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CLINICAL RELEVANCE OF THE PYRAMIDALIS MUSCLE WITH ITS MORPHOMETRIC CHARACTERIZATION

Anatomy

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ABSTRACT

Introduction: Pyramidalis muscle is the muscle of the anterior abdominal wall situated within the rectus sheath in front of the lower part of the rectus abdominis muscle. Owing to small size of muscle, its inconstancy and it's not well defined function, little data exists in literature regarding its morphometry and clinical significance. Current study was designed to assess diversity and anatomical morphometric particulars of the pyramidalis muscle with its clinical relevance.
Materials and Methods: 30 embalmed cadavers were dissected and studied. Morphometric measurement, variation of origin and insertion of the muscle were noted.
Results: Pyramidalis muscle was present in 24 cadavers (21 males and in one female cadaver). In both the genders where muscle was present, it was present bilaterally. The muscle fibres extended vertically with no pennation and muscle continued either as muscle till whole length, as tendon superiorly or as tendon from origin to insertion. The mean muscle length along medial border of pyramidalis muscle was 52.17 ± 12.19mm and average width at base of the pyramidalis muscle was 14.84 ± 2.43mm.
Conclusions: Results of the current study indicate that among the Indians, the Northwest population presents the lower values for both the length and width of the muscle. These alterations on both the dimensions should be taken into thought in reconstructive surgeries where the muscle is used as a free flap and in various stem cell procedures. This knowledge should be reserved for the surgeons due to possibility of encountering insufficient length and width of the muscle.

KEYWORDS

Pyramidalis muscle, morphometric characterization, clinical relevance

INTRODUCTION

Pyramidalis muscle is the muscle of anterior abdominal wall situated within the rectus sheath in front of the lower part of the rectus abdominis muscle. This triangular muscle is attached by the tendinous fibres to the anterosuperior margin of the pubis and to the ligamentous fibres in front of the symphysis. As the muscle runs upwards it diminishes in size, and ends in a pointed apex that is attached medially to the linea alba. This attachment often lies midway between the umbilicus and pubis, but may occur higher also (26). The pyramidalis muscle fibers extend vertically and do not present pennation (19). Considerable variation in the size and presence of the muscle is seen making it not so constant muscle (12). Global incidence found in the literature reported to be as low as 30% (10) and as high as 100% (23).

Though the physiological significance of the muscle is doubtful but it contributes in tensing the lower linea alba where it may also aid in increasing the intraabdominal pressure at the same time locally compressing the bladder (3). Divergent from earlier beliefs, this muscle is considered to be a progressive configuration which is becoming more firmly ingrained as the normal part of human anatomy, rather than a regressive vestige indicating its consequence with the erect posture of man (16). Anson *et al.* (1938) stated that there is no relation between the pyramidalis muscle length and person height. The muscle is commonly encountered by gynaecologists (10) and it is frequently harvested for conducting electro-physiological experiments (7). The pyramidalis muscle can be an appealing donor muscle for the microsurgical transfer to reduce the donor site morbidity as compared with the traditional free flaps as it can be harvested through a relatively inconspicuous Pfannenstiehl incision with negligible donor site morbidity (16).

Owing to the small size of the muscle, its inconstancy and it's not well defined function, little substantial data exists in the literature regarding the morphometry and its incidence in various populations. Current study was designed to assess the diversity and the anatomical morphometric particulars of the pyramidalis muscle with its clinical relevance. And also to access the gender influence, unilateral or bilateral appearance, its shape, and difference by the side in the Northwest Indian population. So that the normal ranges for the muscle size in the discussed population can be established and reviewed with the available literature. The acquaintance regarding this muscle and its inconsistency is important to the general and plastic surgeons.

