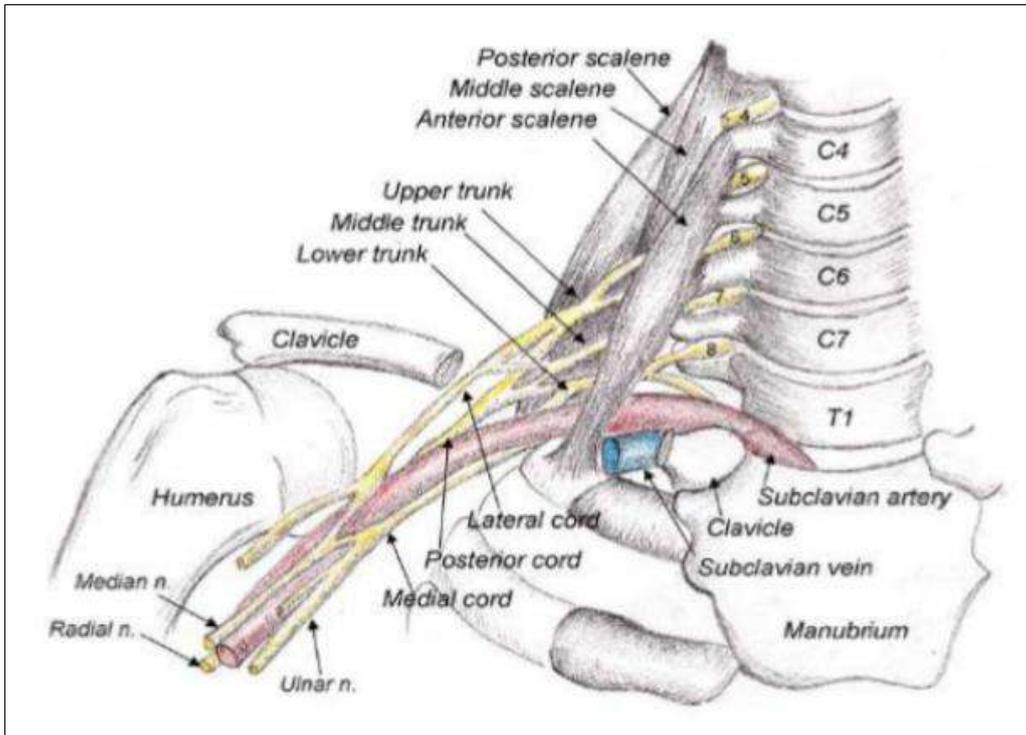


Fig 1: schematic drawing of normal right brachial plexus

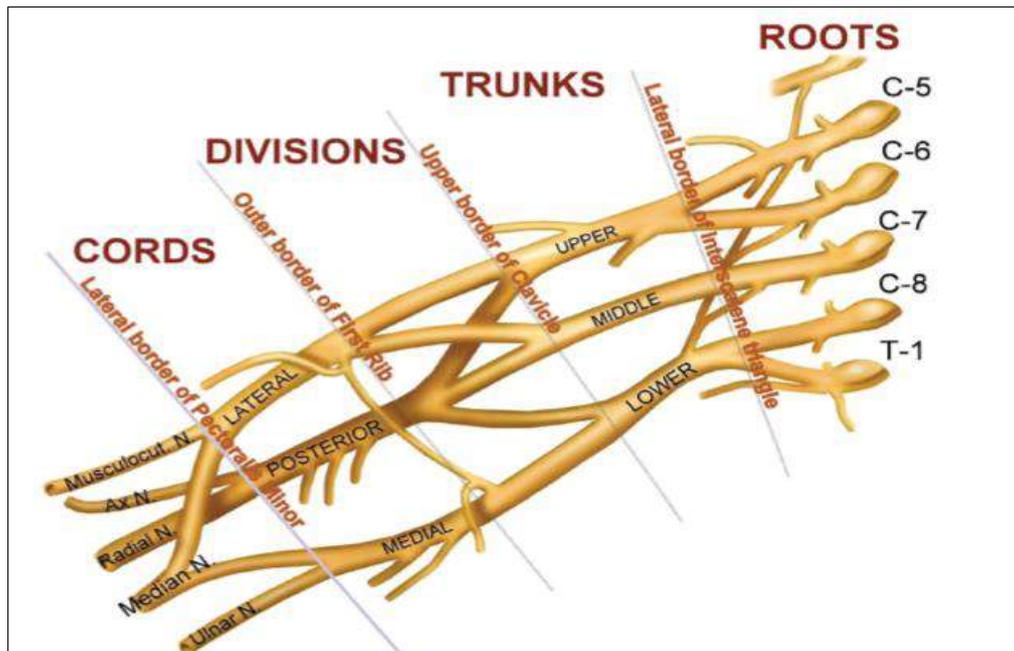


Fig 2: showing different