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Review Article

Entrapment neuropathies due to variations in origin and insertion of biceps brachii muscle

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ABSTRACT

Introduction: Entrapments of nerve and associated neuropathies coupled with variations observed in the attachment of muscles in the arm are not infrequent.
Objective: To assess the various entrapment neuropathies related to biceps brachii reported in literature in India and globally.
Methods: Literature explorations for data sources were done through a comprehensive mining in indexed literature and website based educational research reports. Altogether 53 studies were identified from 200 potentially relevant articles. A broad criterion to define both entrapment neuropathy and role of attachment of biceps brachii in causing it has been used for searching the comments. Moreover, we have also utilized data from personal resources and individual collections.
Results and conclusion: Details of extensive data on anatomical variations of biceps brachii and related neuropathies can be valuable and of significance in pre-operative clinical diagnosis and during surgical procedures.

1. Introduction

The clinical implication of the supernumerary heads and accessory tendon of insertion of the biceps muscle points to the kinematics and may have had an important role in the increased power of flexion and supination of this muscle. Further, variant biceps brachii possibly will confuse professional's performing procedures that might cause iatrogenic injuries or unusual displacement of the bony fragments subsequent to fractures. The surgeons and traumatologists have to keep such muscular variations in mind. There is continued interest in the variations of biceps brachii as understanding and management of different upper limb disorders are hoped to be transparent with enhancement of the anatomical knowledge of this muscle.

An attempt was made to explore overall clinical impact of supernumerary heads and accessory tendon of insertion of the biceps muscle.

2. Study design

This retrospective study design based on systematic review was done on a comprehensive collection of research studies, including proceedings of conferences and personal communications with the researchers in the field and from different soft copy and web sources in which anatomy of biceps brachii was accounted. A widespread website-scanned search was carried out of peer reviewed journal publications and study reports, 53 studies were identified from our exploration among the relevant articles from various institutional libraries of India, and websites on anatomy of biceps brachii published since 1985. The studies were identified by searching Pubmed-entrez and abstracts from scientific meetings (1985–2013) also. Reviews of citations and reference lists were performed to identify additional studies by the search terms insertion and origin of biceps brachii, entrapment neuropathy, etc. Literature search for data sources were done manually from various review articles, cross references and previous meta-analyses.

Moreover, personal resources and desired information from individual collections were also utilized. We also contacted authors for additional information or for translations from languages other than English.

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3. Selection criteria

We formulated some basic criteria to choose studies from among peer-reviewed research articles. First, we developed broad criteria to define entrapment neuropathy. Entrapment neuropathy is clinical condition due to direct strain or compression on a particular nerve. It is acknowledged as a trapped nerve, although this may also refer to as nerve root compression. Second, we also sought to include all those studies that studied origin and insertion of biceps brachii to explain entrapment neuropathy. Finally, other entrapment neuropathies were also taken into consideration.

3.1. Main outcome variable

Biceps brachii, origin, insertion, entrapment.

3.2. Data abstraction and analysis (results and discussions)

3.2.1. Normal anatomy

The distal biceps tendon is typically a flat tendon, forming about 7 cm above the elbow joint with the flat surface of the tendon facing anteriorly. It is originated usually from two heads, a short head and a long head. The short head of each biceps brachii takes its origin from lateral part of tip of the coracoid process of scapula. The long head whereas originates from the supraglenoid tubercle within the capsule of shoulder joint. As the tendon courses distally, it moves obliquely from anterior to posterior and from medial to lateral, twisting 90° so that the anterior surface faces laterally. The tendon expands at its attachment to the radial tuberosity, spreading over an area of 3 cm^2.[1] It also attaches to the bicipital aponeurosis, which is directed downward and medially to get inserted at the subcutaneous border of the ulna in its proximal part through the deep fascia of the forearm.

3.2.2. Deviations from the normal anatomy

The important variations of biceps brachii reported by Macalister in literature ranged from conditions as complete suppression of the muscle to unilateral absence of insertion through fascia.[2] In few instances muscle fibers of long head was found to arise from anywhere in its course or from neighboring structures. Sometimes short head reportedly found to have a slip extending from the area for insertion of pectoralis minor. Occasionally additional heads were also present originating straight from the brachialis muscle.

