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Original Research Article

Traumatic brachial plexus injuries evaluated by 3.0 T MRI

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ABSTRACT

Background: The brachial plexus is a complex network of nerve roots, trunks, divisions, cords, and terminal branches that provides motor and sensory innervation to the upper extremities. Magnetic resonance imaging (MRI) is the imaging modality of choice for evaluating the anatomy and pathology of the brachial plexus due to its excellent soft-tissue contrast and multiplanar capability, which allow clear delineation of neural structures from surrounding fat and adjacent tissues. Traumatic brachial plexus injury is one of the most common indications for MRI evaluation of the plexus. Aims and objectives were to describe and illustrate the spectrum of imaging findings in traumatic brachial plexus injuries at different anatomical levels using 3-Tesla MRI.
Methods: This observational study included 25 patients over a period of 1 year with clinical suspicion of traumatic brachial plexus injury who underwent MRI examination on a 3-Tesla scanner at our institute. Patients of all genders were included. Patients who were unable to complete the MRI examination were excluded from the study. Imaging findings were analyzed with respect to the level and type of injury, including preganglionic and postganglionic involvement.
Results: Among the 25 patients evaluated, 6 patients demonstrated isolated preganglionic injury characterized by pseudomeningocele formation. Combined preganglionic and postganglionic injuries were identified in 6 patients, while 5 patients showed isolated postganglionic injury. No significant abnormality was detected in 8 patients.
Conclusions: MRI plays a crucial role in the evaluation of traumatic brachial plexus injuries by accurately identifying the level and extent of neural involvement, particularly in differentiating preganglionic from postganglionic lesions. This distinction is essential for guiding surgical planning and optimizing patient management.

Keywords: Brachial plexus, MRI, Trauma

INTRODUCTION

The brachial plexus is a complex network of nerve confluences and ramifications that forms the major terminal branches responsible for motor and sensory innervation of the upper extremities.[1] It typically originates from the ventral rami of the C5 to T1 spinal nerves and is anatomically organized into roots, trunks, divisions, cords, and terminal branches. Given its intricate anatomy and deep location, accurate clinical assessment of brachial plexus pathology can be challenging, thereby necessitating reliable imaging techniques for precise localization and characterization of disease processes.[2]

Magnetic resonance imaging (MRI) has emerged as the imaging modality of choice for evaluation of the brachial plexus owing to its excellent soft-tissue contrast resolution and multiplanar imaging capability. MRI allows detailed visualization of the roots, trunks, divisions, and cords due to the inherent contrast between neural elements and surrounding fat planes. In addition, MRI can detect pathological changes such as neural edema, nerve discontinuity,

pseudomeningocele formation, and denervation-related muscle signal alterations, which are often not adequately demonstrated on computed tomography. These features make MRI particularly valuable in differentiating preganglionic from postganglionic injuries, an essential distinction for treatment planning.[3]

Traumatic injury represents one of the most common indications for brachial plexus imaging and is frequently associated with high-energy mechanisms such as road traffic accidents. Early and accurate imaging evaluation is critical for determining the level, severity, and extent of injury, which directly influences prognosis and surgical decision-making. Therefore, understanding the spectrum of MRI findings in traumatic brachial plexus injuries is essential for radiologists and clinicians involved in patient management.

Aims and objectives

To describe and illustrate the spectrum of imaging findings in traumatic brachial plexus injuries at different anatomical levels using 3-Tesla MRI.

METHODS

This retrospective observational study was conducted in the department of radiodiagnosis at S. V. P. Hospital. The study included patients who were clinically suspected to have brachial plexus injury and were referred for MRI evaluation over a period of months.

Study population

A total of 25 patients with suspected traumatic brachial plexus injury were included in the study. Patients of all age groups and both genders presenting with clinical features such as upper limb weakness, sensory deficits, pain, or history suggestive of trauma were evaluated.

Study duration was 1 year (May 2025 to April 2026).

Inclusion criteria

Patients with clinical suspicion of brachial plexus injury having history of trauma including road traffic accidents, fall, assault, or birth injury.

Exclusion criteria

Patients with contraindications to MRI such as cardiac pacemakers, ferromagnetic implants, or severe claustrophobia. Patients with previous brachial plexus surgery. Poor image quality due to motion artifacts.