segments of brachial plexus

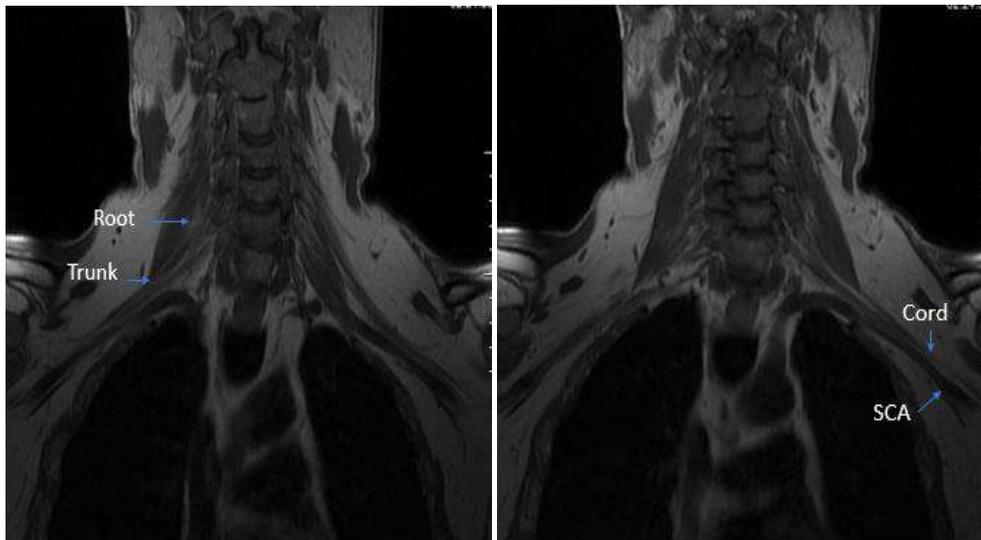


Fig 3: Coronal T1WI shows normal anatomy & component of brachial plexus (SCA- subclavian artery).

