IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 16, Issue 8 Ver. XI (Aug. 2017), PP 57-62
www.iosrjournals.org

Magnetic Resonance Imaging of Adult Traumatic Brachial Plexus Injuries

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Abstract:*The ever increasing trend of motorcyclist accidents in urban cities has increased the role of both neurologist and radiologist in evaluating the cause of neurological symptoms in the trauma patients. Different patterns of brachial plexus injuries were seen depending on nature and etiology of trauma. MRI is the modality of choice in localizing and grading the severity of the injuries. We retrospectively studied 30 positive MRI studies with clinical and electromyographic correlation. In this study emphasis was given to MRI brachial plexus anatomy and MRI findings in various traumatic brachial plexus injuries. Out of 30 patients, 60 % was postganglionic neuropraxic injury, 27 % preganglionic and root avulsion, 13 % posttraumatic sequelae. Some cases had combination of both injuries. We also highlight the need for standard MRI protocol for optimal imaging of brachial plexus which helps better evaluation of complex brachial plexus anatomy. Timely intervention and proper diagnosis will aid in appropriate management and better patient outcome.*

Keywords: *accidents, brachial plexus injuries, magnetic resonance imaging, neurological, trauma*

Date of Submission: 17 -08-2017 Date of acceptance: 28-08-2017

I. 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. Adult traumatic brachial plexus injury is a major contributing factor in the trauma cases. The most common cause of adult traumatic brachial plexus injury is 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 a daunting task for both clinician and radiologists due to complex anatomy and altered soft tissue morphology in trauma setting. Magnetic resonance imaging (MRI) is the modality of choice because of multiplanar and better soft tissue resolution. MRI aids in localizing and assessing the severity of the damage. In our study, we emphasis on MRI anatomy of brachial plexus, evaluating the site of injury and severity of the damage as well as differentiate preganglionic and postganglionic injuries. Therefore the familiarity in the understanding MR brachial plexus anatomy and typical MRI findings in traumatic brachial plexopathies will boost more confident on the evaluating radiologist. The radiologist role is vital forguiding the surgeon for proper diagnosis, which ensures appropriate management and better patient outcome.

Brachial plexus anatomy: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 retroclavicular space, cord and terminal branches in retropectoralis space. On sagittal images, the C8 and T1 are below the proximal part of first rib. 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.

II. Aims and objectives

- To assess normal MR anatomy of brachial plexus

- To evaluate site of injury and severity of damage to the brachial plexus
- To differentiate pre and post ganglionic injury

III. Materials & Methods

We retrospectively reviewed the clinical information of 30 patients those who underwent a total of 55 MR imaging studies from June2015 to May 2016 at our institutions. All patients had clinical or electromyographic evidence of brachial plexopathy. Any patient without trauma or whose imaging studies were not available for review or whose imaging findings did not explain their clinical symptoms were excluded. Of the 55 patients, 20 were excluded. All the 30 positive studies were reviewed by two radiologists and all diagnosis were determined by consensus. The final diagnosis were clinically correlated with follow up images.

MR imaging was performed with a 1.5-T unit (Signa HCxt; 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 4 mm and 1.5 mm intersection gaps. MRI contrast agents was not routinely used.

A dedicated protocol is used for imaging of the brachial plexus. Both left and right brachial plexus are imaged to allow comparison and better detection of abnormalities. We use following protocol:

Sequence	FOV (mm)	Matrix	TR (ms)	TE (ms)	ST/GAP (mm)
Coronal STIR	250	256 x 256	2600	62	4 /1.5
Coronal T1	250	256 x 256	550	15	4/1.5
Axial T2	270	256 x 192	2700	62	4/1.5
Axial T1	250	256 x 256	650	12	4/1.5
Sagittal STIR	250	256 x 256	2600	62	4/1.5

STIR: short tau inversion recovery, TE: echo time; TR: repetition time; TSE: turbo spin-echo

