An unreported infraspinatus muscle variation – two-headed infraspinatus minor muscle and three-headed fusion with the teres minor muscle

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Research Article

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Abstract

The infraspinatus muscle is situated under the scapular spine in the infraspinous fossa and inserts into the greater tuberosity of the humerus. It is a component of a crucial shoulder muscle group, the rotator cuff. There are a few interesting additional muscles in the infraspinal region. In the literature they are called the infraspinatus superficialis, infraspinatus minor and infraspinatus accessory muscles. The infraspinatus minor muscle is described as a superficial muscle bundle running under the scapular spine.

During routine anatomical dissection, an unreported variation of the infraspinatus minor muscle was found. It derived from the inferior surface of the scapular spine and the infraspinous fossa. It had two heads. The superior head inserted on the greater tuberosity of the humerus. The inferior head inserted on the tendinous part of the infraspinatus muscle. There was also an unusual fusion of the infraspinatus muscle with the teres minor muscle. In this paper we will discuss the anatomical and physiological relationships of this morphological variation.

Introduction:

The infraspinatus is one of the rotator cuff muscles [17]. It is situated under the scapular spine in the infraspinous fossa. It is proximally attached to the dorsal scapular surface in the infraspinous fossa; its origin occupies the three-quarters of the fossa [24]. The infraspinatus muscle inserts on the middle and lateral impression of the greater tuberosity [19]. It is perfused by the suprascapular and scapular circumflex arteries and is innervated by the suprascapular nerve [24].

The roles of the infraspinatus muscle are lateral rotation of the humerus. With three other muscles of the rotator cuff (subscapularis, supraspinatus, and teres minor) it maintains the humeral head in the glenoid fossa [24].

The shoulder girdle region is characterized by muscle variations. For example, the deltoid muscle can lack its acromial part [15]. It can create fusions with the pectoralis major, trapezius, infraspinatus or latissimus dorsi muscles [7, 15, 22]. The number of bellies of the subscapularis muscle ranges from one to nine [26]. Accessory subscapularis muscles have been described in the literature [25, 27]. The infraspinatus muscle can be fused with the deltoid or teres minor muscles [15, 18]. Additional infraspinatus muscles such as the infraspinatus minor, infraspinatus superficialis and accessory infraspinatus have been found [7, 14, 15, 22]

The infraspinatus muscle is crucial in remplissage, a method of surgical treatment of the Hill-Sachs lesion [10, 11]. The Hill-Sachs lesion can occur after anterior shoulder dislocation. Remplissage in combination with arthroscopic Bankart repair successfully prevents recurrence of such dislocation [11]. Atrophy of this muscle is sometimes a reason why an athlete's performance is limited [8, 9]. At the root of this pathology, compression of the suprascapular nerve in the spinoglenoid notch is common [24]. Atrophy of the infraspinatus muscle restricts overhead throwing motions, which are important in sports such as softball [16].

This case report describes a previously unreported variant of the infraspinatus muscle. The infraspinatus minor had two bellies with different distal attachments. The superior belly inserted into the greater tuberosity of the humerus near the infraspinatus muscle attachment. The inferior belly inserted into the tendon of the infraspinatus. There was also an unusual fusion with the teres minor muscle. We discuss the anatomical, clinical and physiological relationships of this morphological variation.

Case Report:

The right upper limb from a female cadaver 83-years-old at death was subjected to routine anatomical dissection for research and teaching purposes in the Department of Anatomical Dissection and Donation, Medical University of Lodz, Poland. During this traditional anatomical dissection, we found a previously unreported variant of the infraspinatus muscle [20, 25, 28]. We identified a two-headed infraspinatus minor muscle and an infraspinatus muscle fused with the teres minor. The teres minor and infraspinatus muscles exchanged three muscle slips with each other (Fig. 1.).

The infraspinatus muscle originated in the infraspinous fossa and inserted on the posterior surface of the greater tuberosity of the humerus. It comprised one muscle belly. It was fused with the teres minor muscle; the fusion was located at the beginnings of both muscles. There were also three muscle slips from the superior medial part of the teres minor muscle to the infraspinatus muscle (Fig. 1). The lengths of these bellies are given in Table 1.