Moreover a slip from coracobrachialis merging with the fibers of short head of biceps is described by Macalister[2] and Wood.[3] Presence of an accessory head at coracoid process was also reported, where it was seen merging with the main belly separately or sometimes joins either the short or long head of biceps.[3]

Gujaria et al. observed biceps with extra third head arising from superomedial part of brachialis with the presence of fused higher origin of brachioradialis concurrently.[4] Additional head of biceps fused with higher origin of brachioradialis were also found.[5]

Mori described various origins of the third or supplementary heads and noted that additional third head of biceps were found in 20% cases. He showed marked variations among their sites of origin (Table 1).

1. In maximum of 8% additional head took the origin from the deltoid tuberosity in its lower part.
2. In around 6% fibers also originated from middle of the medial border of humerus where the coracobrachialis gets inserted.
3. In about 4% fibers took their origin at the lateral lip of intertubercular sulcus where pectoralis major is attached.
4. In the other 2%, accessory heads were rare and took several different forms. In the cases when fully developed, they arose close from the neck of the humerus, just below the lesser tubercle and beneath the tendon of pectoralis major muscle to which they were more or less coupled. Many a times, the long head of biceps brachii joined the belly on lateral side of the two slips. The short head here was found to join on the more medial side.[6] In other instances, the two heads of the biceps muscle may be separate or joined. In the absence of the long head, the origin of tendon is from varying sites as from intertubercular sulcus, greater or lesser tubercle, and capsular ligament of shoulder joint. At times, such tendon with no long head is also seen extending from the tendon of pectoralis major. It is also sometimes doubled or instead of insertion as a tendon it may end in an aponeurosis.[7] Such doubled aponeurosis, also known as lacertus fibrosus, is one of the key causes of compression of the median nerve which has symptomatic similarity with pronator syndrome.[8]

Table 1
Global variations in origin of biceps brachii.

Research workers	Incidence of third head of biceps brachii (percentage)
Greig et al. (1952)[47]	21.5% (South African Blacks)
Bergman et al. (1984)[12]	8% (Chinese)
	10% (European White)
	12% (African Black)
	18% (Japanese)
Asvat et al. (1993)[14]	20.5% (South African Black)
	8.3% (South African White)
Santo Neto et al. (1998)[16]	20% (Brazilian White)
	9% (Brazilian Black)
Nakatani et al. (1998)[39]	8%
Kopuz et al. (1999)[17]	15%
	15%
Khaledpour (1985)[48]	31.2%
Santo Neto et al. (1998)[16]	9% (Black)

In Indian population especially in South, variations of biceps head were relatively rare (Table 2).[9]

Variations of biceps brachii muscle are significant because of their clinical, functional, morphological as well as academic importance. Supernumerary heads were found in 10.2% of 1453 arms by Tountas and Bergman in 1993.[10] Supernumerary heads of biceps brachii have been found in 8.0% of Chinese, 10.0% of White Europeans, 18.0% of Japanese, 20.5% of South African Blacks, 8.3% of South African Whites, 15.0% of Turkish and 37.5% of Colombians by various workers from time to time.[11–17]

Depending on origin and location, supernumerary heads of biceps brachii have been classified as superior, inferomedial, and inferolateral humeral heads. Among all, inferomedial humeral head is the most common.[18,19]

Though variations in the origin of biceps brachii are common, as regards variations in its insertion a very few cases have been reported upon. Dirim et al. in 2008 in their study have reported that the distal biceps tendons are completely separated in 40% and bifurcated in 25% of cases.[20] In 17 patients suffering from median nerve entrapment, Seyffarth in 1951 reported that the nerve

Table 2
Variations of biceps brachii origin in Indian population.