MATERIAL AND METHODS

The present study was conducted on the 30 embalmed cadavers (26 males and 4 females) obtained from the Department of Anatomy of our Institute over a period of 2 years. The cadavers with any injury scars or surgery marks on the anterior abdominal wall were excluded from the study. The distance between the pubic symphysis and the umbilicus was measured. During dissection of the anterior abdominal wall, the anterior wall of the rectus sheath was reflected laterally to expose the pyramidalis muscle on the lower part of the rectus abdominis muscle. Presence of the pyramidalis muscle along with its shape was noted. Morphometric observations of the muscle length along the medial border and the width at the base, calculated along the muscle insertion at the pubic crest were taken. Presence of any morphological variation of the origin and insertion of the muscle was also noted. Measuring tape and digital vernier caliper were used for measurements. Pyramidalis- puboumbilical index was calculated as the percentage of the distance between the pubic symphysis and umbilicus into which the pyramidalis muscle extends (length along the medial border).

STATISTICAL ANALYSIS

Statistical analysis was performed using the Student's t-test. Pearson correlation test was used to calculate correlations between the measured values and was performed between the right and the left muscle length along the medial border of the pyramidalis muscle, the right and the left width at the base of the pyramidalis muscle, the right-sided muscle length along the medial border and the width at the base of the pyramidalis muscle and the left-sided muscle length along the medial border and the width at the base of the pyramidalis muscle. A level of significance of $p < 0.05$ was used.

RESULTS

The pyramidalis muscle was present in 24 cadavers (73%) out of total 30 studied cadavers. In males it was present in 21 out of total 26 male cadavers. In case of the female cadavers, the muscle was absent in 3 cadavers and was present only in single cadaver. In both the genders where the muscle was present, it was present bilaterally. No anatomical variation in relation to origin or insertion of the muscle was seen. The muscle fibres extended vertically with no pennation from its origin from pubic symphysis and the muscle continued either as muscle till whole length, as tendon superiorly or only as tendon from origin to insertion.

The mean muscle length along the medial border of the pyramidalis muscle was 52.17 ± 12.19mm (30mm-75mm), with the most medial fibres analogous to the axis of the medial border. The length along the medial border of the pyramidalis muscle (Figure 1) varied widely, however 95% Confidence Interval for mean was 46.54mm- 57.80mm.

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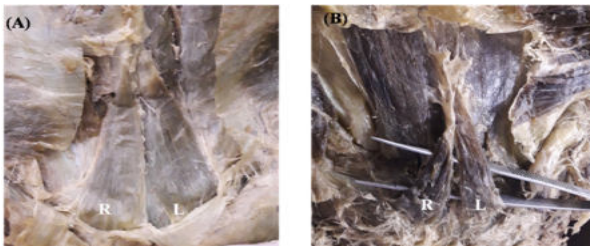

Figure 1: Bilateral pyramidalis muscle in the lower part of anterior abdominal wall (A) Both sided pyramidalis muscle ending at the same level; (B) Right sided pyramidalis muscle ending at lower level; (R-Right, L-Left)

In 4 sides it was noted that muscle fibres superiorly continued as thin tendinous bands ranging from 15.5-57.8mm in length and 5–11mm in width (Figure 2).

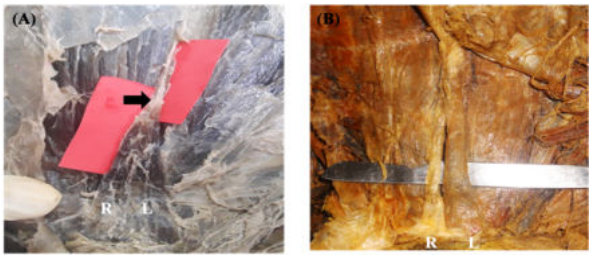

Figure 2: Bilateral pyramidalis muscle in the lower part of anterior abdominal wall (A) Arrow on right side showing the extent of muscle whereas on left side it continued superiorly as a tendinous band; (B) Right side complete tendinous band and left side as muscular fibres; (R-Right, L-Left)

In 53% cases it was between 51-70 mm, in 42% cases it was between 30-50mm while in rest (5%) it was above 71mm. On comparing both the sides, the average muscle length along the medial border of the pyramidalis muscle was slightly higher on the left side in comparison to the right side (Table 1) however no statistically significant difference (p=0.8) was noted. In almost 78% cases it was seen that the length along the medial border of the pyramidalis muscle was same on comparing both sides. A maximum difference of 22mm was seen in the length along the medial border of the pyramidalis muscle on comparing both sides. No statistically significant correlation was observed between two sides when the muscle lengths along the medial border of the pyramidalis muscle was compared (r=0.79, p>0.05).