The infraspinatus minor muscle originated from the inferior surface of the scapular spine, and the medial part of the infraspinous fossa was also blended with the deltoid muscle fibers. The superior head ended on the greater tuberosity, and the inferior head ended on the tendinous part of the infraspinatus muscle (Fig. 2). The infraspinatus minor muscle was innervated by branches of the suprascapular nerve (Fig. 1, Fig. 3). Its morphometric measurements are given in Table 2.

The infraspinatus and infraspinatus minor muscles were perfused by the suprascapular and scapular circumflex arteries (Fig. 3).

The muscles described above were very carefully dissected to minimize measurement errors. Then the prepared cadaver was subjected to detailed morphometric measurements and photographic documentation. The measurements were taken twice with up to 0.1 mm accuracy using an electronic caliper (Mitutoyo Corporation, Kawasaki-shi, Kanagawa, Japan). No other morphological variations were found.

Table 1
Lengths of distinct parts of the morphological variant represented by fusion between the teres minor muscle and the infraspinatus muscle

	Length
Superior	75.93 mm
Medial	65.63 mm
Inferior	89.21 mm

Table 2
Morphometric measurements of the infraspinatus minor muscle

	Superior belly	Inferior belly
Length	77.12 mm	44.14 mm
Width PA	22.60 mm	6.19 mm
Thickness PA	1.61 mm	1.08 mm
Width DA	3.84 mm	4.14 mm
Thickness DA	0.43 mm	0.48 mm
PA – proximal attachment; DA – distal attachment		

Discussion:

During development, the deltoid, teres major, ifraspinatus and supraspinatus muscles arise from a common premuscle mass continuous with the pectoral mass and the common arm sheath. In an 11 mm embryo the deltoid muscle has partially split off from the mass towards its origin from the acromion and clavicula. In embryos 14–16 mm in length it has much the adult form, with usually a distinct slip arising from the fascia over the infraspinatus muscle. In a 20 mm embryo it has practically the adult form and attachments. The development of the acromion from the cephalic border of the scapula partially separates the supraspinatus muscle from the infraspinatus in an 11 mm embryo. The infraspinatus and teres minor muscles are very closely associated from the outset and cover only a portion of the lateral surface of the scapula in an 11 mm embryo. In a 14 mm embryo the infraspinatus is quite distinct from the deltoid muscle, but does not cover the whole of the fossa infraspinata even in a 16 mm or 20 mm embryo [2–4].

Only a few variants of the infraspinatus muscle have been described previously. Macalister [15] described an infraspinatus muscle split into two laminae, which did not completely overlay each other [15]. The

infraspinatus muscle fascia derived from the deltoid muscle to the infraspinatus muscle, and in the reverse direction from the infraspinatus to the deltoid [5, 15]. A case found by Ashaolu et al. [1] showed two infraspinatus muscles attached to the medial surface of the infraspinous fossa and the humeral greater tuberosity [1]. There was a case that described an infraspinatus accessory muscle [14]. This additional muscle derived from the medial scapular border, ran directly under to the scapular spine and ended on the greater tuberosity of the humerus [14].

The following two variations are most significant for this paper. The infraspinatus muscle can be fused with teres minor [5, 15, 18]. According to data completed by Mori [18], this fusion occurs in 10% of the Japanese population [18]. An additional muscle named the infraspinatus minor derives directly below the scapular spine and inserts into the greater tuberosity of the humerus. It can be observed not completely differentiated from the main muscle mass of the infraspinatus [7, 22]. An infraspinatus minor muscle with two bellies has not been mentioned in the previous literature [7, 22].

Kato et al. [13] redefined the structure of the infraspinatus muscle, dividing it into two parts, transverse and oblique. The oblique part has the shape of a fan. It originates from the infraspinous fossa and inserts into the greater tuberosity of the humerus. The transverse part originates from the inferior surface of the scapular spine and ends on the tendinous part of the oblique part of the infraspinatus muscle [13].