MRI technique

MRI of the brachial plexus was performed using a 3 Tesla Siemens Magnetom skyra MRI scanner with dedicated neck and body coils. Patients were positioned supine with arms by the side in a neutral position.

The imaging protocol included: axial T1-weighted images, axial and coronal T2-weighted images, axial and coronal fat-suppressed/STIR images, sagittal T2-weighted images, coronal 3D STIR SPACE/nerve sequence.

The scan coverage extended from the cervical spine to the axillary region to evaluate roots, trunks, divisions, cords, terminal branches, and associated musculature.

Data collection and analysis

Demographic details including age, sex, mechanism of injury, and clinical findings were recorded.

MRI findings were documented systematically according to the level and type of injury. MRI images were evaluated for: nerve root avulsion, pseudomeningocele formation, nerve edema or thickening, discontinuity of nerve fibers, neuroma formation, postganglionic injury muscle denervation changes, associated soft tissue or skeletal injuries. The collected data were analyzed using descriptive statistics.

RESULTS

The study included 25 subjects, of which 18 were male and 7 were female, demonstrating a higher frequency of traumatic injuries among male patients (Figure 1). The patient age range spanned from 1 to 67 years (Figure 2).

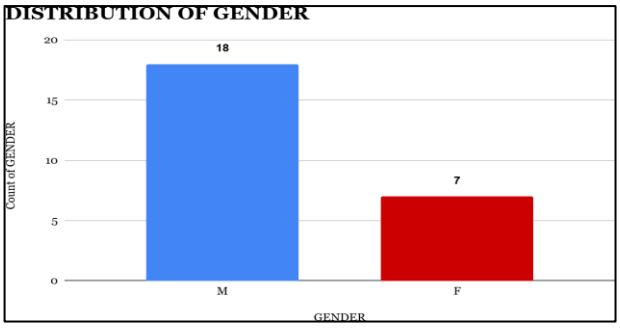


Figure 1: Gender distribution of the study population.

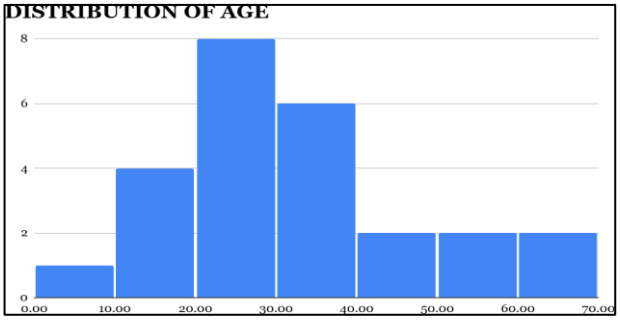


Figure 2: Age group distribution of the included patients.

The majority of patients presented with a history of road traffic accidents, while a smaller subset reported a history of general trauma or assault, and one patient presented with a birth injury.

Among the 25 evaluated patients, isolated preganglionic injuries were observed in 6 patients, combined preganglionic and postganglionic injuries in 6 patients, and isolated postganglionic injuries in 5 patients (Figure 3). No significant MRI abnormality was detected in 8 patients.

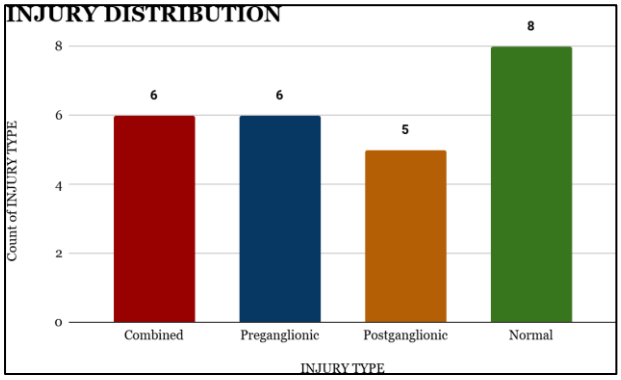


Figure 3: Distribution of injury types (preganglionic, postganglionic, or combined) among the patients.

