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Morphometric properties of the tensor fascia lata muscle in human foetuses

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Background: *In neonatal and early childhood surgeries such as meningomyelocele repairs, closing deep wounds and oncological treatment, tensor fasciae lata (TFL) flaps are used. However, there are not enough data about structural properties of TFL in foetuses, which can be considered as the closest to neonates in terms of sampling. This study's main objective is to gather data about morphological structures of TFL in human foetuses to be used in newborn surgery.*

Materials and methods: *Fifty formalin-fixed foetuses (24 male, 26 female) with gestational age ranging from 18 to 30 weeks (mean 22.94 ± 3.23 weeks) were included in the study. TFL samples were obtained by bilateral dissection and then surface area, width and length parameters were recorded. Digital callipers were used for length and width measurements whereas surface area was calculated using digital image analysis software.*

Results: *No statistically significant differences were found in terms of numerical value of parameters between sides and sexes ($p > 0.05$). Linear functions for TFL surface area, width, anterior and posterior margin lengths were calculated as $y = -225.652 + 14.417 \times$ age (weeks), $y = -5.571 + 0.595 \times$ age (weeks), $y = -4.276 + 0.909 \times$ age (weeks), and $y = -4.468 + 0.779 \times$ age (weeks), respectively.*

Conclusions: *Linear functions for TFL surface area, width and lengths can be used in designing TFL flap dimensions in newborn surgery. In addition, using those described linear functions can also be beneficial in prediction of TFL flap dimensions in autopsy studies.* (Folia Morphol 2018; 77, 3: 498–502)

Key words: tensor fascia lata, linear functions, surface area, foetus

INTRODUCTION

Tensor fascia lata (TFL), a muscle in gluteal region, originates from the outer lip of the iliac crest, the anterolateral iliac fossa just below the iliac crest, the deep surface of the fascia lata, the iliac tubercle, the lateral aspect of the anterior superior iliac spine and a notch below the anterior superior iliac spine. TFL attaches to two layers of the iliotibial tract of the fascia lata and ends usually around the greater trochanter. It assists the medial rotation and abduction of thigh in addition to lateral rotation of leg by iliotibial tract [11, 12, 15, 27].

Flaps of TFL, which is short and straight, are not only widely used in a large number of applications in adults [6, 15, 19–21, 26], but also in early childhood surgeries as well [1, 20, 22]. Some of the applications where musculocutaneous or free-form flaps of TFL are used can be summarised as burn treatments [1], chest

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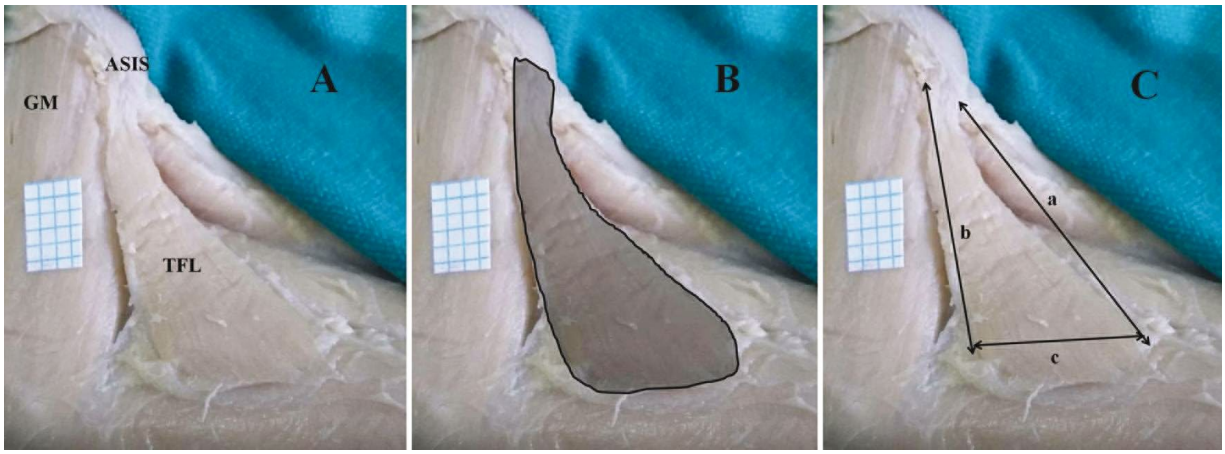

