



## **Psoas Minor Muscle – A Topographic and Morphometric Cadaveric Study with Its Clinical Insight**

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**Citation of this Article:** Dr. P. Potaliya, Dr. A Choudhary, Dr. S. Ghatak, “Psoas Minor Muscle – A Topographic and Morphometric Cadaveric Study with Its Clinical Insight,” IJMSAR – October – 2022, Vol. – 5, Issue - 5, Page No. 38-45.

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**Type of Publication:** Original Research Article

**Conflicts of Interest:** Nil

### **Abstract**

#### **Objective**

In the posterior abdominal wall Psoas group comprising of three muscles i.e. psoas major, minor and tertius. Both psoas minor and tertius are occasionally present. It extends from the bodies of the twelfth thoracic and first lumbar vertebrae and inserted into the iliopectineal eminence. The main objective of the study was to establish the incidence, morphology and morphometric analysis of the muscle in the Western Indian population with its clinical correlation.

#### **Method**

This study was carried out in the Department of Anatomy at All India Institute of Medical Sciences Jodhpur, Rajasthan (India) on twenty-four cadavers.

The length, width, of the belly and tendon of the muscles were measured. The collected data were inferred in a descriptive way and compared with previous studies.

#### **Results**

The incidence of psoas minor muscles was found in 37% cases in which 29% were bilateral (7/24) and 8% unilateral (2/24). The average length of the muscle was 20.95 cm, average width of belly was 3.08 cm. Distinct variation in insertion sites and patterns were observed.

#### **Conclusion**

To assimilate the disseminated existing information about variations in different parameters of

psoas minor muscle and accentuate its substantial role in radiographic and surgical procedures, a review of literature is done for comprehension of various associated clinical conditions. The study of variants in psoas major with its review and its disposition in the retroperitoneum would serve to comprehend and aid in the interventional procedures and differential diagnosis of relevant clinical conditions.

### **Keywords**

Psoas minor, belly, tendon, variations

### **Advances in Knowledge**

- Adding to the comprehensive existing literature regarding various variations of psoas minor muscle.
- To the best of the authors' knowledge, the present study is the first to highlight the variations of psoas minor with associated complications in Western region of India.

### **Application to Patient Care**

- Psoas syndrome is a complex musculoskeletal condition which is mostly mis-diagnosed.
- Anatomic considerations as variations in psoas minor is of significant importance in diagnosis of psoas syndrome.
- Psoas syndrome may manifest as any of a variety of clinical scenarios

### **Introduction**

The Psoas minor muscle is one of the three muscles of psoas group, which constitutes posterior abdominal wall. In total, this group has three long muscles as major, minor, and tertius. Among them, the psoas major is the only muscle, which is present in all the individuals.

The origin of another one in the group i.e. psoas minor muscle extends from the bodies of the twelfth thoracic and first lumbar vertebrae. Attached

as elongated fascicles it is finally inserted into the iliopectineal eminence. It is a slender muscle and lies ventrally on psoas Major on the posterior abdominal wall. It has inconsistent presence in individuals as reported in census and when present, shows substantial variability <sup>[1]</sup>.

Its origin involves bodies of vertebra along with their intervening intervertebral disc. Inferiorly its insertion is as a long tendon that is mostly flattened varying in length from 11-13 cm length. Its attachment here extends from iliopectineal eminence, pectineal line and by its lateral border even into the iliac fascia. It has nerve supply by ventral ramus of first lumbar nerve. Its major function is concerned with weak flexion of trunk, stabilizing the hip joint and aids in lateral flexion of lumbar spine <sup>[2]</sup>. It is interesting to note that this muscle is seen obligatory muscle in lower animals where rapid propagation is necessary. In evolutionary alterations, it got vestigial with upright posture <sup>[3]</sup>.

Comprehensive literature shows that a major predisposition of this muscle for agenesis, which has racial and structural variations rather than gender differences <sup>[4]</sup>.

Human variation of the psoas minor muscle is often reported at various instance but its clinical correlation with varied incidences and variability is still to be adequately documented. The review of psoas minor and its disposition in the retroperitoneum is crucial for understanding and regulating the interventional approaches and differential diagnosis of relevant simulating clinical conditions.