IV. Images, Bargraphs, Charts

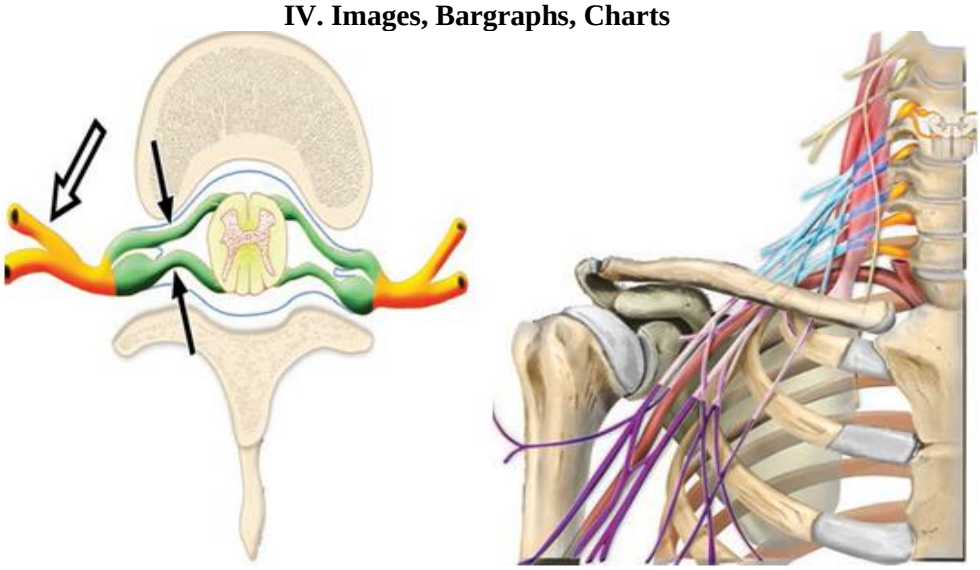


Figure 1: Schematic illustration of Anatomy of brachial plexus: A. Illustration shows first portion of brachial plexus, which are called roots, subdivided into preganglionic (green) and postganglionic (orange) portions. B. Illustration shows trunks (blue) positioned between anterior and middle scalene muscles, divisions lateral to scalene muscles and above clavicle, cords (pink) inferior to clavicle, and branches lateral to expected location of lateral margin of pectoralis minor muscle. Courtesy: Brachial Plexopathy: A review of traumatic and nontraumatic Causes- AJR2014; 202:

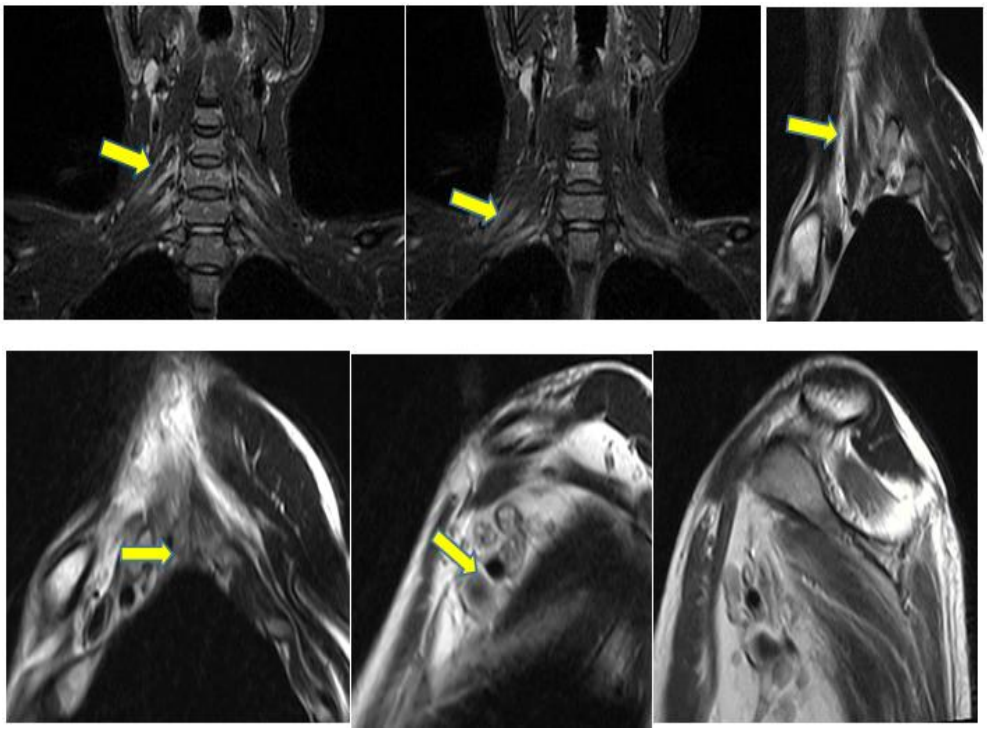


Figure 2: Normal MRI anatomy of brachial plexus. A. STIR coronal: Trunks B. STIR coronal: Divisions. C. Interscalene triangle. brachial plexus between anterior and medial scalene muscles. D. Sagittal oblique T2 – costoclavicular space, brachial plexus lies anterior to subclavicular vein. E. Sagittal oblique T2 at midclavicle are cords. F. Retropectoral minor space- cords and terminal branches (yellow arrow).

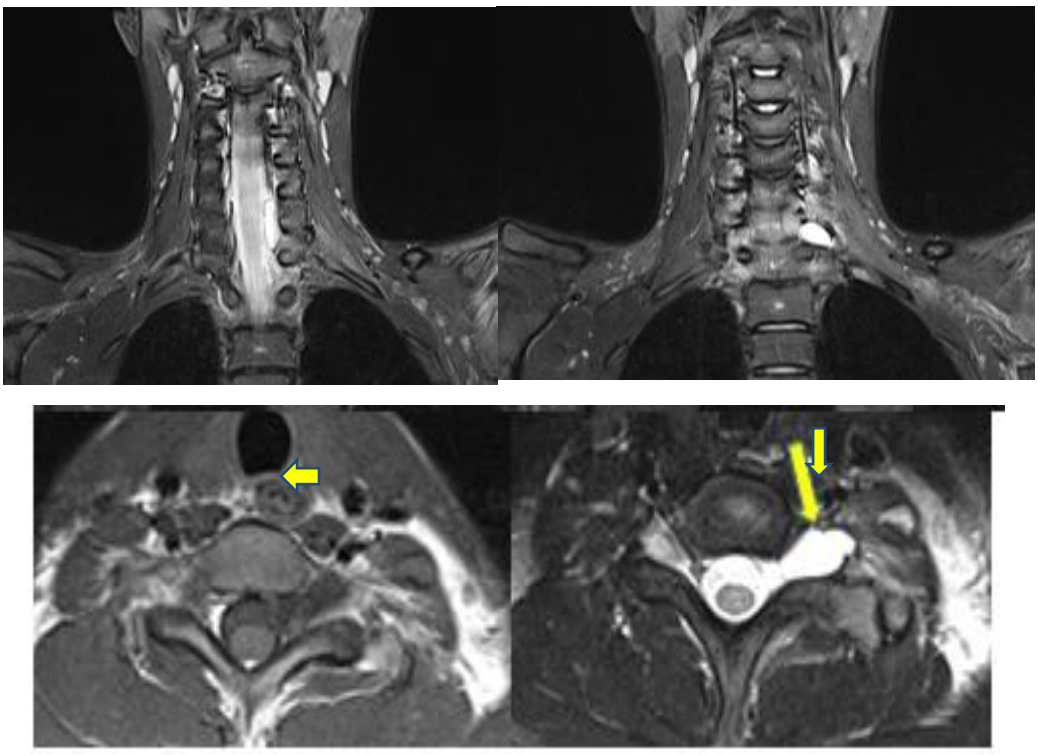


Figure 3: Root avulsion injury with pseudomeningocele at C7/T1 level on left. STIR coronal weighted images (A, B), axial T1 and axial T2 Fat suppressed (C, D) images (yellow arrow)