Figure 1. Tensor fascia lata (TFL) and measured parameters; **A.** TFL with millimetric scale; **B.** TFL surface area; **C.** TFL parameters: a — anterior margin; b — posterior margin; c — width (at widest level); ASIS — anterior superior iliac spine; GM — gluteus medius muscle.

and abdominal wall reconstruction [6, 21], correcting defects in head-neck region [3, 5, 9], treatment of oncology patients [7, 10, 24], meningomyelocele repair [22, 23], and correction of functional disorders of upper or lower extremities [16, 28].

In the literature, data about TFL structural properties in foetuses, which can be considered as the closest in resemblance to neonates, is quite limited. Our study's main objective is to define morphometric properties of TFL in foetal period and its growth dynamics to be used in neonatal surgery.

MATERIALS AND METHODS

Fifty foetuses (24 male, 26 female) with gestational age range from 18 to 30 weeks (mean 22.94 ± 3.23 weeks) present in Mersin University Faculty of Medicine Anatomy Department were included in the study and bilateral dissection was performed in each sample. Between 2000 and 2005, foetuses were donated to our department. There were limited documentary of the cause of death of foetuses. Therefore, foetuses with structural defects were excluded from this study. They were preserved in 10% formalin solution for more than 12 years. The study was approved by the Ethics Board of Medicine Faculty (2017/313). After positioning the foetuses in lateral decubitis, skin and fascias were lifted. TFL was exposed by microscope-aided (Carl Zeiss f-170) dissection. The following parameters were recorded (Fig. 1):

— TFL surface area;
— TFL lengths of the anterior and posterior margin (the distance between its origin and insertion);
— TFL width (at its widest level);
— TFL proximal attachment sites and attachment levels to iliotibial tract in distal plane.

As the reduction of plasticity was reported as 0.5–1% in the previous studies [8, 14], tissue shrinkage caused by formalin fixation was disregarded. All samples were photographed from the same distance in the same position with millimetric scales (LG) and surface area was calculated using digital image analysis software (Digimizer Software). The length and width parameters were measured using digital callipers with 0.01 mm precision. All the parametric measurements were performed by the same researcher (O.B.) under same conditions in three different dates and the mean value of measurements were calculated. One-way ANOVA test, post-hoc RIR Tukey tests and intra-class correlation coefficients (ICC) were used to assess intra-observer reproducibility. Gestational age was determined by measuring foot lengths according to Malas et al.'s study [18]. Normality controls were performed with the Shapiro-Wilk test. Gestational age (months) was used in comparison of sides and sexes. Paired sample t-test was used for comparing sides and independent sample-t test was used to compare sexes. Homogeneity of variances was tested using Levene test. One-way ANOVA and Bonferroni tests were used to compare the changes with gestational age (months) in surface area and morphometric data on length and width. Simple linear regression analysis was used to calculate the regression equations which showed the relationship of changes in morphometric data with respect to gestational age (weeks). Statistical significance level was set as $p < 0.05$.

RESULTS

Table 1 summarises the demographic values of foetuses included in the study. All sides had TFL (Fig. 1).

Table 1. Data related to age, number and sex of foetuses

Gestational age		Foot length [mm]	Number of side	Number of sexes	
Months	Weeks			Male	Female
V	18	25.55 ± 0.28	6	2	1
	19	27.98 ± 0.27	8	2	2
	20	30.72 ± 0.26	14	1	6
VI	21	32.80 ± 0.20	10	2	3
	22	34.50 ± 0.30	12	5	1
	23	38.65 ± 0.33	12	2	4
	24	40.71 ± 0.36	8	3	1
VII	25	41.89 ± 0.49	6	2	1
	26	45.56 ± 0.36	6	1	2
	27	48.42 ± 0.44	8	2	2
	28	52.01 ± 0.28	4	1	1
VIII	29	53.30 ± 0.11	2	1	0
	30	54.57 ± 0.59	4	0	2
Total			100	24	26