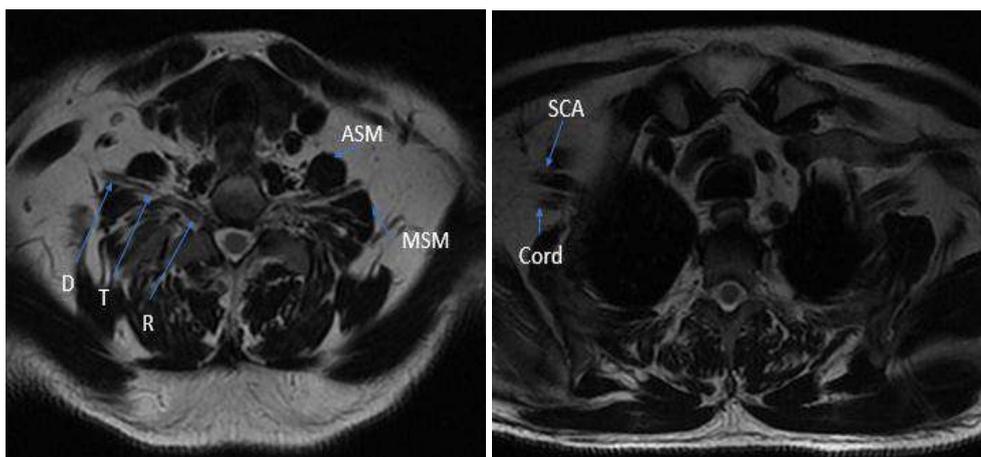
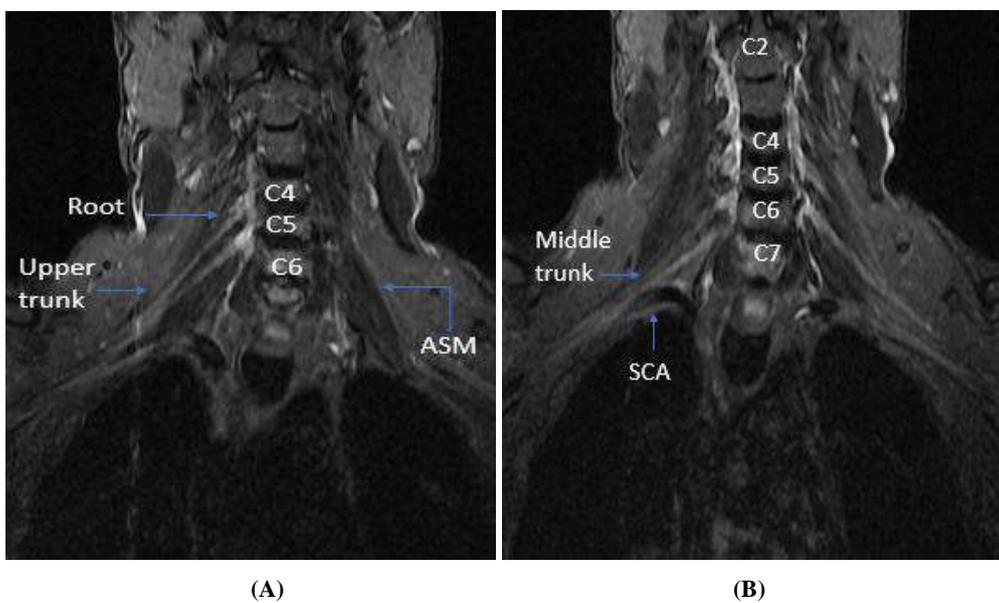
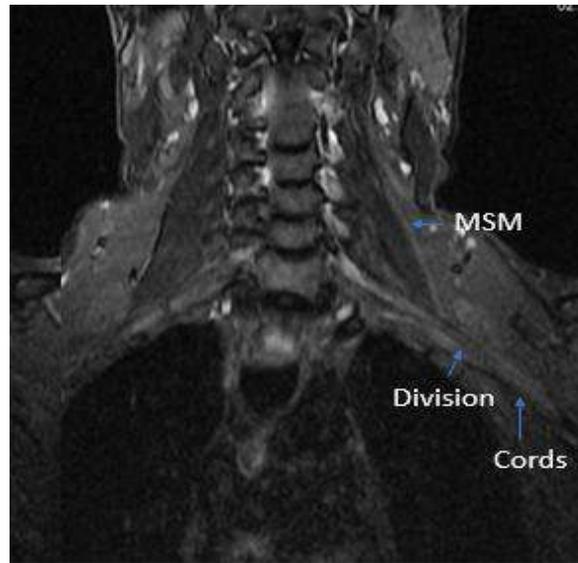


Fig 4: Axial T2WI shows normal component of right brachial plexus, scalene muscles and subclavian vessel. (R= Root, T=Trunk, D=Division, ASM=Anterior scalene muscle, MSM=Middle scalene muscle, SCA=Subclavian artery).



(A)

(B)



(C)

Fig 5: Coronal STIR (A, B) showing scalene triangle and normal hyperintense roots and trunks. Division and cords seen at retro clavicular and infraclavicular location respectively (C). (ASM- Anterior scalene muscle, MSM- Middle scalene muscle, SCA- Subclavian artery).

