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Fetal anatomy of the abductor pollicis brevis and its clinical importance

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Abstract

Objectives: The abductor pollicis brevis exhibits a variant course in newborns with radial polydactyly or syndactyly; however, its morphology in human fetuses has not been previously studied. This study aims to document the dimensions and attachment points of abductor pollicis brevis in human fetuses.

Methods: The study consisted of 27 (15 females and 12 males) fetuses with a mean gestational age of 24.08±4.18 weeks. The attachment points (its insertion and origin) of abductor pollicis brevis were determined. The width, length and area of the muscle were measured with ImageJ software. The insertion and origin points were classified according to the literature.

Results: The mean width, length and area of abductor pollicis brevis were 3.52±1.33 mm, 9.19±2.73 mm and 30.84±20.39 mm^2, respectively. The muscle most commonly originated from the flexor retinaculum and the tubercle of the scaphoid bone (Type 1) and inserted at the lateral side of the first metacarpophalangeal joint (Type A).

Conclusion: This study is the first to classify the origin and insertion of the abductor pollicis brevis in human fetuses. These findings could be valuable for hand surgeons performing surgical interventions in this region in newborns. Additionally, the growth patterns identified in our study may be used to estimate the size of the abductor pollicis brevis in fetuses.

Keywords: abductor pollicis brevis; fetus; thenar region; thumb

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Introduction

The thenar region muscles play a crucial role in thumb strength and movement, and they are closely associated with anomalies and surgical procedures in this area. One of the thenar muscles, the abductor pollicis brevis (APB), is a slender muscle located at the proximal and lateral part of the thenar eminence. The muscle primarily originates from the flexor retinaculum, with additional fibers arising from the tendon of the abductor pollicis longus and the scaphoid tubercle. It attaches to the base of the proximal phalanx.[1] Variations related to the APB, such as the absence of the muscle, double-headed muscle, fusion with the abductor pollicis longus, or attachment to other thenar muscles, have been documented in the literature.[2]

Thenar muscle agenesis can occur in cases of thumb hypoplasia.[3] During thumb anomalies like syndactyly and radial polydactyly—conditions that are sensitive in pediatric surgery both aesthetically and functionally—the APB may deviate from its normal course in newborns. Atrophy or hypoplasia of this muscle, whether occurring before or after syndactyly and polydactyly surgery, underscores the importance of understanding the normal developmental and morphometric characteristics of the muscle.[4–8] However, a fetal study on the anatomical features of the APB has not been reported in the literature. Furthermore, no previous classification exists regarding the origin and insertion of the APB. In this context, this study aims to establish new classifications based on the origin and insertion of the APB and to examine its morphometric features in human fetuses to inform early childhood surgeries.

This study was presented as an oral presentation at the 20th IFAA Congress held from August 5–7, 2022.

Materials and Methods

This study was conducted in accordance with the ethical standards outlined in the 1964 Declaration of Helsinki and its subsequent amendments. The thenar regions of 27 fetuses (12 males, 15 females) with a mean gestational age of 24.08±4.18 (range: 18–35) weeks which had been fixed in 10% formalin, were dissected bilaterally. Fetal age was determined based on foot length, as detailed in **Table 1**.[9] Fetuses with deformities such as polydactyly, syndactyly, or cleft lip were excluded from the study.

The dissections were carried out in the university's anatomy department. Fetal samples were placed in the supine position with their hands open. Using a surgical microscope (Leica S4E; Leica Microsystems GmbH, Wetzlar, Germany) the skin and fasciae were carefully dissected. These structures were then retracted laterally and/or medially to expose the APB muscle.

The thumbs were photographed in standard position using a 64 MP camera (Apple iPhone 13 mobile device, running the iOS 14.2.1 operating system) with x10 digital magnification. Measurements were taken three times by two independent observers from the photographs using a digital image analysis program (ImageJ; US National Institutes of Health, Bethesda, USA). The following parameters were measured (**Figure 1**):

- **APB-L (mm):** the length of APB (the distance between the origin and insertion of the muscle) (**Figure 1a**)
- **APB-W (mm):** the width of APB (the width at the widest part of the muscle) (**Figure 1b**)
- **APB-A (mm^2):** the area of APB (the area measured by drawing the boundaries of the muscle) (**Figure 1c**)

Previous studies related to variations of the origin of APB were searched in PubMed and Google Scholar databases, and a classification was developed to encompass all identified variations. Articles lacking detailed information on these variations were excluded based on the following criteria: absence of data about sides, non-English language articles, and articles with only an abstract. The literature search was conducted using the following keywords: "abductor pollicis brevis," "abductor pollicis brevis and origin," and "abductor pollicis brevis and variation." As a result of this search, 178 studies were included in our classification, leading to the division of the origin of the APB into seven types (**Table 2**).