Table 2. Morphometric data related to tensor fascia lata considering the gestational months

Parameters	V month (n = 28)	VI month (n = 42)	VII month (n = 24)	VIII month (n = 6)	Total (n = 100)	p
Surface area [mm^2]	58.45 ± 19.35	94.14 ± 22.46	150.92 ± 33.19	215.75 ± 17.71	105.07 ± 50.01	< 0.001
Length of anterior margin [mm]	13.09 ± 2.67	16.24 ± 2.15	19.45 ± 2.94	19.58 ± 1.37	16.57 ± 3.69	< 0.001
Length of posterior margin [mm]	10.70 ± 2.81	12.89 ± 2.38	16.37 ± 2.67	17.58 ± 1.58	13.39 ± 3.41	< 0.001
Width (the its widest level) [mm]	5.95 ± 1.28	7.85 ± 1.68	9.91 ± 0.96	12.06 ± 0.71	8.06 ± 2.22	< 0.001

No statistically significant difference was found in the assessment of intra-observer reproducibility of numerical values of TFL ($p > 0.05$). In addition, ICC score for TFL parameters was calculated as ICC 0.996–0.999 ($p < 0.001$) which shows an excellent intra-observer reproducibility. As TFL surface area, width and length did not show a statistically significant difference between the sides and sexes ($p > 0.05$), numerical values were summarised in Table 2, according to gestational months. Figures 2 and 3 present the regression graphs and equations which show the parameter changes with gestational weeks. Linear functions for TFL surface area, width, anterior and posterior margin lengths were calculated as $y = -225.652 + 14.417 \times$ age (weeks), $y = -5.571 + 0.595 \times$ age (weeks), $y = -4.276 + 0.909 \times$ age (weeks) and $y = -4.468 + 0.779 \times$ age (weeks), respectively. Anterior margin of TFL was found to be longer than posterior margin ($p < 0.001$). TFL attached to the lateral aspect of the anterior superior iliac spine and a notch below it by tendinous fibres and the deep surface of fascia lata in proximal plane. In distal plane, TFL joined iliotibial tract under greater trochanter on the upper 1/3 area of thigh.

DISCUSSION

In this study, we obtained precious data regarding the morphometric properties of TFL in foetuses to be used in neonatal surgery, which is quite limited in the literature. We revealed the algebraic change of TFL in foetuses between 18^{th} and 30^{th} weeks of gestational age.

Tensor fascia lata flaps are used in closing deep wounds, meningomyelocele repairs and treatment of oncology patients during the early term of life [7, 20, 22–24]. Akyürek and Şafak [1] treated a 12-month-old male with a burn on his right arm using TFL flap. Ohno et al. [20] used TFL flap in treatment of rhabdomyosarcoma in pelvic region in a 10-month-old male patient and reported no complications or function loss. Phillips and Lindseth [22] retrospectively reviewed 47 meningomyocele patients with a mean age of 4.6 years and reported that 41 were treated

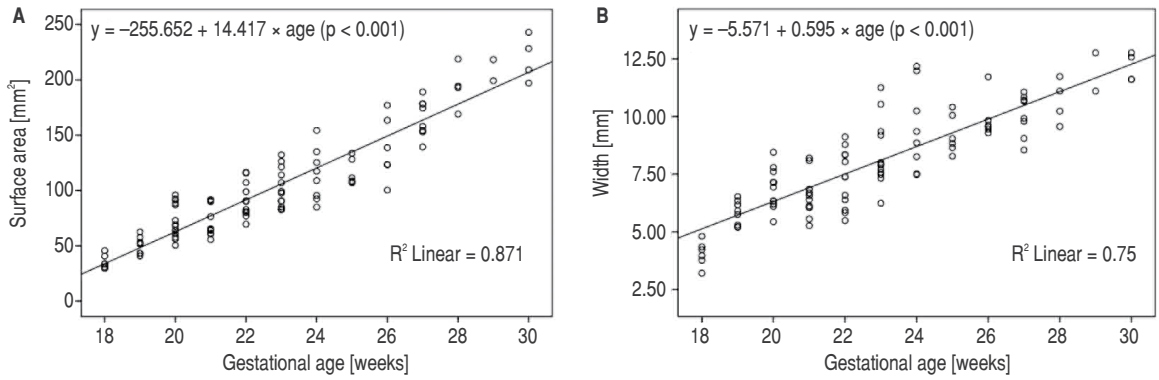

Figure 2. Linear regression lines; **A.** Tensor fascia lata (TFL) surface area; **B.** The width of TFL.