We identified the muscle masses located directly under the scapular spine not as the transverse part of the infraspinatus muscle, but as the infraspinatus minor muscle. We found that the muscle bundles were easy to separate from the main part of the infraspinatus.

Atrophy of the infraspinatus muscle has been observed by clinicians. The usual reason for this pathology is compression of the suprascapular nerve in the spinoglenoid notch [24]. Infraspinatus muscle atrophy commonly occurs in sports with overhead throwing motions such as tennis [8] and volleyball [9]. This pathology is not painful, but it limits the athlete's achievements [8, 9]. Such atrophy can be treated with exercises that strengthen the external rotators of the glenohumeral joint. If the rehabilitation is not effective, this pathology can be treated surgically. Neurolysis of the compressed nerve succeeded by temporary immobilization and rehabilitation brings satisfactory results [9]. The infraspinatus muscle is important in the treatment of the Hill-Sachs lesion by remplissage; this lesion can occur secondary to an anterior glenohumeral joint dislocation. The manifestation of the Hill-Sachs lesion is a defect in the humeral head that leads to destabilization of the glenohumeral joint. One step in the remplissage method is translocation of the humeral attachment of the infraspinatus muscle [10, 11].

A double-headed infraspinatus minor muscle can provide additional strength and precision for movements in the shoulder girdle. It can be crucial for athletes practicing sports such as softball, tennis or volleyball [8, 9, 16]. Fusion between the infraspinatus and teres minor muscles with three additional muscle slips can support both muscles. The infraspinatus minor muscle can take a supportive role in remplissage.

There are situations in which a muscle is used as a graft. For example, the latissimus dorsi can be used for breast reconstruction after mastectomy [23]. Is there any possibility of using the double-headed infraspinatus minor muscle as a graft? In our opinion, surgical use of this additional muscle is doubtful. Harvesting it would be a problem as during dissection, we had to cut the deltoid muscle transversely. An endoscopic approach would also be problematic. Tight spaces and the presence of the suprascalupar nerve and artery could result in injury of those structures during graft preparation. Possible complications after such procedures would be serious.

Muscle variations are occasionally responsible for nerve and vessel compression. A good example of this problem is a variation of the lateral insertion of the latissimus dorsi muscle, the axillary arch. The muscle slip running from the latissimus dorsi to the pectoralis major muscle can compress the neurovascular bundle in the cervico-axillary region [6, 21]. In our case, there was little chance of nerve or artery compression. On the other hand, there is a chance that the suprascapular nerve and artery could run between the bellies of the infraspinatus minor muscle, so the double-headed infraspinatus minor muscle could cause neurovascular compression in that region.

Conclusion:

The infraspinatus muscle can vary in many ways. It is important to know its possible variants. Each of them can change the biomechanics of the rotator cuff. Moreover, variants of this muscle should be cataloged so that if seen in future dissections or clinically, researchers will have a reference for this anatomy.

Declarations:

Ethical approval and consent to participate

The study protocol was accepted by the Bioethics Committee of the Medical University of Lodz. The cadavers were the property of the Department of Anatomical Dissection and Donation, Medical University of Lodz. Informed consents were obtained from all participants before they died.

Consent to publish

Not applicable

Availability of data and materials

Please contact authors for data requests (Łukasz Olewnik, PhD – email address: lukasz.olewnik@umed.lodz.pl).

Competing interests

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Authors' contributions

Krzysztof Koptas – Assistant – project development, data collection and management, data analysis and manuscript writing.

Nicol Zielinska– Associate Professor – data analysis and manuscript editing.

Richard Shane Tubbs (PhD) – Professor – data analysis and manuscript editing.

Łukasz Olewnik (D.P.T., PhD) – Associate Professor – data collection, data analysis and manuscript editing.

All authors have read and approved the manuscript.

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Figures

Figure 1

Legend not included with this version.

Figure 2

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Figure 3

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