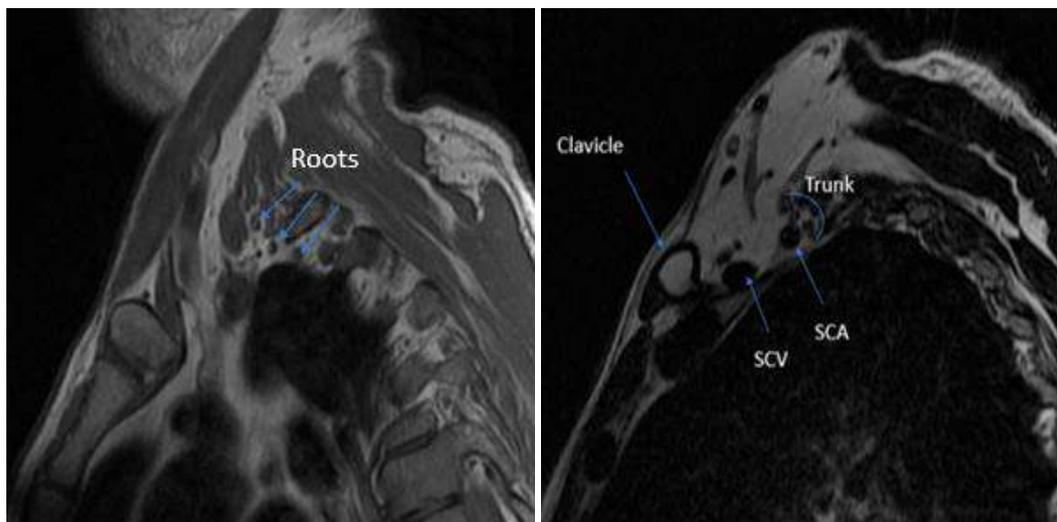


Fig 6: Sagittal T1WI shows normal root and trunk of brachial plexus which appears isointense to muscle. (SCA=Subclavian artery, SCV= Subclavian vein).

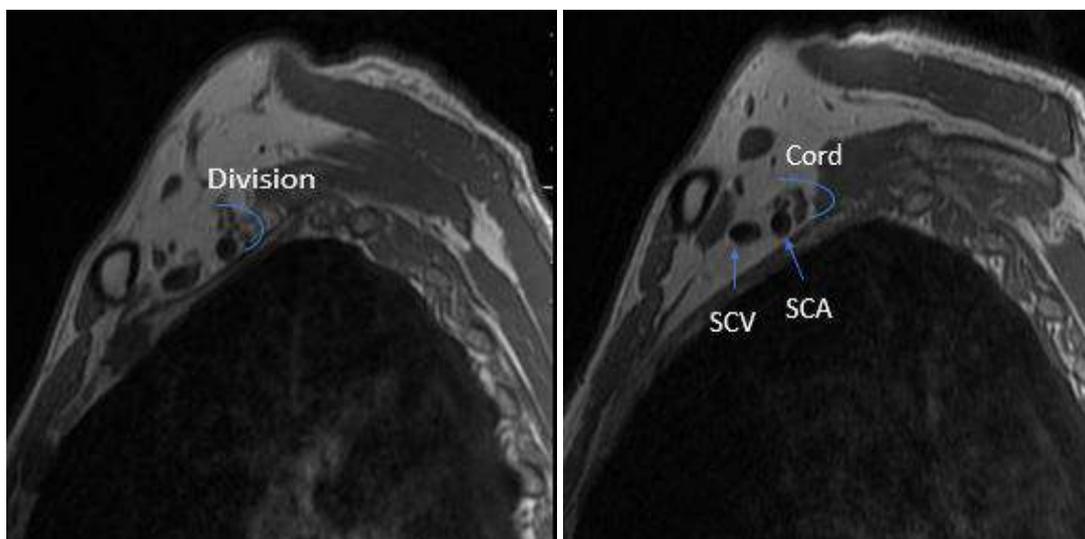


Fig 7: Sagittal T1WI shows normal division and cord of brachial plexus which appears isointense to muscle. (SCA=Subclavian artery, SCV= Subclavian vein).

1.2 Aims and objectives

- To assess normal MR anatomy of brachial plexus.
- To evaluate role of MRI in diagnosing brachial plexus injuries of all age group.
- To evaluate site of injury to the brachial plexus.
- To differentiate pre and post ganglionic injury.

2. Material & Methods

2.1 Study Design

Record based descriptive study

2.2 Sample Size

Time bound (22 cases)

2.3 Study Duration

September 2018 to October 2019

2.4 Inclusion Criteria

- Patients coming to emergency and outpatient department of SSG hospital having history of cervical spine or shoulder trauma with suspicious involvement of brachial plexus.
- Patients coming directly to Sahyog imaging centre from other hospitals for brachial plexus MRI.

- Patients of all age groups will be included in the study.

2.5 Exclusion criteria

- Patients who are pregnant.
- Patients with metallic implants, cardiac pacemakers, cochlear implants and metallic foreign body.
- Patients who are claustrophobic.
- Patients who are unwilling for imaging.

2.6 Methods

The study was carried out on the patients visiting the OPD/IPD referred from other health centre for advance treatment of brachial plexus injuries to the Department of Radiodiagnosis, Medical College, Vadodara for a period of 13 months duration.