Similarly, studies related to variations in the insertion of the APB were searched in the PubMed and Google Scholar databases. Articles without detailed information on variations were excluded using the same criteria: absence of data about sides, non-English language articles, and articles with only an abstract. The keywords used for this literature review were: "abductor pollicis brevis", "abductor pollicis brevis and insertion", and "abductor pollicis brevis and variation." Following this search, 178 studies were included in our classification, and the insertion of the APB was categorized into four types (**Table 3**).

Table 1
Demographic data of fetuses.

Month	Gestational week	N	Length of right foot (mm)	Males (n)	Females (n)
V	18	1	27.12	0	1
	19	2	29.34±0.50	1	1
VI	21	3	33.16±1.38	2	1
	22	3	37.01±1.54	1	2
	23	2	40.40±0.55	0	2
	24	2	42.12±1.85	0	2
VII	25	2	44.19±0.57	2	0
	26	1	45.25	0	1
	27	3	49.66±1.03	1	2
	28	2	51.97±0.04	1	1
VIII	29	1	54.75	1	0
	32	1	59.08	1	0
IX	35	1	62.86	0	1
Total	24.08±4.18	27	41.38±9.83	12	15

N, n: number of fetuses.

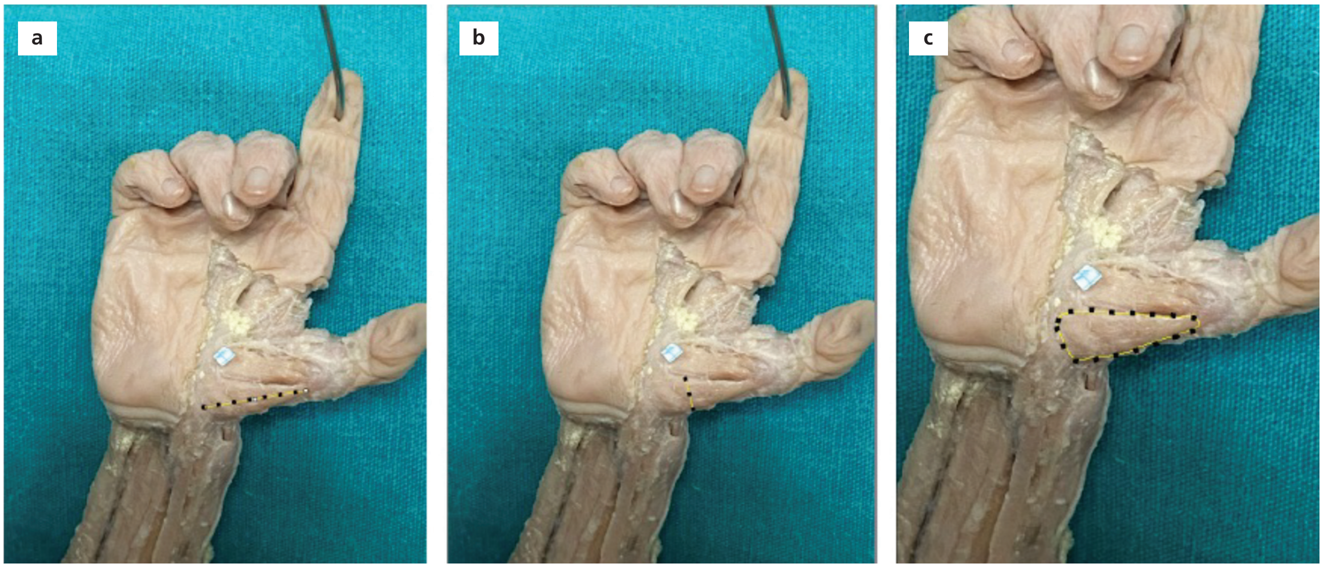

Figure 1. Measurements of length (**a**), width (**b**) and area (**c**) of abductor pollicis brevis.

Intra-observer and inter-observer evaluations were conducted to test the reliability of the measurements. Two researchers independently measured the parameters three times in total. The first observer (SSA) performed the measurements twice, while the second observer (SK) conducted the measurements once. The mean values were calculated by averaging these three measurements. A paired samples t-test was used to compare the two measurements made by SSA, and the intraclass correlation coefficient (ICC) was calculated to compare the measurements taken by SSA (first measurement) and SK.