In the present study, the conventional classification in incidence and morphological variations of psoas minor are supplemented with information on its embryological basis, gender

disparity, race dependent variation and its clinical correlation in details with discussion of the percentage of various types of anatomical variation of the muscle, which fills the “gap” in the literature.

The study attempts to classify individual anatomical variants of psoas minor, comprising occasional and unusual findings. Specific attention has been paid to the variability of origin and insertion sites and the variability in the extensions from the muscle. Moreover, exceptional findings of anomalies of psoas minor are also been presented.

Hence, this study was done to review the morphology, various variants and their clinical implications of this vestigial, evolutionary significant but functionally inconsequential muscle.

### **Method**

The study was carried out in the Department of Anatomy at All India Institute of Medical Sciences Jodhpur, Rajasthan (India) on cadavers used for routine dissection. The study was based on the standard dissection of the posterior abdominal wall on total twenty-four cadavers. The ethics clearance was obtained by institutional ethics committee of All India Institute of Medical Sciences Jodhpur. A statistical approach was undertaken to know the incidence of the muscle, along with morphological and morphometric variations. Measurement of the length of the muscle belly and its tendon and their width at the widest point, were done. Muscle belly and tendon were differentiated at myotendinous junction by histological analysis. Extent of attachment, length of belly, tendon and aponeurosis were measured using digital Vernier calliper accuracy up to 0.01 mm. The collected data were inferred in a descriptive statistical manner.

A review was conducted using arduous literature search including various online search engines, PubMed, Excerpta Medica Database, Scopus, Cochrane Library, and Google Books and Google Scholar to retrieve studies reporting variations of the psoas minor muscle; with recent update till 2020. The medical terms and text words used were ‘psoas minor muscle’, ‘psoas minor and its variations’, ‘anatomical variations of psoas minor muscle’, ‘morphology of psoas minor muscle’, ‘psoas minor muscle and its structural variations’ or ‘development or embryology of psoas muscle’. Relevant published manuscripts in the references and their cross references, from online publications to journals, bibliography of books were also explored. There were no time frame-constraint for the literature reviewed. All three authors performed the data mining and search. They independently examined the abstracts and full texts of the manuscript publications were selected for inclusion. Discrepancies were resolved by consensus. Each author prepared a list of the most important papers based on their literature search and made a set of preliminary recommendations. For each item, a complete literature search was performed to identify new or additional randomized controlled trials and systematic reviews/meta-analysis, if any, not used in the existing guidelines. Consensus was defined as agreement greater than 80%. Error in search were reduced using two ways to search terms in PubMed: without field tags, which activates automatic term mapping, or with field tags. All possible variations of the terms were considered. Truncation were used to avoid having to explicitly include all possible variants in the strategy. Dual independent screening of full text, disagreements between two authors reconciled via consensus or arbitration by a third author was

performed. Exclusion criteria were published manuscripts in language other than English. Inclusion criteria criterion was an established diagnosis of a variation of the psoas minor muscle.

### **Result**

In the present study, out of 24 cadavers, the incidence of psoas minor muscles was found in 37% cases in which 29% were bilateral (7/24) and 8% unilateral (2/24), in which one on the right side and other on the left side.

All the muscles were taking origin from the lateral surface of the body of T12 and L1 vertebra and from intervening tendinous arch. Marked variation was observed in morphology and morphometry of muscle. We did not find any psoas accessories muscles though. Muscles were having broad to narrower belly ranging from 1.5-3.1 cm with no significant difference on right and left sides. Insertion of muscles also showed distinct variations ranging from various morphometric differences in length of tendon to site of insertion. In one case, we observed aponeurotic insertion (Figure 1 a). In another instance, on the left side, tendinous insertion merged with fascia iliaca laterally (Figure 1 b). In two cadavers, it was observed that fibres of psoas minor were intermingled with fibers of belly of psoas major and insertion was also musculotendinous (Figure 1 c). Tendon in some cases were very slender and as narrow as 0.4 cm and in few cases it was broad up to 1.3 cm. Long tendon was also observed up to 17 cm of length (Figure 2 a). In another case, we found slender tendon of muscle with medially directed aponeurotic insertion (Figure 2 b).