MR imaging was performed with a 1.5-T unit (Signa; GE Medical Systems). Imaging were performed in the axial, coronal and oblique sagittal planes covering the axilla to middle of the neck. Axial images parallel to the disc spaces, coronal images parallel to the vertebrae and shoulders and oblique sagittal images perpendicular to the brachial plexus are obtained. All images were obtained with use of a body coil and section thickness of 3-5 mm and 1.5 mm intersection gaps. MRI contrast agents was not routinely used.

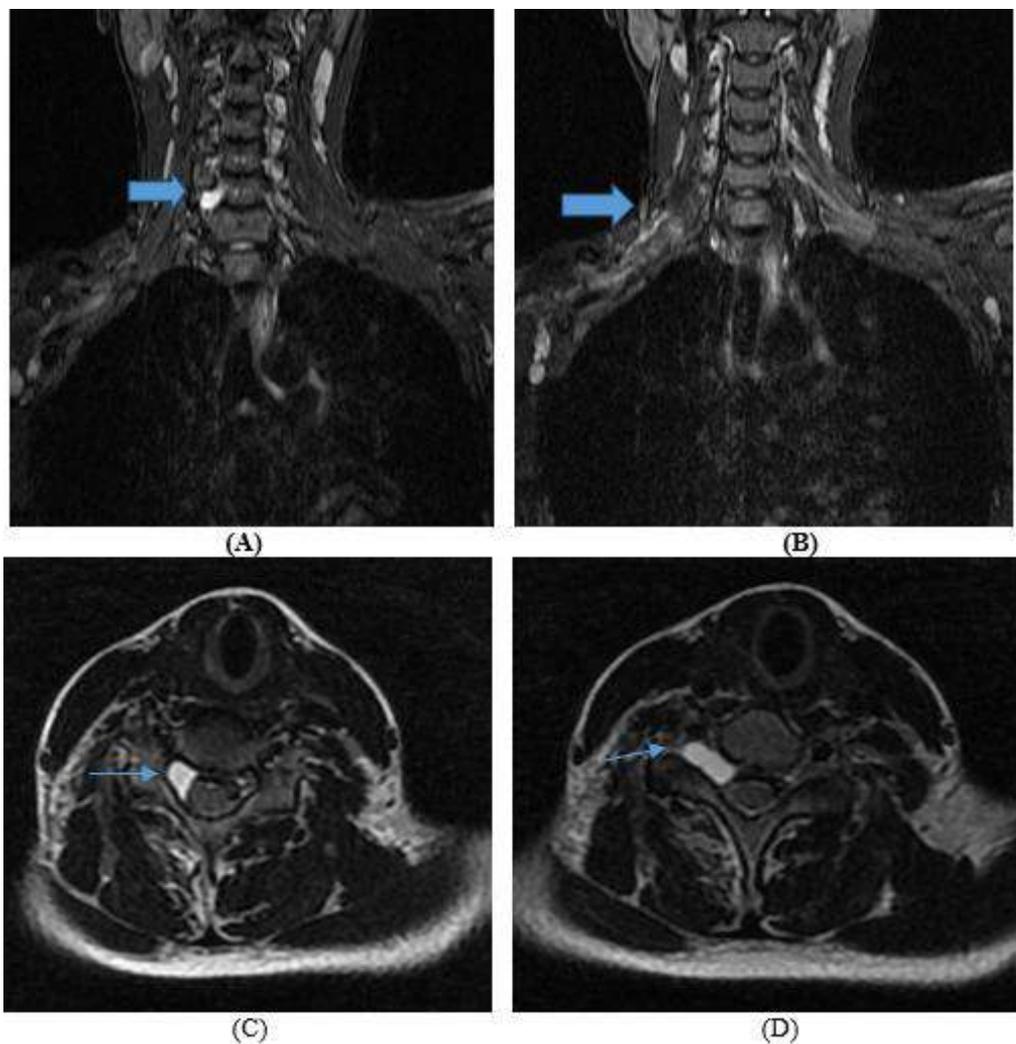


Fig 8: Coronal STIR (A) and axial T2 (C, D) images shows pseudo meningocele formation (blue arrow) in right neural foramen at C6-C7 level. Irregular waviness & clumping with subtle abnormal hyperintense signal seen in trunks and divisions of right brachial plexus within inter scalene triangle and costo-clavicular region (blue arrow) (B) - Pre and post ganglionic injury.