Changes in the measured parameters according to gestational weeks and months were analyzed using one-way ANOVA followed by a post-hoc Bonferroni test. An inde-

Table 2
Description of types related to the origin of APB in the literature.

Type	Descriptions of types (attachment sites)	n (%)
1	Tubercle of scaphoid bone, flexor retinaculum	44 (84.62)
2	Flexor retinaculum	6 (11.54)
3	Tendon of abductor pollicis longus	2 (3.84)
4	Scaphoid bone	0
5	Flexor retinaculum and distal part of the fibrous sheath of the flexor carpi radialis tendon	0
6	Tendon of the palmaris longus	0
7	Absence of APB	0

Table 3
Description of types related to the insertion of APB in the literature.

Type	Descriptions of types (attachment sites)	n (%)
A	Lateral side of first metacarpophalangeal joint	40 (76.92)
B	Distal and lateral side of first metacarpal bone	9 (17.31)
C	Lateral side of first proximal phalanx	3 (5.77)
D	Absence of APB	0

Table 4
Comparison of the measured parameters in terms of sex and side.

Parameters	Sex			Side		
	Male (20 sides/40%)	Female (30 sides/60%)	p-value	Right	Left	p-value
APB-L (mm)	9.89±3.10	8.82±2.48	0.191	9.56±2.64	8.84±2.79	0.359
APB-W (mm)	3.83±1.53	3.35±1.20	0.228	3.51±1.19	3.51±1.47	0.991
APB-A (mm^2)	37.46±24.77	27.43±17.14	0.100	30.59±18.48	31.07±22.36	0.934

APB-A: area of abductor pollicis; **APB-L:** length of abductor pollicis brevis; **APB-W:** width of abductor pollicis brevis.

pendent samples t-test was used to compare male and female measurements, while a paired samples t-test was employed for right-left comparisons. The Pearson correlation coefficient was used to assess the relationships between the measured parameters. Simple linear regression analysis was applied to derive regression formulas for the measured parameters. Statistical analysis was performed using the SPSS for Windows, version 22.0 (IBM, Armonk, NY, USA), and a p-value of <0.05 was considered statistically significant.

Results

No statistically significant differences were observed in the measurements performed by the same investigator. Additionally, the intraclass correlation coefficient (ICC) score (ICC= 90%–98.6%) indicated that the reliability of the measurements was excellent. Measurements could not be clearly performed on four hands; therefore, the analysis was completed on 50 hands. The origin and insertion of the muscle could not be clearly defined on two hands, so these aspects were defined on only 52 sides. Side and sex comparisons of the measured parameters are presented in **Table 4**, which shows that the parameters did not differ based on side or sex. Growth patterns of the parameters relative to gestational weeks and months are provided in **Tables 5** and **6**, indicating that the parameters increased significantly with fetal age. Additionally, the parameters exhibited a significant positive correlation with each other (p<0.05).

Table 5
Growth patterns of the parameters according to gestational weeks.

Gestational week	APB–L (mm)	APB–W (mm)	APB–A (mm^2)
	Mean±SD (min–max)	Mean±SD (min–max)	Mean±SD (min–max)
18	7.31±2.85 (5.29–9.32)	2.60±0.51 (2.24–2.96)	16.44±7.47 (11.16–21.72)
19	7.25±0.85 (6.44–8.13)	2.42±0.77 (1.76–3.27)	15.79±6.38 (11.79–23.15)
20	6.57±1.09 (5.12–8.14)	2.19±0.17 (2.05–2.51)	13.00±1.94 (10.10–15.28)
21	7.71±1.40 (6.21–9.40)	2.60±0.20 (2.26–2.80)	19.24±1.67 (17.54–20.99)
22	7.70±0.96 (5.99–8.88)	3.62±0.53 (3.11–4.31)	24.97±4.60 (19.40–31.86)
23	7.91±0.57 (7.44–8.63)	2.90±0.39 (2.33–3.15)	19.47±1.57 (17.95–21.64)
24	11.72±4.15 (7.78–16.13)	4.10±1.14 (3.37–5.79)	48.11±33.46 (21.23–95.19)
25	9.46±1.50 (8.05–11.03)	3.46±0.55 (2.85–3.93)	28.48±8.40 (19.61–36.32)
26	7.84±1.51 (6.77–8.91)	2.01±0.76 (1.47–2.54)	12.77±8.00 (7.11–18.43)
27	10.59±1.63 (8.94–13.14)	3.92±0.82 (3.37–5.29)	36.38±9.54 (26.14–47.01)
28	11.36±1.15 (10.26–12.63)	4.32±0.42 (3.84–4.81)	44.20±6.40 (38.93–53.53)
29	12.02±1.22 (11.16–12.88)	5.64±0.25 (5.46–5.82)	68.75±8.29 (62.88–74.61)
32	15.81±0.03 (15.79–15.83)	6.19±0.49 (5.84–6.54)	80.92±0.57 (80.52–81.32)
35	11.15±0.82 (10.57–11.73)	6.30±2.21 (4.73–7.86)	49.30±16.24 (37.81–60.78)
Total	9.19±2.73 (5.12–16.13)	3.52±1.33 (1.47–7.86)	30.84±20.39 (7.11–95.19)
p-value	0.001	0.001	0.001