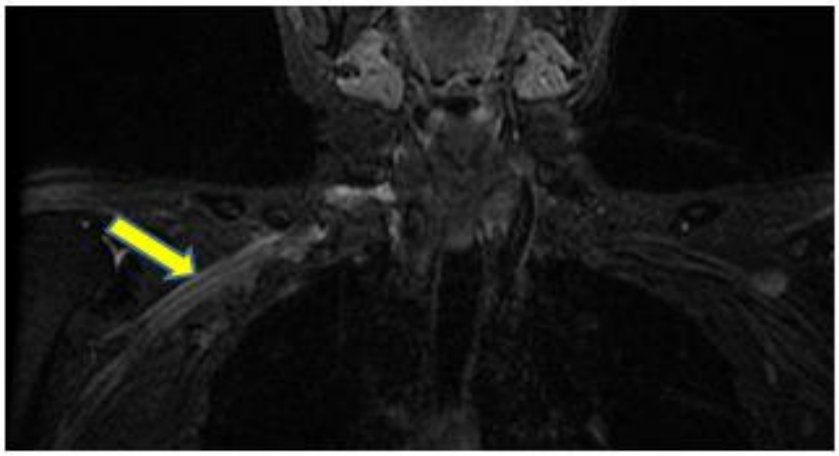


Figure 4: 32 year old male with RTA. Coronal STIR image shows swollen, hyperintense cords of right brachial plexus- post ganglionic neuropraxic injury

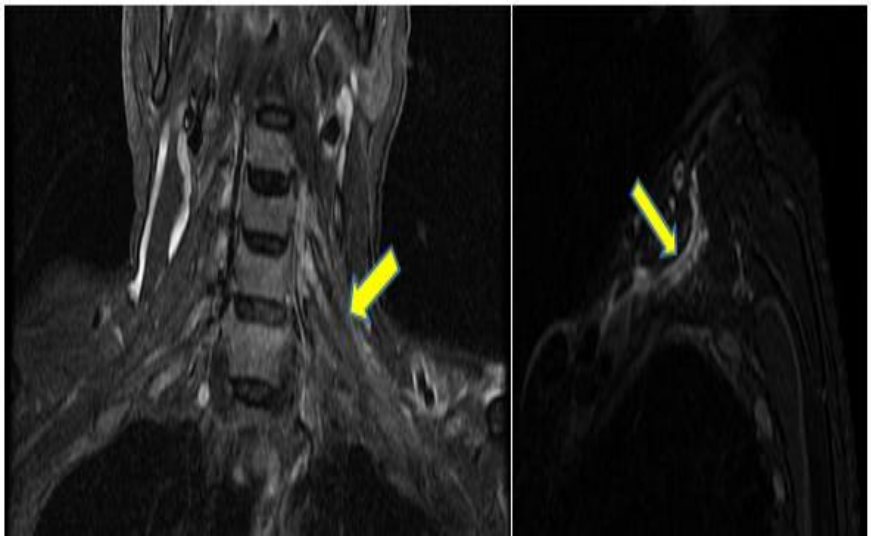


Figure 5: 66 year old male with RTA. Trunk and divisions of left brachial plexus involving left C5 and C6 nerves are swollen hyperintense signal, surrounding soft tissue oedema – post ganglionic neuropraxic injury (yellow arrow)