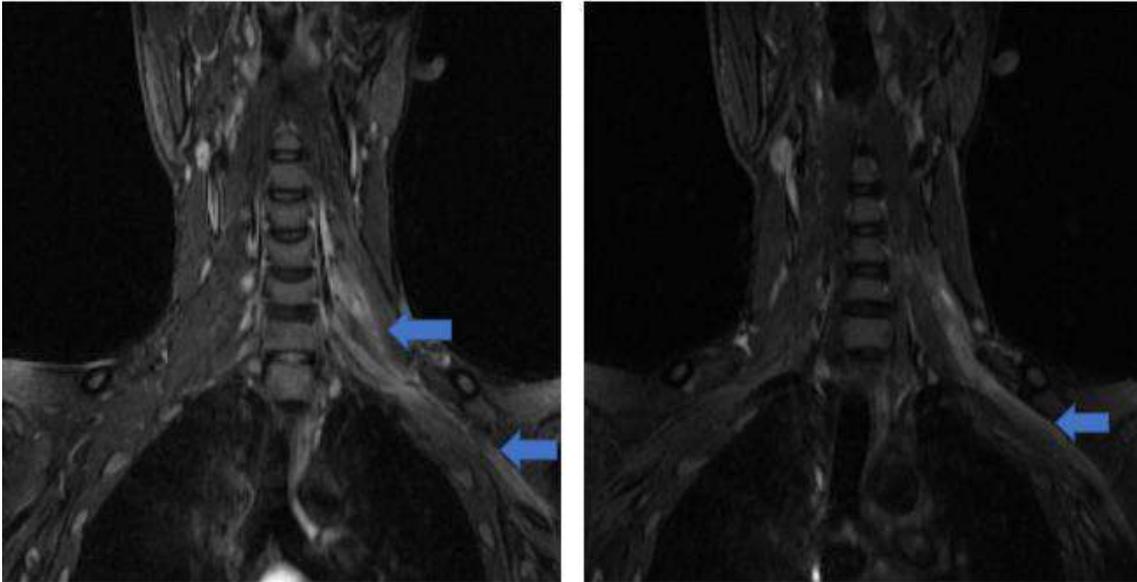


Fig 9: Coronal STIR showing swollen, thickened and hyperintense trunks and cords on left side in scalene triangle, costo-clavicular and infraclavicular location (blue arrow) - Post ganglionic injury.

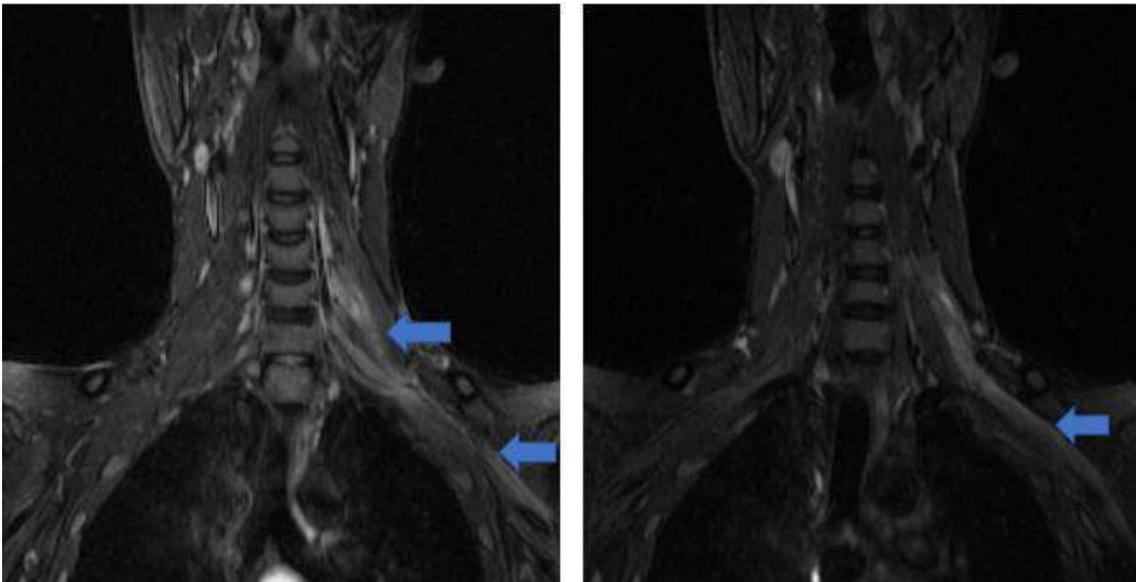


Fig 10: Coronal STIR showing hyperintensity within interscalene and costoclavicular region of right brachial plexus which is due to edema and enlargement of lower trunks and divisions (blue arrow) - Post ganglionic injury.