Of the patients with preganglionic injuries, majority of the preganglionic injuries were seen in the C7 and C8 nerve roots- implying maximum injuries to this area near the shoulder joint as the region is more prone for injury and also sudden lateral flexion would stretch this area more.

Of the patients with postganglionic injuries, the roots and trunks were most commonly involved. The roots of C5 and C6 nerves were most commonly involved and of the trunks, superior trunk was more frequently involved.

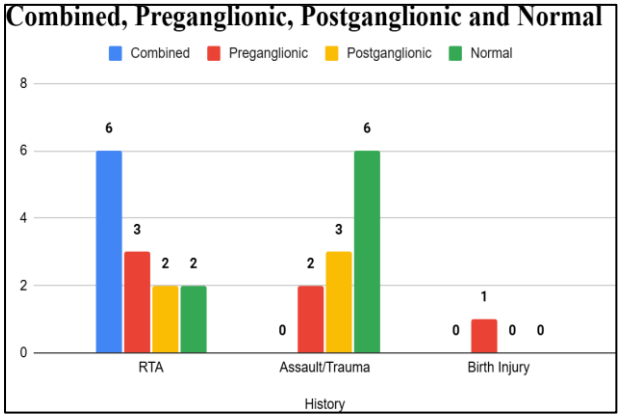


Figure 4: Distribution of injury levels categorized by mechanism of injury (road traffic accident, assault/trauma, birth injury).

The distribution of injury levels categorized by the mechanism of injury (road traffic accident, assault/trauma, and birth injury) is detailed in Figure 4.

DISCUSSION

The diagnosis and management of traumatic brachial plexus injuries (BPI) rely heavily on a nuanced understanding of its complex anatomy and the manifestation of nerve damage on magnetic resonance imaging (MRI). The brachial plexus typically originates from the ventral rami of spinal nerves C5 through T1. While 75% of cases follow this standard C5-T1 distribution, anatomical variations such as prefixed (C4 contribution) or postfixed (T2 contribution) plexuses occur, with variations in divisions and branches estimated to be as high as 50%.[4]

Anatomic landmarks and MRI localization

Accurate MRI interpretation requires the use of five specific osseous and muscular landmarks to identify the plexus subdivisions: These landmarks are the neural foramen, the interscalene triangle, lateral border of the first rib, medial border of coracoid process and lateral border of pectoralis minor muscle.

The neural foramen

This corresponds to the plexus origin where ventral and dorsal roots merge. The dorsal root ganglion (DRG) located here is a critical landmark for distinguishing preganglionic from postganglionic injuries

The interscalene triangle

Formed by the anterior and middle scalene muscles, this space houses the trunks. On sagittal MRI, the first rib serves as a key marker: the C8 root is positioned above it, while T1 is below.

Lateral border of the first rib

At this junction, the trunks divide into anterior and posterior divisions. These divisions appear as a triangular cluster of six points superior to the axillary artery.

Medial border of the coracoid process

This is the site where divisions converge into cords, exhibiting a “paw-print” configuration around the axillary artery on sagittal views. The cords are named according to their placement around the axillary artery. On sagittal MRI, the lateral cord is located most anteriorly, the posterior cord most superiorly, and the medial cord most posteriorly.

Lateral border of the pectoralis minor

Here, the cords separate into terminal branches, including the musculocutaneous, median, ulnar, axillary, and radial nerves. As the posterior cord travels inferolaterally, it gives off a branch posteriorly, looping under the scapular neck to become the axillary nerve. The remaining four

branches are centered around the axillary or brachial artery (depending on the location). The position of these branches can be approximated into quadrants. The median nerve is located within the anterior superior quadrant; the musculocutaneous nerve, in the posterior superior quadrant; the radial nerve, in the posterior inferior quadrant; and the ulnar nerve, in the anterior inferior quadrant.[2,5,6]

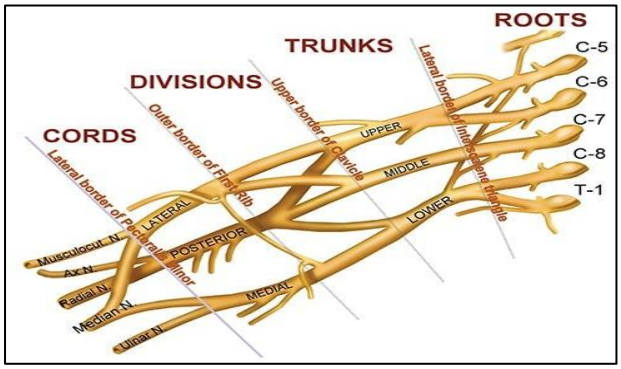


Figure 5: Pictorial representation of the brachial plexus from its origin to its terminal branches.