APB-A: area of abductor pollicis; **APB-L:** length of abductor pollicis brevis; **APB-W:** width of abductor pollicis brevis.

Table 6
Growth patterns of the parameters according to gestational months.

Month	APB-L (mm) Mean±SD (min–max)	APB-W (mm) Mean±SD (min–max)	APB-A (mm^2) Mean±SD (min–max)
5th	6.89±1.30 (5.12-9.32)	2.33±0.43 (1.76-3.27)	14.39±4.26 (10.10-23.15)
6th	8.59±2.53 (5.99-16.13)	3.30±0.82 (2.26-5.79)	27.17±17.98 (17.54-95.19)
7th	10.17±1.76 (6.77-13.14)	3.66±0.96 (1.47-5.29)	33.55±12.79 (7.11-53.53)
8th	13.92±2.30 (11.16-15.83)	5.92±0.45 (5.46-6.54)	74.83±8.51 (62.88-81.32)
9th	11.15±0.82 (10.57-11.73)	6.30±2.21 (4.73-7.86)	49.30±16.24 (37.81-60.78)
p-value	0.001	0.001	0.001

APB-A: area of abductor pollicis; **APB-L:** length of abductor pollicis brevis; **APB-W:** width of abductor pollicis brevis.

Based on our literature review and dissections, the origin of the APB was classified into seven types (**Table 7**). In this study, we identified three different types related to the origin of the APB (**Figure 2**). Type 1 was the most common, observed in 44 sides (84.62%) (right: 23, left: 21; male: 17, female: 27). Type 2 was detected in six sides (11.54%) (right: 2, left: 4; male: 2, female: 4). Type 3 was the least common, found in two sides (3.84%) (right: 1, left: 1; male: 1, female: 0).

Based on our literature review and dissections the insertion of APB was classified into four types (**Table 8**). In this study, we identified three different types related to the insertion of the APB (**Figure 3**). Type A was the most common, observed in 40 sides (76.92%) (right: 20, left: 20, male: 17, female: 23). Type B was detected in nine sides (17.31%) (right: 4, left: 5, male: 4, female: 5). Type C was the least common, found in in three sides (5.77%) (right: 2, left: 1, male: 1, female: 2).

The linear function for APB length (APB-L) was calculated as $y=-1.738+0.454 \times$ weeks ($p<0.001$), for APB width (APB-W) as $y=-2.449+0.248 \times$ weeks ($p<0.001$), and for APB area (APB-A) as $y=-51.342+3.413 \times$ weeks ($p<0.001$) (**Figure 4**).

Discussion

Previous studies showed that developmental anomalies in the hand or forearm occur in approximately one in 600 newborns[1] and congenital muscle diseases have an estimated prevalence of 4.7 per 100,000 newborns.[10] The most crucial period for the development of hand anomalies is between 12 and 16 weeks of gestation.[1] During early human development, limb formation begins with the establishment of the limb's foundation within the somatopleure of the lateral plate mesoderm. This foundation typically forms around the 24th day after conception, with the initial emergence of upper limb projections occurring in the lower cervical area. Following the formation of the limb foundation, three interconnected signaling hubs regulate the spatial arrangement of the limb in three dimensions. The primary signaling hub controls the expansion of the limb from the shoulder to the hand. The second hub, known

Table 7
Description of types related to the origin of APB in the literature .