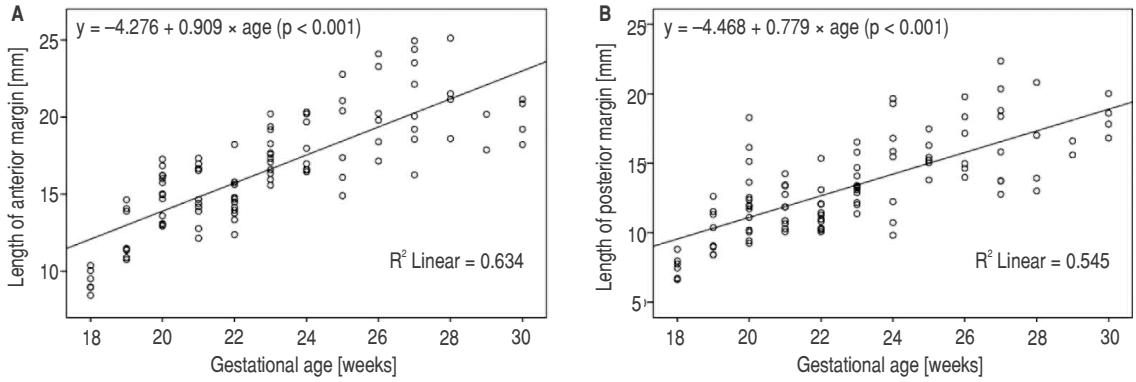

Figure 3. Linear regression lines; **A.** Length of anterior margin; **B.** Length of posterior margin.

using the external oblique, the adductors and TFL (triple transfer) method. However, the authors also reported that the remaining 6 patients were treated with a double transfer of the external obliques and the adductors due to insufficient TFL tissue [22]. Since it's known that burns, congenital malignant tumours or meningomyelocele can be seen during neonatal period and TFL flaps can be used in the treatment of those conditions [10, 22, 23], the importance of defining algebraic anatomy and variations of TFL becomes clear for neonatal surgery. In our study, TFL was present in all sides without any exceptions. As the numerical data of TFL showed no statistically significant difference between sides, TFL flaps on both sides can be used in treatment of conditions where TFL free tissue flaps are used. As expressed in Beger et al.'s study [4] on latissimus dorsi muscle, TFL regression equations can be used in designing TFL flap dimensions, especially in treatment of conditions such as meningomyelocele.

Although literature reported a number of differences in many muscle growth dynamics between foetuses [2, 4, 13, 14, 17, 25], no quantitative studies on TFL were found. In accordance with the previous study results on morphometric properties of different muscle groups [2, 4, 13, 14, 17], this study revealed a rational increase in numerical values of TFL surface area, width and lengths from 18th to 30th week and showed no statistically significant difference between sides and sexes.

Proximal and distal attachment points of TFL show variety [11, 12, 15, 27]. In our study, we showed that TFL originates from the deep surface of the fascia lata and lateral aspect of the anterior superior iliac spine and a notch below it in proximal plane by tendinous fibres. In distal plane, TFL joined iliotibial tract under greater trochanter on the upper 1/3 area of thigh. Our data related to attachment points of TFL showed greatly coherent with previous studies [11, 12, 15, 27].

CONCLUSIONS

The algebraic values of TFL surface area, width and lengths showed a rational increase from 18th to 30th week and no statistically significant difference between sides and sexes. Linear function of surface area, which was calculated as "y = –225.652 + 14.417 × age (weeks)", can be used in designing TFL flap dimensions in neonatal surgeries. Using linear functions to approximate TFL flap dimensions can be beneficial in autopsy studies.

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