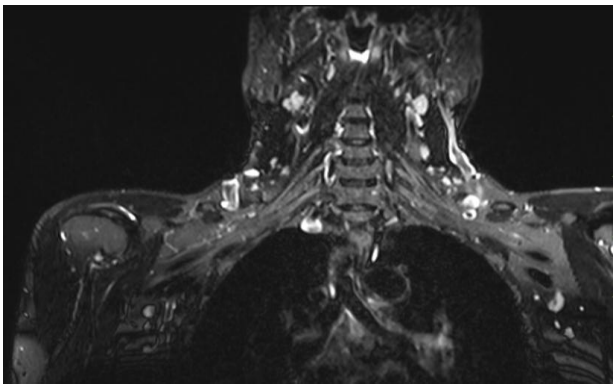


Figure 6: Demonstration of the normal MRI appearance of the brachial plexus, with sequential visualization of the roots, trunks, divisions, and cords.

Pictorial representation of the brachial plexus from its origin to terminal branches (Figure 5) and MRI of normal brachial plexus (Figure 6).

Imaging findings of traumatic injury

MRI findings in BPI are categorized by the location, severity of nerve disruption and the presence of indirect signs of trauma.

Preganglionic injury and pseudomeningoceles

A hallmark of high-energy spine trauma is the post-traumatic pseudomeningocele (PTP). These consist of a tear in the meningeal sheath leading to cerebrospinal fluid (CSF) extravasation into the neighboring paraspinous soft tissues. While PTPs are easily identified as T2-hyperintense fluid collections, they are considered valuable but not pathognomonic signs of root avulsion.[7,8,9,13]

An example of preganglionic injury with pseudomeningocele formation is shown in Figure 7.

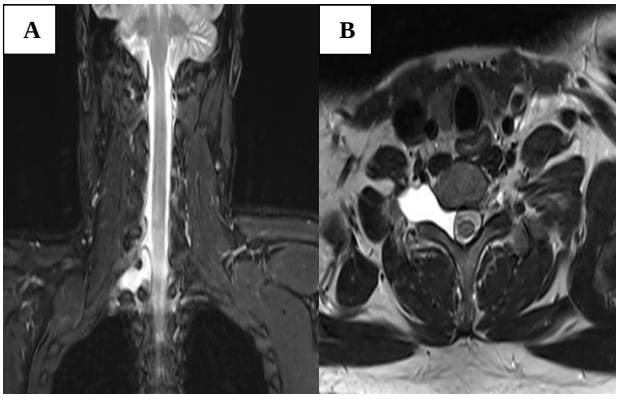


Figure 7 (A, B): Preganglionic injury with pseudomeningocele formation.

Postganglionic injury and grading

Pathologic nerves typically exhibit hyperintensity (approaching adjacent vessel signal intensity), focal or diffuse enlargement, and fascicular disruption.

The post ganglionic injuries are graded according to Sunderland and Mackain classification into five degrees from grade I to grade V with increasing severity.[12]

Grades I-III

Often show diffuse swelling without focal enlargement or heterogeneous signal. Distinguishing between grade II and III remains a challenge with current MRI resolution. It is shown in Figures 8.

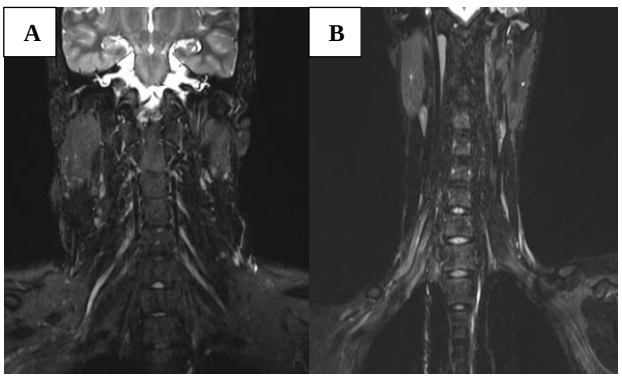


Figure 8: A) Nerve edema as evidenced by increased T2 signal intensity without disruption of the nerve fibers, corresponding to neuropraxia (1st-degree injury); B) nerve thickening as evidenced by increased T2 signal intensity and enlargement of the nerve without disruption of the nerve fibers, corresponding to axonotmesis (2nd to 3rd-degree injury).