Type	Descriptions of types (attachment sites)	n (%)
1	Tubercle of scaphoid bone, flexor retinaculum	44 (84.62)
2	Flexor retinaculum	6 (11.54)
3	Tendon of abductor pollicis longus	2 (3.84)
4	Scaphoid bone	0
5	Flexor retinaculum and distal part of the fibrous sheath of the flexor carpi radialis tendon	0
6	Tendon of the palmaris longus	0
7	Absence of APB	0

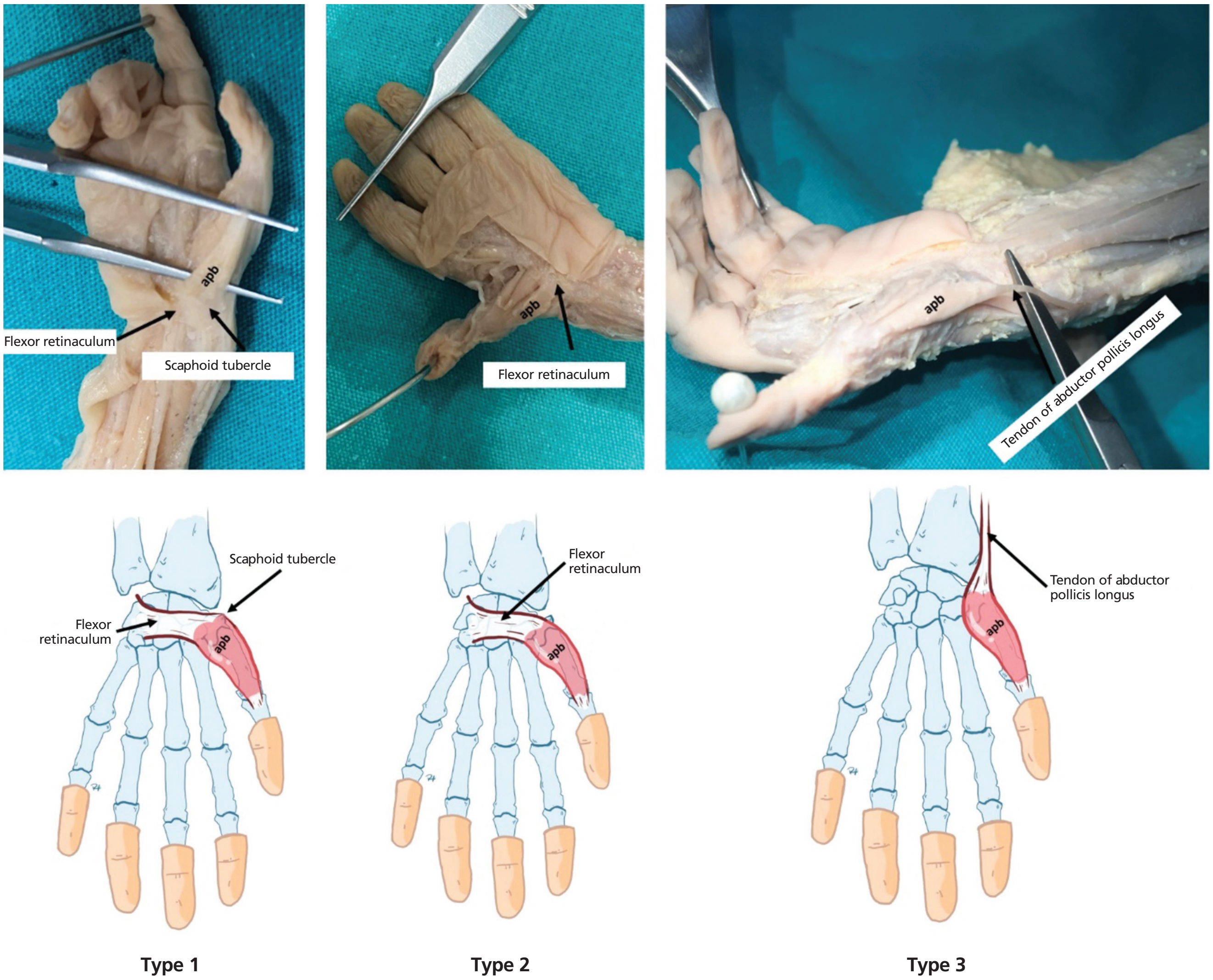

Figure 2. The types related to the origin of abductor pollicis brevis.

as the anteroposterior signaling center, governs growth from the index finger to the pinky finger. Disruptions in this axis can lead to digit anomalies, with polydactyly being an example of such a disruption. The third signaling hub, known as the dorsoventral center, directs growth from the upper side of the hand down to the palm. Interference with this signaling mechanism can result in the absence of certain fingers.[7] Anomalies in

Table 8
Description of types related to the insertion of APB in the literature.