3. Result and discussion

In modern era, ever rising trends of motor vehicle collision is a major contributing cause of traumatic brachial plexopathy [2]. Other forms of trauma include fall from height, impact of heavy objects on shoulder, sports injuries. Depending on nature and etiology of trauma, different patterns of brachial plexus injuries were studied. Seddon proposed classification of nerve injuries namely neuropraxia (mild), axonotmesis and neurotmesis (severe) [3]. On the basis of management, brachial plexus injuries can be

divided into pre- and postganglionic lesions. The preganglionic lesions are avulsion of the nerve roots at their origin while postganglionic lesions may be lesions in continuity or nerve ruptures or combination of both [4].

A total of 22 cases who came to sahyog imaging center, SSG hospital Vadodara for MR brachial plexus were studied. The study population included a total of 4 females and 18 male patients. Out of these 22 patients, 18 were found to have pathologies. Thus, prevalence of abnormalities was 81.82%.

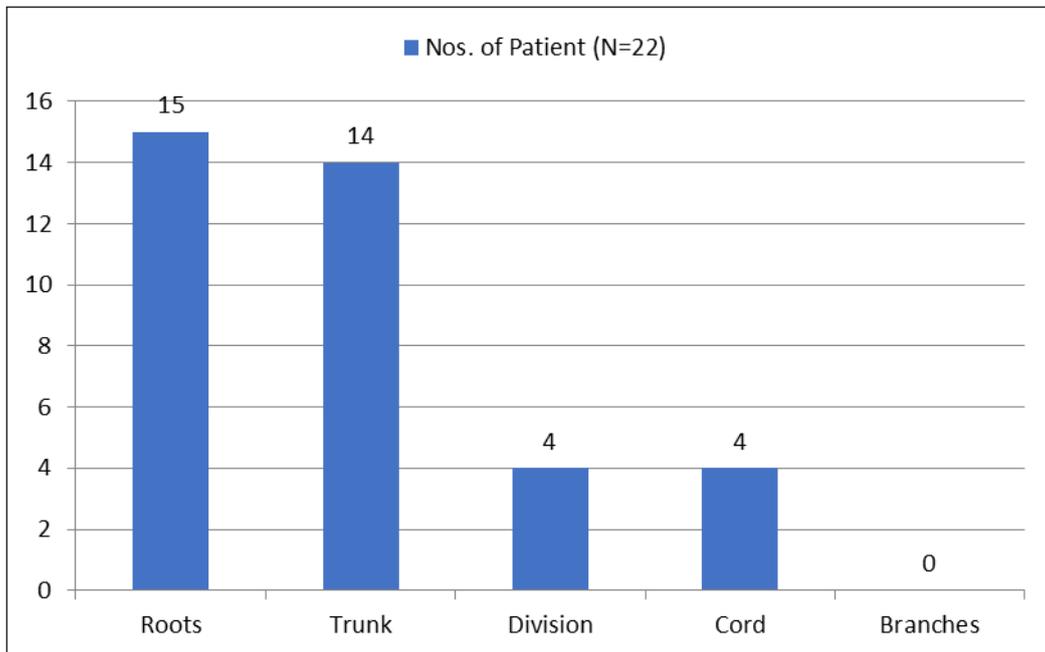


Fig 11: Component of BP Involved

Out of 5 components of brachial plexus, the most common component involved in brachial plexus injuries was roots in 68.18% (15 patients) of cases followed by trunks in 63.63% (14 patients) of cases. Divisions and cords involved in 18.18% (4 patients) and 18.18% (4 patients) of cases respectively. In our study no patient has involvement of branches.