### **Discussion**

#### **Incidence and Morphological Variations of Psoas Minor**

The Psoas minor muscle exhibits marked variations in its morphology and measurements. It showed characteristic difference from individual to individual and various populations. In a cohort study mean length and breadth were found as 19.66 cm and 1.73 cm respectively <sup>[5]</sup>. It was observed that tendon is main entity constituting more than half of the muscle <sup>[6]</sup>. Psoas minor muscle incidence was found in a study on Indian population to be 30% with a mean length and breadth as 23.75 cm and 1.32 cm respectively <sup>[7]</sup>. Another study reported the incidence to be 26.66% with average length around 22.12 cm <sup>[8]</sup>. Our study was closer to this finding as in this study average length was found to be approximately 20.45 cm and width approx. ranging from 2.24-2.41 cm (Table 1 and 2). In a study on south American population incidence of psoas minor muscle was approximately in 60%. Here morphological dimensions included length approximately 23.93 cm and a mean width of 1.71 cm <sup>[9]</sup>. It was close to the finding where mean length of the muscle was found approx. 23.85 cm <sup>[10]</sup>. Therefore, it was found that majority of studies showed the incidence of psoas minor in 35-40% population.

#### **Variations of Origin**

Common variations of the psoas minor are associated with the spinal level from where it originates. In majority fibres are seen to originate from T 12, L1 spinal level and from the intervening disc. It exactly corresponded to present study. Sometimes it takes its origin only from lumbar vertebra L1 or L2 and the disc between them <sup>[11-12]</sup>. It is also seen to take its origin from the sub-diaphragmatic fascia. In that case few fibres were also arising from medial arcuate ligament. Crus of diaphragm is another entity associated with fibres taking its origin from

there [13]. Another interesting feature is dual heads of origin. This is found most seldom and also reported rarely in literature. Most earlier reporting of such dual head was in seventeenth century when two heads of psoas minor were seen both lying over each other [11]. Many authors found it to fragment incompletely or completely before the insertion [11-12]. Morphology of complete muscle was well described and documented by Macalister in literature [12].

#### **Variations in the Insertion**

It was found that sometimes psoas minor tendon fragments into two and in that case, other than from its usual insertion the alternative band is attached on the synchondrosis between the L5 vertebra, iliopectineal line, and sacrum [2,12]. Occasionally the insertion is incessant with the pelvic fascia or unswervingly with the iliac fascia [2,12]. The tendon can also insert into the pectineal line of the femur, neck of the femur, lesser trochanter with the iliopsoas, the arched line, the iliac fascia, the inguinal ligament, or the pectineal ligament [6]. In fetal study psoas minor muscle was seen to pass posteriorly to the crural arch and attach finally to the pectineal line of the femur [6, 12]. A study in Indian Population found instances where the muscle has a voluminous fleshy belly and the attachment lower down was stout and widened with fibres inserting to the iliopectineal eminence and pecten pubis [8]. In couple of cases, they also found a lean muscle with a long and spread lower down. The insertion was at iliopectineal eminence and fibres amalgamated with the obturator and iliac fascia medially and laterally respectively.

Various other variation as accessory expansion is also a frequent variation that is well described. It is found that few of muscle fibers extends from deep surface of psoas minor and runs

downwards to merge with iliacus and psoas major [14]. Expanded fanlike expansions are also found extending from the tendon of the psoas minor that was seen to join the fascia of the psoas major [6]. This indicates that such psoas accessories are result of partial separation between the psoas major and minor muscles at time of development. Another study in Indian diaspora documented a variation where the fibers arising from undersurface of the psoas minor and superficial fibers of the Psoas major were seen to intermingle [13].

Though, this study had no clue on the incidence or the site of attachments precisely, making it vague and confusing whether it was Psoas accessories or not.