Type	Descriptions of types (attachment sites)	n (%)
A	Lateral side of first metacarpophalangeal joint	40 (76.92)
B	Distal and lateral side of first metacarpal bone	9 (17.31)
C	Lateral side of first proximal phalanx	3 (5.77)
D	Absence of APB	0

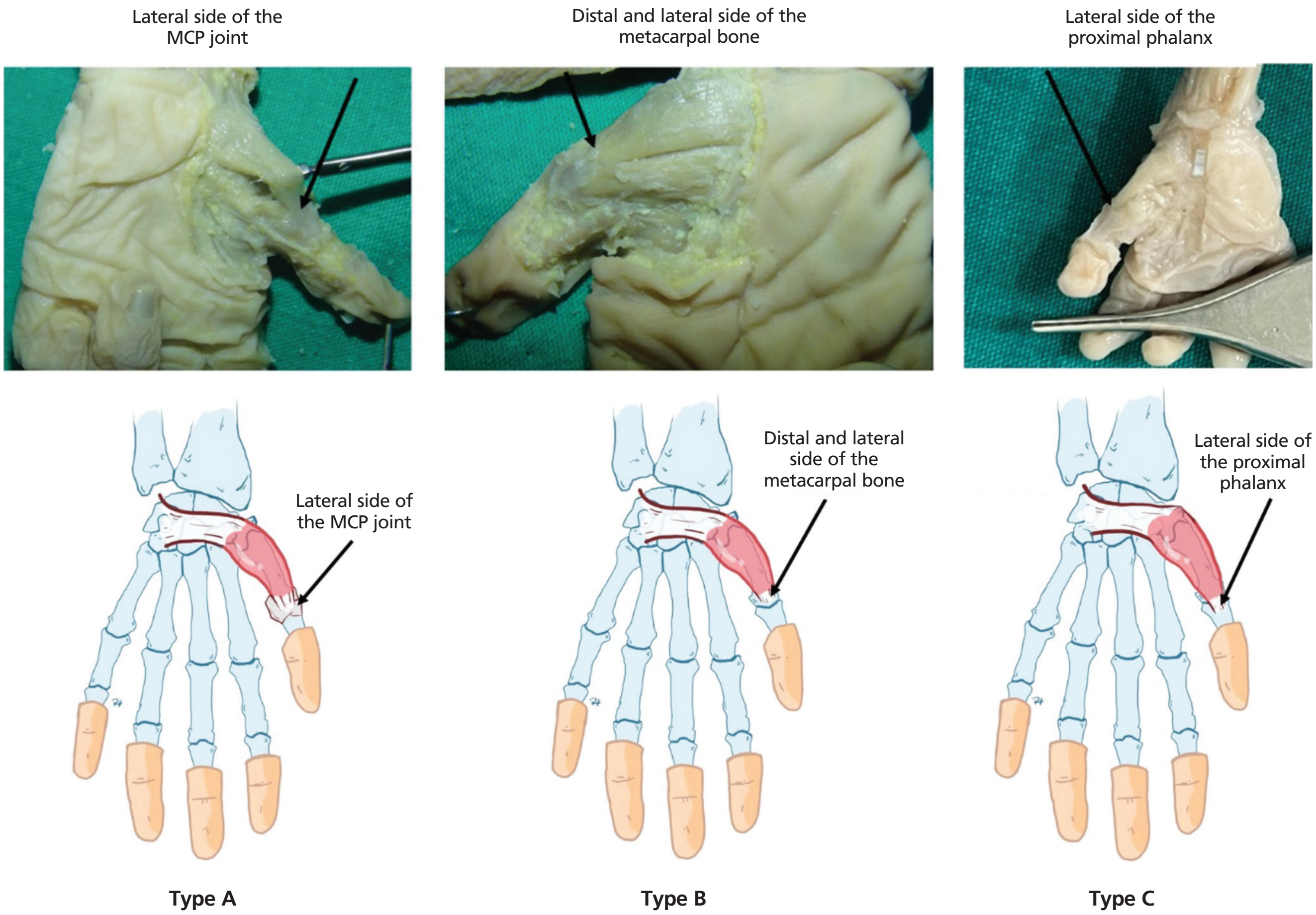

Figure 3. The types related to the insertion of abductor pollicis brevis.