Grade IV (neuroma-in-continuity)

Characterized by focal fusiform nerve enlargement and internal heterogeneity, which differentiates it from the homogeneous swelling of lower grades. It is shown in Figure 9.

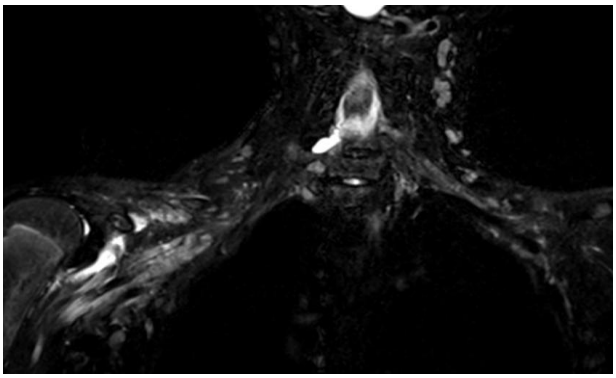


Figure 9: Neuroma formation representing a non-neoplastic proliferation of injured nerve tissue, corresponding to a 4th-degree injury.

Grade V (neurotmesis)

It demonstrates a clear nerve gap with intervening hemorrhage or fibrosis. Identifying the length of this gap is crucial for surgical planning. They are shown in Figures 10.

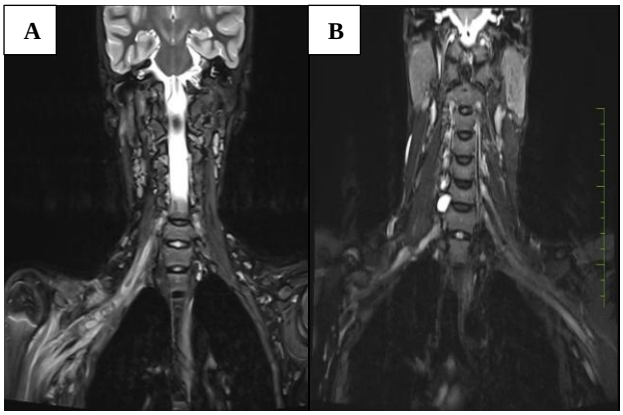


Figure 10 (A, B): Complete discontinuity of the nerve fibers, consistent with neurotmesis (5th-degree injury).

A critical secondary finding is regional muscle denervation, which presents as signal changes in the muscles distal to the site of nerve injury.[9,10,13]

Thus, magnetic resonance imaging serves as an indispensable tool for characterizing traumatic brachial plexus pathology, demonstrating high efficacy in establishing the anatomical extent and precise location of neural damage. In particular, its capacity to distinguish preganglionic root avulsions from postganglionic nerve disruptions provides critical diagnostic clarity necessary for directing surgical intervention and tailoring clinical management strategies.

While this study provides valuable insights into the spectrum of 3-Tesla MRI findings in traumatic brachial plexus injuries, several limitations must be acknowledged, including a small cohort and a retrospective design. Specifically, the investigation focused primarily on imaging findings without routine long-term follow-up or comparison against surgical exploration (the gold standard), limiting our ability to directly correlate specific MRI grades with long-term functional recovery or surgical outcomes. Furthermore, current MRI resolution limits the precision required to distinguish between grade II and grade III postganglionic injuries, as both frequently present with diffuse edema in the absence of complete fiber disruption.

CONCLUSION

MRI plays a crucial role in the evaluation of traumatic brachial plexus injuries by accurately identifying the level and extent of neural involvement, particularly in differentiating preganglionic from postganglionic lesions. This distinction is essential for guiding surgical planning and optimizing patient management.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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