Research workers	Incidence of third head of biceps brachii (percentage)
Rai et al. (2007)[49]	7.1% (Indian population)
Ravindranath et al. (2005)[50]	1.8%
Poudel and Bhattarai (2009)[51]	12.5% (Nepalese population)
Nayak et al. (2006)[52]	2.0%
Avadhani and Chakravarthi (2012)[53]	16.66%

passed through the pronator teres muscle or the flexor digitorum superficialis (FDS) arch and termed it as pronator syndrome.[21]

On every occasion when the bicipital aponeurosis is attached to pronator teres in the form of a musculotendinous extension; it ends up in a range of functional differences.[22]

3.3. Phylogeny

The biceps brachii muscle variations can be explained phylogenetically as a remnant of a "tuberculoseptale" head present in hylobates but is a product of regression in humans and anthropoids.[23] The third head of the biceps brachii is a remnant of the long head of the coracobrachialis,[24] an ancestral hominoid state, predominantly in the conditions, where the accessory head crop up from the region of insertion of the coracobrachialis.

When the muscle primordial fails to disappear during intrauterine life, it may account for the occurrence of the accessory muscular bands.[25]

3.4. Clinical anatomy

Seyffarth is the one who is credited to describe pronator syndrome for the first time in 1951.[21] In his pioneer work, he found the patients, complaining of symptoms of neuropathy related to median nerve, had compression in its course in forearm either between heads of pronator teres or while passing beneath the fibrous origin of flexor digitorum superficialis. Therefore the term 'Pronator' syndrome is slight misnomer as other muscles were also responsible for it. Nowadays it is frequently referred to as the so-called pronator syndrome for the reason that it has a generalized clinical presentation but a diversified range of sites of compression. Surgical corrective measures have shown complete recovery in all these cases. Various other sites are also identified, where the compression can happen. It included ligament of Struthers, an infrequent component that is hardly ever assumed to cause pronator syndrome,[10,11,26,27] tight or thickened lacertusfibrosus[28–30] and fibrous band within the pronator teres.[28] Sometimes origin of flexor digitorum superficialis, which forms a sublimus arch is also a potent site of compression.[29]

On comparison of marked clinical manifestations due to supernumerary head compressing the median nerve, ample resemblance is observed with that of pronator syndrome.[31]

Median nerve is also found sometimes to be entrapped in the cubital fossa by abnormal tendinous slip which may be straight or may divide into two from the biceps at its insertion.[32,33] Sometimes median nerve gets entrapped, when it passes through antecubital fossa deep to the bicipital aponeurosis, which has multiple sites of origin, not only from biceps, but others such as from the fascia of flexor-pronator mass.[34,35]

Insertion of biceps with additional heads may also be as long musculo-aponeurotic tunnels with not only median nerve but brachial artery as well in it.[36] The most common areas of compression of the median nerve are at the level of the flexor digitorum superficialis arch[37] or at the site, where the nerve is passing through the pronator teres muscle.[38]

Not only median nerve but also musculocutaneous nerve variations and its compression is also associated with extra heads of biceps.[39]

Other conditions associated with supernumerary head of biceps can be absence of musculocutaneous nerve or numbness in hand caused by compression of ulnar nerve by the head of biceps, etc.[40] Sometimes superficial branch of radial nerve is also found to be compressed by the accessory tendon aponeurosis which traverses from biceps to extensor carpi radialislongus.[41]

The pronator syndrome is much less common than the carpal tunnel syndrome (CTS). It is gender specified, more common in middle aged women. The symptoms are insidious in onset, with a delay in diagnosis ranging from 9 months to 2 years.[27,28,42]

The patient most commonly complains of throbbing pain around the proximal forearm and the distal arm. Frequent and vigorous forearm movements cause the pain to extend to the proximal region of upper extremity. This is most common with pronation-supination movements.[8,21] As is the case in CTS, there is usually associated paraesthesia and, possibly, altered sensibility in the radial three and a half digits, but night awakening and nocturnal pain are rare – a focal indicator in discriminating from CTS.[27]