the course of the APB have been reported in developmental thumb anomalies such as polydactyly and syndactyly.[3–4]

Several variations of the APB have been documented in the literature. These variations include absence of the muscle, double-headed muscle, triple-headed muscle with one head originating from the opponens pollicis, presence of the accessory slips (which may arise from the styloid process of the radius, scaphoid bone, abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus, adductor pollicis, flexor pollicis brevis, opponens pollicis, accessory extensor carpi radialis, extensor carpi radialis longus, or palmaris longus) and fusion with the abductor pollicis longus.[2,11–14] In a 3D reconstruction study performed on an 8-week-old embryo, it was found that the opponens pollicis, flexor pollicis brevis and abductor pollicis brevis develop from a common muscle belly.[11] Additionally, in some cases, APB may insert to the radial sesamoid of the metacarpophalangeal joint and the dorsal extensor tendon hood.[15] This specific insertion of the APB is particularly significant in tendon transfer procedures, which are used to restore thumb opposition in cases of loss.[16]

Knowing the incidence of these variations in human fetuses is important for surgeries performed around thenar region, especially in newborns.[3,4,17] For instance, Carpenter et al.[17] successfully excised an extra finger in a 9-day-old newborn with polydactyly. Saito et al.[8] reported a strong correlation between the insertion level of APB and the bifurcation level of the radial thumb in individuals with polydactyly. Additionally, some authors have noted that variant attachments of the APB in subjects with polydactyly.[3,4]

To better understand its potential attachment points, we developed two classification systems encompassing different configurations related to the origin and insertion of