The average width at the base of the pyramidalis muscle was 14.84 ± 2.43mm (8mm-19mm) with 95% Confidence Interval of 13.71mm-15.96mm. In most of cases (56%) the range of the width at the base of the pyramidalis muscle lies between 12-15mm. In 30% cases it was between 16-18mm, in only 5% cases it was between 8-11mm while in rest of 8% it was above 18mm (Figure 3).

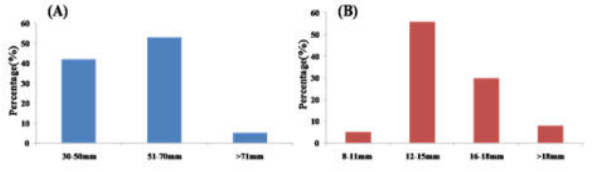

Figure 3: Bar diagram showing the frequency of distribution of (A) muscle length along the medial border of the pyramidalis muscle (B) width at the base of the pyramidalis muscle; Y axis frequency in %; X axis range in figures

On comparing both the sides it was documented that the average width at the base of the pyramidalis muscle was somewhat higher on the left side in comparison to the right side (Table 1) but without any statistically significant difference (p=0.5). A maximum difference of about 6mm in the width at the base of the pyramidalis muscle was seen when both the sides were compared and in half (50%) cases it was seen that width at the base of the pyramidalis muscle was same on both the sides. The width at the base of the pyramidalis muscle when compared on both the sides showed no statistically significant correlation (r=0.74, p>0.05).

Table 1 Metric parameters of the pyramidalis muscle

Parameters	Side	Mean ± SD (mm)	Range (Minimum-Maximum)(mm)	95% Confidence Interval (mm)
Length along the medial border	Right	51.58 ± 12.18	30-75	45.95-57.20
	Left	52.76 ± 12.53	30-75	46.97-58.54
Width at the base	Right	14.58 ± 2.73	8-19	13.32-15.84
	Left	15.09 ± 2.15	12-19	14.10-16.08

On comparing the right-sided muscle length along the medial border and the width at the base of the pyramidalis muscle no statistically significant correlation was observed (r=0.34, p>0.05). Similar results were seen on the left side when the left-sided muscle length along the medial border and the width at the base of the pyramidalis muscle were correlated (r=0.27, p>0.05).

The mean value of the Pyramidalis- puboumbilical index is 34.43± 7.82% with the range of 18.75%- 51.85%. The 95% Confidence Interval for the same is 30.82%-38.04%.

DISCUSSION

Not many papers in the literature talk about the pyramidalis muscle function due to the muscle constancy and some have even documented it as vestigial (9,19). Even though the muscle is appreciably allied with the erect posture in humans (3, 28), no definitive relationship had been documented between the muscle length and the body height (2). The use of free pyramidalis muscle flap harvested through a lower abdominal vertical midline incision is related to minimum donor-site morbidity, esthetic considerations and functional deficit (16). Current study was designed to enrich the available literature about the normal ranges for the muscle size in the discussed population and reviewed with the available literature. The acquaintance regarding this muscle and its inconsistency is important to the general and plastic surgeons.