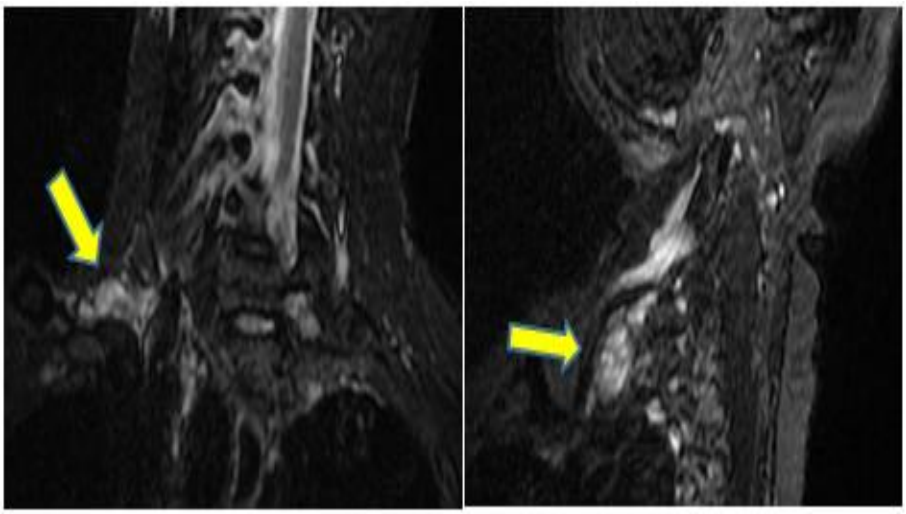


Figure 6: 42 year old male presenting in numbness and weakness of right upper limb muscles. Coronal STIR, right oblique STIR shows post ganglionic neuroma secondary to old trauma (yellow arrow)

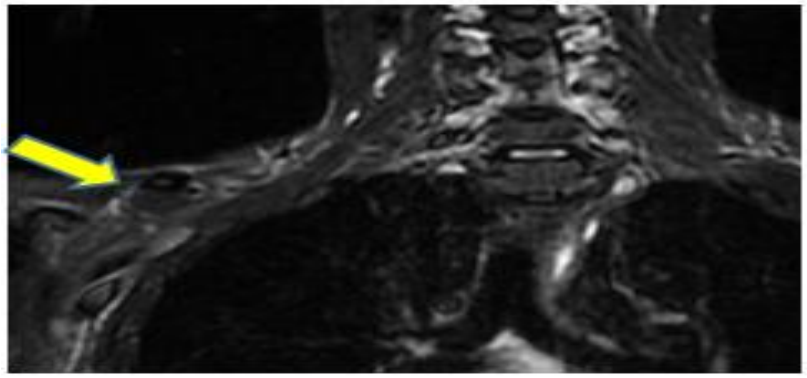
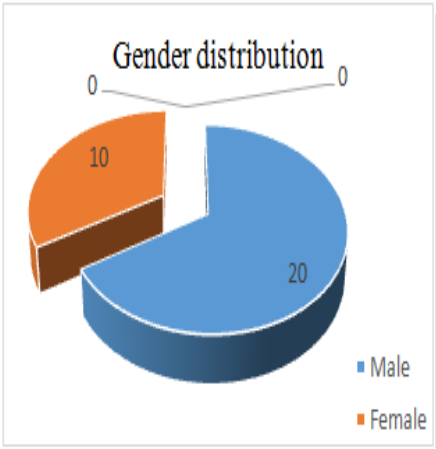
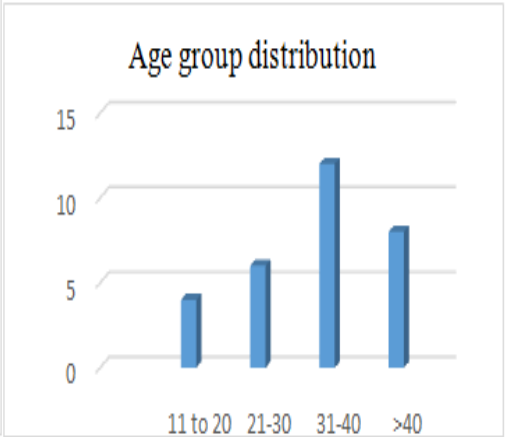
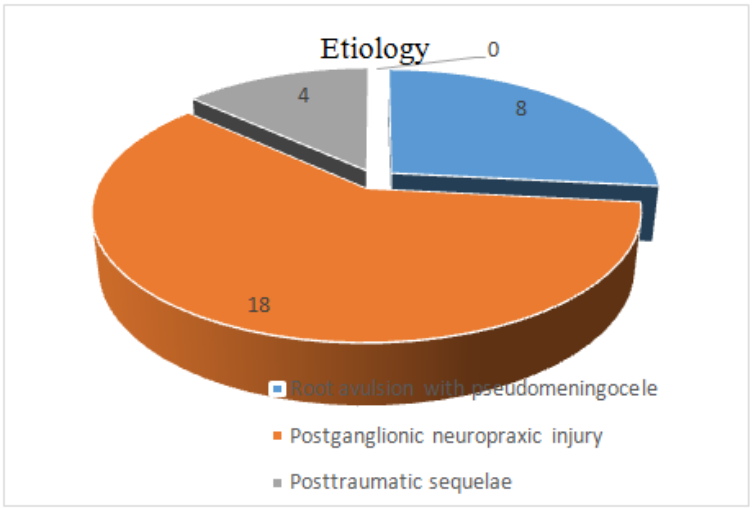