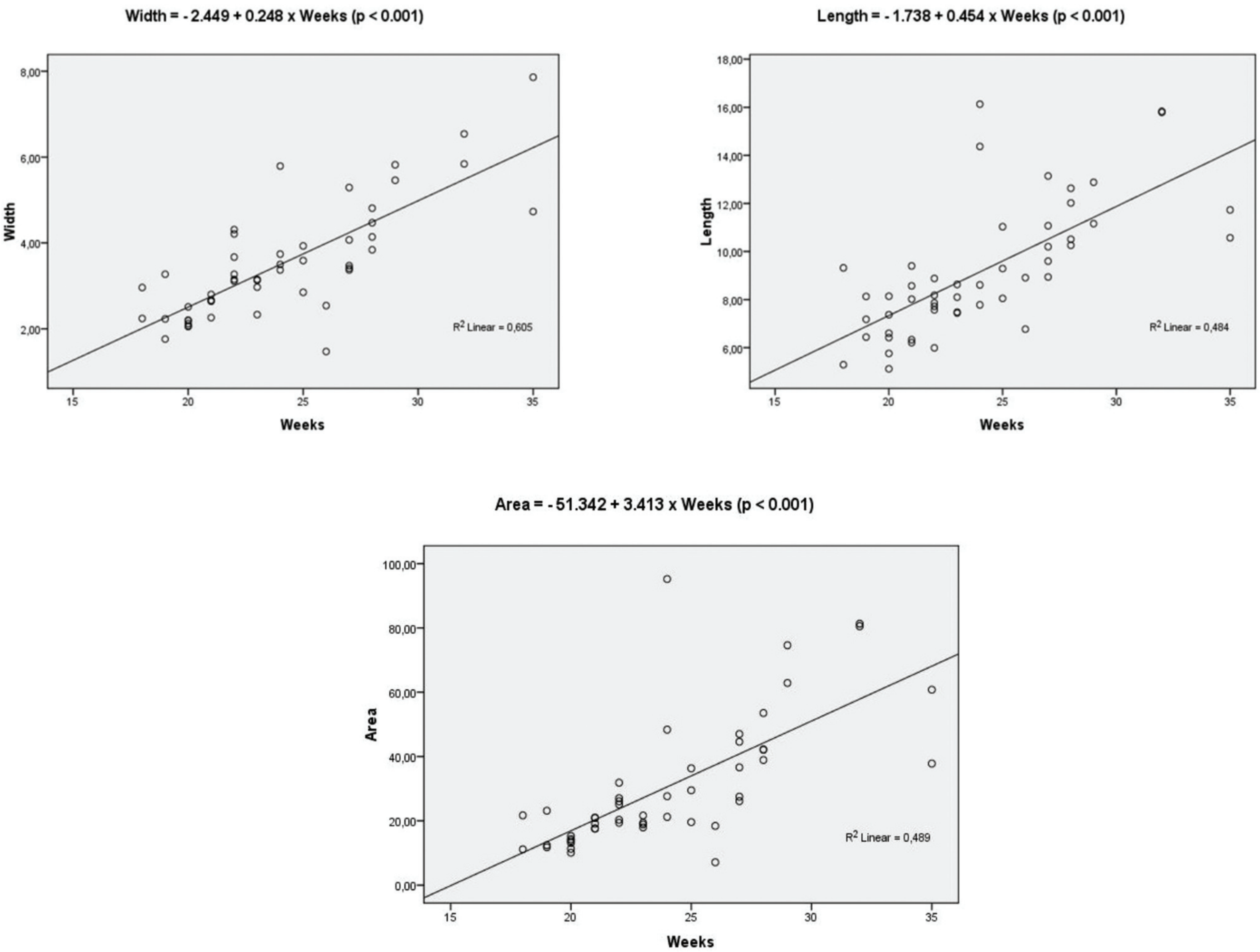

Figure 4. The linear function and scatter plots for the width, length and area of abductor pollicis brevis according to gestational weeks.

the muscle. Based on literature data, the origin and insertion of the APB were classified into seven and four types, respectively. These broad classification systems include all variations reported in previous studies. We then conducted a study on fetal subjects to determine the incidence of these types. In our findings, three different types related to the origin (Type 1 in 84.62% of sides, Type 2 in 11.54%, and Type 3 in 3.84%) and insertion (Type A in 76.92% of sides, Type B in 17.31%, and Type C in 5.77%) of the APB were observed. To the best of our knowledge, this study is the first to classify the origin and insertion of the APB in the literature. The classification we established for the origin of the APB may be particularly useful in surgical approaches, such as tendon transfer procedures for carpometacarpal joint osteoarthritis. In these procedures, which aim to stabilize the base of the first metacarpal bone, it is crucial to accurately determine the course and origin of the APB.[18,19] Our classification may provide valuable guidance in these types of surgeries.

In this study, the average APB area (APB-A), length (APB-L), and width (APB-W) were determined as 30.72 mm², 9.16 mm, and 3.53 mm, respectively. The morphometric characteristics of the muscle may be important for surgeons during procedures such as tendon transfer and muscle grafting.[5,18–21] For example, some authors have noted that underdeveloped thenar muscles can contribute to zigzag deformity of the thumb, and hypoplasia of the APB may lead to joint deformities.[20] In this study, the linear functions for APB-A, APB-L, and APB-W were calculated as follows: = -51.342+3.413

× weeks (p<0.001), y = -1.738+0.454 × weeks (p<0.001), and y = -2.449+0.248 × weeks (p<0.001), respectively. Considering the mean values and standard deviations from this study, these formulas may be particularly useful for estimating the size of the APB in fetuses.

This study does have some limitations. The number of fetal subjects was relatively small, so future studies with larger sample sizes could provide more comprehensive insights into the dimensions and variations of the APB, which may be beneficial for early childhood surgeries. Additionally, the anatomical features of the APB during the first trimester are important for understanding its embryonic development. In this study, the APB was observed to be distinguishable from the 15th week onward. However, the number of fetal samples in the first and third trimesters, particularly near term, was limited. Therefore, future studies should include anatomical examinations of fetal APB beyond 32 weeks to better inform early childhood surgeries. Further research in larger populations may provide more detailed information about the size and developmental patterns of the muscle.

Conclusion

The morphometric and morphological features of the APB are crucial for clinicians when performing surgical interventions around the thumb. To the best of our knowledge, this study is the first to classify the origin and insertion of the APB in human fetuses. Our classification systems may serve as a valuable guide for future studies, particularly those focused on thumb anomalies such as polydactyly and syndactyly in newborns, especially when conducted with larger sample sizes.

Conflict of Interest

The authors declare that they have no conflicts of interest.

Author Contributions

SSA: designed the research study, performed the research, analyzed the data and wrote the manuscript; SK: performed the research study; OB: designed the research study, contributed towards analytic tools, analyzed the data and wrote the manuscript; İB: designed the research study, performed the research, analyzed the data and wrote the manuscript; PK: manuscript writing and editing; MO: manuscript writing and editing. All authors have read and approve the final manuscript.

Ethics Approval

The study was conducted in accordance with the ethical rules of the Declaration of Helsinki and its later amendments.

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