The differential diagnosis of the pronator syndrome is exceedingly critical as this entity is comparatively unusual in contrast with CTS. In fact, as noted by Lister, symptoms of CTS are very similar to those of pronator syndrome. Similarities between two syndromes: pain in wrist and forearm regions, weakness of thenar muscles numbness/paraesthesia of radial three and a half digits. Differences in two syndromes: No nocturnal pain in pronator syndrome, negative Tinel's sign at wrist in pronator syndrome, nerve conduction study demonstrates – no delay at wrist in pronator syndrome. Various symptoms such as dysesthesia in palmar cutaneous distribution are seen in pronator syndrome. Besides this, further significant differential diagnosis comprise thoracic outlet syndrome, proximal brachial plexus compression, cervical radiculopathy and polyneuropathy. Electrophysiologic exploration is extremely helpful in appropriate diagnosis of these conditions.[8]

Taking into account the complete course of the median nerve, a number of prospective sites are there where compression neuropathy can take place. Therefore systematic correct appraisal of the situation is necessary before reaching to a conclusion about the presence of the popular compressive neuropathies.

A third head of the biceps brachii muscle has its functional and clinical implications. Regardless of the position of the shoulder joint, the third humeral head of the biceps brachii muscle may add to the pronation of the forearm.[12] Relatively large supernumerary heads may provide additional strength to the biceps tendon. The association of unusual bone displacement subsequent to fracture with the third head is its clinical significance.[43] The supernumerary heads, if unilateral, may confuse a surgeon during shoulder operations and may be confused with pathological conditions such as tumors.[15]

Supernumerary heads pierced by musculocutaneous nerve or the nerve passing between supernumerary heads is usually reported to be associated with its interconnection with median nerve. The intramuscular course is a potential compression site. Compression of musculocutaneous nerve in between heads of biceps may cause paraesthesia and weakness of elbow flexion and supination due to involvement of brachialis and nerve to long head of biceps. A small case series of injuries of musculocutaneous nerve with mechanism spectrum extending from exhausting physical workouts to weight lifting, hurling of football, etc. has been reported by Hsu et al.[44]

In individuals, who complain of peripheral neuropathy, a systematic consideration of the signal characteristics of the muscles on T1-weighted SE (spin echo) and T2-weighted fat-suppressed or STIR (short-T1 inversion recovery) sequence images is of vital value.[45]

Variations of the distal biceps brachii tendon are of clinical interest. Imaging of the distal biceps tendon is somewhat difficult due to its anatomy. An innovation in patient positioning where the patient lying prone with the arm overhead, the elbow flexed to 90°, and the forearm supinated, with the thumb pointing superiorly, has been recently described for magnetic resonance imaging (MRI) of the biceps tendon in its distal part. To describe this position the acronym FABS (flexed elbow, abducted shoulder, forearm

supinated) has been used.[46] The FABS position creates tension in the tendon and curtails its obliquity and rotary motion, ensuing in a "true" longitudinal view of the tendon. For visualization of the distal tendon and in detecting other pathologic conditions in the cubital fossa, MRI and, to a lesser extent, ultrasonography is useful. In the assessment of the distal biceps tendon, Imaging with FABS positioning can complement conventional MRI, particularly in the axial plane.

3.4.1.1. Strengths of the study

To the best of our horizon of knowledge, we are yet to find any systematic review on the entrapments of nerves related to disparities associated with the attachments of biceps brachii muscle in the upper limb.

3.4.1.2. Limitations of the study

This novel attempt of the systematic review on the entrapments of nerves related to disparities associated with the attachments of muscles in the upper limbs had several limitations. Some studies could not be properly analyzed where we could not find full text. Lastly we were unable to find the role of confounding variables like neuropathies as clinical history and cause of death are not usually available with the bodies available for dissections.

3.4.1.3. Future directions of the study

In future we want to extend our study with extensive literature searches.

4. Conclusion

To sum up, origin and insertion of biceps brachii, role of its variation in entrapment neuropathies of upper limb and the crucial contribution of additional heads and other structures play an important diagnostic and therapeutic potential. Besides for practicing clinicians, we hope our systematic review may also help medical undergraduates to understand importance of variations in morbid anatomy, which can be later utilized in their clinical set-ups.

Author's contribution

The authors have substantially contributed to the conception and design, acquisition, analysis and interpretation of data. Also, collectively drafting of the article or revising it critically for important intellectual content was done.

Conflicts of interest

The authors have none to declare.

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