Figure 7: 30 year old male with neck pain and thenar muscles wasting in right hand. STIR coronal images demonstrates small soft tissue lesion beneath the right clavicle adjacent to right subclavian vein, likely represent fibroma secondary to old trauma







V. Discussion

In modern era, ever rising trends of motor vehicle collision is a major contributing cause of traumatic brachial plexopathy (1). Other forms of trauma include fall from height, impact of heavy objects on shoulder, spot injuries. Depending on nature and etiology of trauma, different patterns of brachial plexus injuries were studied.In adult population, 31-40 age group were common with male dominance as compared to female (2:1).Sedon proposed classification of nerve injuries namely neuropraxia (mild), axonotmesis and neurotmesis (severe) (2). 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 (5).

Preganglionic injuries resulting from high energy impacts such as road traffic accidents causing traction of the nerve roots. The C7 to T1 are mostly commonly avulsed in traction injury. Traction can also lead to epidural sleeve being pulled away from spinal cord, leading to pseudomeningocele formation (3). 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 pseudomeningocele- fluid pockets similar to cerebrospinal fluid intensity in the majority instances (5). Secondly, enhancement of paraspinal muscles with post contrast images reflects denervation injury which is a indirect sign of root avulsion injury (4). In our 8 cases (27%), 4 patients shows multiple root avulsion injuries at C5,C6 and C7/T1 roots and further 4 demonstrates additional small pseudomeningocele at C7/T1 level (figure 3). 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 (3). 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, 5). In addition, soft tissue oedema and hematoma are seen in acute setting. In our 18 cases (60 %), 10 cases showed neuropraxic injuries with T2 hyperintense signal and thickening which showed slow recovery from 2 month to 6 months (figures 4, 5). 4 cases showed nerve avulsion with soft tissue hematoma which was treated with surgical evacuation of hematoma, later nerve graft procedure was performed. 4 cases required minor surgical nerve repair in which motor function is relatively preserved while gradual slow improvement in sensory function. Approximately 13 %, studies showpost-traumatic neuromas and fibromas with weakness and numbness in thenar and forearm muscles (figures 6, 7). These cases were surgically resected, gap was filled by nerve grafting. The recovery of sensory and motor were slow for few months to year and still is follow up in outpatient clinics. 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 (8). The ruptured neurons are surgically treated with nerve auto graft using the sural, phrenic, spinal accessory or medial pectoral nerve (6, 7).

VI. Conclusion

MRI is modality of choice in evaluating traumatic brachial plexopathy. Thorough knowledge of anatomy and proper scan protocol are essential for complete evaluation of brachial plexus injuries. The prognosis depends on nature, relevant MRI findings and timely intervention.

Conflict of interest: Nil
Fund support: Nil

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