Preganglionic injuries resulting from high energy impacts such as road traffic accidents causing traction of the nerve roots. Traction can also lead to epidural sleeve being pulled

away from spinal cord, leading to pseudo meningocele formation [5]. MRI features includes T2 hyperintense signal in nerve root or adjacent to spinal cord indicating soft tissue oedema with/ without root avulsion and also presence of pseudo meningocele- fluid pockets similar to cerebrospinal fluid intensity in the majority instances [4]. Secondly, enhancement of paraspinal muscles with post contrast images reflects denervation injury which is an indirect sign of root avulsion injury [6].

Table 1: Segment of Root Involved

Roots	Nos. of Patient (N=15)	Percentage
C5	6	40.00%
C6	11	73.33%
C7	11	73.33%
C8	4	26.67%
T1	3	20.00%

In our 15 cases with nerve root pathology, the most common segment involved was C6 and C7 in 73.33% (11 patients) of cases followed by C5 in 40.00% (6 patients) of cases. 10 patients (66.67%) shows multiple root injuries.

Table 2: Level of Pseudo meningocele Formation

Pseudo meningocele Level	Nos. of Patient (N=9)	Percentage
C3-C4	1	11.11%
C4-C5	2	22.22%
C5-C6	3	33.33%
C6-C7	8	88.88%
C7-T1	3	33.33%
T1-T2	3	33.33%

Out of 9 patients with pseudo meningocele formation, the most common level involved was C6-C7 in 88.88% (8 patients) of cases.

Second most common level involved were C5-C6, C7-T1 and T1-T2 in 33.33% (3 patients) of cases each.

The management of preganglionic injuries depends on the

nature of brachial plexus injury from surgical repair to more complex procedures, for instance may require nerve transfer from other sites to connect nerve stumps if the nerve roots has limited potential of recovery. About 50 % cases had better prognosis following nerve graft and other half with nerve repair showing slow recovery and residual impairment in the sensory and motor functions.

Postganglionic brachial plexopathies include stretching of brachial plexus in which preserved continuity or complete rupture. The majority of cases are found superior to clavicle affecting the roots and trunks, particularly C5 and C6 nerve roots as well as upper trunk due to tractional injuries. Those injuries inferior to clavicle affecting the cords and terminal branches are less frequent. The axillary and musculocutaneous nerves are prone to tractional injuries as they are fixed at glenohumeral region [5]. The MRI features include indistinct nerve more distally to the rupture site and retraction of proximal segment. Other features are thickening and T2 hyperintense signal of nerve in neuropraxic injury, denervation injury in acute phase with soft tissue oedema and atrophy in chronic phase. A T2

hypointense signal with thickening is seen in the chronic condition due to underlying fibrosis [4, 6]. In addition, soft tissue oedema and hematoma are seen in acute setting. In our 14 cases with trunk injury, 85.71% (12 patients) cases shows upper trunk involvement while middle and lower trunk involved in 64.28% (9 patients) and 71.43% (10 patients) of cases respectively. 9 patients (64.28%) has multiple trunk involvement.

Out of 4 patients with division involvement, both anterior and posterior divisions are involved in 100.00% (4 patients) of cases.

Out of 4 patients with cord involvement, all the segment; lateral, posterior and medial cord are involved in 75.00% (3 patients) of cases each. 3 patients (75%) have multiple cord involvement.

The postganglionic injuries have better prognosis and functional recovery as compared to preganglionic injuries as affected neurons have potential for regeneration. Stretch injuries without rupture tend to have better outcomes and usually managed with conservative treatment [7]. The ruptured neurons are surgically treated with nerve auto graft using the sural, phrenic, spinal accessory or medial pectoral nerve [8, 9].

4. Conclusion

The brachial plexus is a complex network of nerves which is responsible for much of the sensory and motor innervation of the upper limb. Pathology of the brachial plexus can therefore cause great psychological and physical dysfunction. MRI is the imaging modality of choice to demonstrate anatomy and pathology of the plexus.

The brachial plexus can be effectively interpreted by the general radiologist when approached from a practical standpoint. Knowledge of a normal anatomy and associated pathology is paramount for interpretation and reporting.

Practical and useful information that can help the referring physician and neurologist include, pre- vs. postganglionic location of injury, mass vs. non-mass like lesion, laterality or bilateral nature of disease, location of injury/mass/abnormality in BP segments (e.g. root, trunk, division, etc.), and anatomical region and surrounding structures involved (e.g. interscalene space, costoclavicular triangle, relationship to subclavian/axillary vessels).

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