The results of incidence of pyramidalis muscle of present study (73%) corroborates with the African-Americans and the native Africans (69.2–91.2%) (2, 5), Europeans (74% in English–89.3% in French) (17, 28) and White Americans (73.2–81.8%) (4, 11). The incidence rate is noted higher among the Greeks (93.8%) (22) and the Japanese (range 95.3–96.9%) (1, 15). These observations show genetic variability between the different ethnic groups and races. Current study demonstrated no side predominance as against the observations of Natsis *et al.* (2016) and Chouke (1935) which observed left-side preponderance and Monkhouse and Khalique (1986) established the right-side predominance.

The pyramidalis muscle presents very high inconsistency in the presence, form, size and structure. Morphological variations of the pyramidalis muscle in humans exist in different races (2). Some authors have documented the unilateral presence of two, three or four muscles (3, 20) and some documented it bilaterally (2) with varying range of shape (triangular, quadrilateral, pyramidal) or with an aponeurotic type in the inferior third of the muscle, or muscle with very thin tendinous bands with few indistinct muscular fibers (22). In the present study also variability in constitution of muscle fibre was noted as in some cadavers muscle fibres superiorly continued as thin tendinous bands ranging between 15.5-57.8mm in length and 5–11mm in width.

The muscle length along the medial border of the pyramidalis muscle also varied widely in different populations. Assortment of the muscle length along the medial border exist among Europeans (2.0–13.8 cm) (19), Greeks (2.0–14.0 cm) (22), White Americans (range 0.5–15.8 cm) (2, 3), Japanese (5.7–10.3) (21) and Africans (0.5–11.5) (2). The results of current study for the muscle length along the medial border of the pyramidalis muscle varied from 3-7.5 cm. So the study population had comparatively shorter length in comparison to other populations.

As regards the width at the base of the pyramidalis muscle it was seen in current population the width is lower (0.8-1.9 cm). These findings are in oppose to that of other populations where it was seen muscle was wider at its pubic extremity as in the Africans (0.5–3.7) (2, 6), White Americans (0.5–6.0 cm) (2, 3), Europeans (1.0–3.0) (18) and Japanese (1.0–3.0) (21). However our results corroborates with those of Greeks (22) who also reported the lower widths (0.5–2.6 cm). The results of the current study indicate that among the Indians, the Northwest

population presents the lower values for both the length and width of the muscle.

The muscles in Greeks (22) are more elongated and narrow, while in other ethnic groups (2, 3, 6) smaller and broader pyramidalis muscle was documented. This knowledge should be reserved for the surgeons due to the possibility of encountering insufficient length and width of the muscle in the study population. These alterations on both the dimensions should be taken into thought in the reconstructive surgeries where the muscle is used as a free flap.

Surgeons use the pyramidalis muscle as a landmark for making the midline infraumbilical incision (25), hence pyramidalis-puboumbilical index (12) was calculated. The average pyramidalis-puboumbilical index reveal that the pyramidalis muscle covers the lower 34% of the distance between the umbilicus and pubic symphysis. These values may be clinically significant for the surgeons. Besides the use of the pyramidalis muscle as free flap (16), other proven applications of the pyramidalis muscle includes the isolation of stem cells (14) which undergo self-renewal differentiation leading to the treatment of stress urinary incontinence in males (27), and sphincter regeneration in females (13). In classical caesarean section, while making longitudinal incision the pyramidalis muscle is referred to determine the midline and location of the linea alba (24). In children with neurogenic bladder, the Goebell–Frangenheim–Stoeckel procedure increases the bladder outlet resistance after using the pyramidalis muscle and the rectus fascia transplants (16). Taking into consideration the above facts and proven applications of the pyramidalis muscle, the above results might help the surgeons, clinicians during the lower abdominal wall surgeries.

CONCLUSION

The results of incidence of pyramidalis muscle of present study (73%) confirm a relatively lower frequency in the study population. The pyramidalis muscle unevenness in various populations regarding its frequency, morphometry and irregularity reveal genetic differences between different races. Results of the current study indicate that among Indians, Northwest population presents lower values for both length and width of muscle. This knowledge should be reserved for surgeons, clinicians during the lower abdominal wall surgeries.

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