#### **Agensis**

The most common variation is agensis of psoas minor. This is seen to most commonly underwent agensis when compared with other muscles as pyramidalis, peroneus tertius, palmaris longus, and plantaris. The average occurrence of psoas minor is between 33.4 and 52% [2]. In a 450 cadaveric study, psoas minor was absent in approximately 40.66% cases bilaterally whereas unilaterally absent in 15.33% [8]. In another extensive cadaveric study, bilateral agensis was found in 54.5% cadavers [11]. In a study on 182 subjects, 70 had bilateral presence whereas 12 had right-sided, and eight were left-sided [8,11]. One cadaveric study showed the incidence only of 26.66% [8]. In an Asian study the presence of the psoas minor was found to be 36.67% with 81.81% bilateral and 18.19% unilateral [13]. A study on twenty-two fetus showed presence of psoas minor in thirteen fetus with ten to be bilateral [6]. Seib found prevalence of psoas minor in 38.6% cases with predominantly absent in females [14]. This

was not in accordance with Bergman et al where it was found more frequently absent in males [11]. The most recent belief seems to be no gender disparity associated with prevalence of psoas minor [12,15]. Variation is still reported as male were found to have long, slender tendon as compared to females [13].

Gender disparity:

The prevalence of Psoas minor muscle is more in females [16]. It had been contradicted in other study, where the gender bias was found to be insignificant [17]. It is interesting to note that no scientific evidence is available regarding its apparent gender specific correlation [16].

#### **Race Dependent Variation**

Race dependent variation of the incidence is well documented. Remarkable disparity was seen in agenesis of muscle in young white and black males. Even the muscle belly was found to be thicker in whites [4]. The incidence of agenesis in a study on Asian subjects was around 50% in white subjects whereas more than that in black subjects i.e. 66.6% [11]. In another extensive examination on agenesis of psoas minor in races showed it be least in Russian followed by blacks and Chinese and maximum in Irish followed by Scotsmen population. Alsations and English showed almost closer incidence rate of agenesis i.e 57-59%. [14].

#### **Clinical correlation**

An important clinical condition associated with psoas minor is psoas minor syndrome. Psoas minor is situated such as the infection and malignancy can readily reach even to the retroperitoneal region. Most of the clinical features appear because of compression of neurovascular structures here. As a result enhanced tension is observed in the muscle. Clinical representation of syndrome includes iliac

fossa where pain is felt. Aggravation is caused by palpation of the taut tendon. Also interestingly physician should be careful as clinical indications from it are found to replicate that of diverticulitis and appendicitis. Management of psoas minor syndrome includes removal of tendon [8]. Physical exertion is observed with difficulty in jumping etc. underlying reason to develop the syndrome is still unknown. Literature has not much cited the role of variation being the cause. Further studies are expected to know the role of variations in enhancing the intensity and susceptibility for infection or malignancy to spread to the retroperitoneal region. It was found that conditions in which psoas minor fibres took its origin from the diaphragmatic fascia and medial arcuate ligament or even if some from body extend from crus of diaphragm, moreover lead to retroperitoneal infections and even reaching to the endothoracic cavity [13].

#### **Conclusion**

The psoas minor muscle showed distinct variation in morphology, morphometry and its incidence in western Indian population and reports from other populations. This study conducted showed the presence of psoas minor muscle in 37.5% cases. Wide variations at insertion were noted. In this study, we presented several variations seen in psoas minor muscle with occasional incidence associated with it. Our exploration added to the existing literature the knowledge of numerous variants of the psoas minor muscle.

#### **Limitations of Study**

Further studies are desirable to totally explicate the role of these variants on functioning and discourse of associated pathologies.



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## Legends for Images

Figure 1:

- a) Psoas minor showing aponeurotic insertion
- b) Psoas minor showing tendinous insertion merging with fascia iliaca laterally
- c) Psoas minor showing fibres intermingled with psoas major muscle along with musculotendinous insertion

Figure 2:

a) Psoas minor showing i. fibres at origin merged with psoas major ii. Long slender tendon of insertion

b) Psoas minor showing slender tendon with medially directed aponeurotic insertion

