Telocytes are associated with uterine remodeling during pregnancy in Kyrgyz mares

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ABSTRACT

The relationship between telocytes and the changes occurring in the morphometric structure of the uterus during pregnancy has not yet been sufficiently clarified. This study was conducted to evaluate the relationship between pregnancy-related morphometric changes in the uteri of Kyrgyz mares and telocyte counts. A total of 53 mares, both pregnant and non-pregnant, aged 2-6 months, were examined; uterine tissues were analyzed using light microscopy and immunohistochemical methods. In general, a positive relationship was found between gland density and telocyte count, while in non-pregnant mares, this relationship was found to be inversely and significantly correlated. A negative correlation between gland diameter and telocyte count was detected in many groups, particularly in the 5-month pregnancy group. Furthermore, a positive correlation was found between endometrial thickness and both myometrial and total telocyte counts in 6-month pregnant mares. Consequently, it is thought that telocytes are associated with structural changes in the uterus during pregnancy and may play an important role in the remodeling and functional adaptation of the uterus, particularly in the later stages of pregnancy.

Key words: morphometric; uterus; Kyrgyz; mare; telocytes; pregnancy.

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Introduction

Telocytes are a specialized type of interstitial cell characterized by distinct cellular extensions containing thin segments (podomers) and dilations (podomes) found in various organs, including the uterus.[1,2] Telocytes interact with various cells and structures, but their roles in regulating the function of many cell types remain unclear. However, it is known that telocytes play an important role both in maintaining tissue organ integrity and in the pathophysiology of many diseases, particularly cancer. They establish homo- or heterocellular contacts to form a three-dimensional network structure *via* telopods and transmit signaling molecules to the vascular, nervous, and endocrine systems *via* juxtacrine and/or paracrine junctions through budding vesicles. During this interaction, they transfer mRNA, microRNA, long non-coding RNA, and genomic DNA along with organelles.[3] Shortly after the morphological and functional characterization of telocytes, it became apparent that their roles in tissue regeneration and repair would be common to most organs. Campeanu *et al*.[4] suggested that the different responses of telocytes obtained from pregnant and non-pregnant uteri to low-level laser stimulation indicate that telocytes obtained from pregnant uteri may be involved in regeneration.

A study examining the distribution, organization, and morphometric measurements of telocytes in different layers of the adult bovine oviduct reported that these cells are scattered in the lamina propria, muscle layer, and serosa, and that different telocyte types (small, large, and giant telocytes) exist according to their size. The same study indicates that small telocytes are the most common type and are found in all layers, large telocytes are observed in the epithelium, lamina propria, and inner/outer perimuscular and intramuscular sheaths, and giant telocytes are located in the outer layer of the outer perimuscular sheath.[1] Uterine telocytes are reported to exhibit characteristics similar to those found in the oviduct, expressing oestrogen and progesterone receptors, thereby acting as hormone sensors. Therefore, it is suggested that telocytes regulate hormone-dependent changes associated with the endometrial cycle, pregnancy, and motility.[5,6]

In a situation where telocytes are functionally or morphologically destroyed, it has been suggested that numerous diseases may develop, including premature ovarian failure, endometriosis, ectopic pregnancy, infertility, pre-eclampsia, and even breast cancer.[7]

In mares, the endometrium has a glandular and secretory structure. Structural or functional abnormalities in the endometrial glands pose a serious risk to the continuation of pregnancy. It is accepted that the marked hyperplasia and hypertrophy of the endometrial glands during pregnancy is a physiological response to the increased histotrophic needs of the developing embryo. However, pathologies such as glandular inactivity, irregular glandular differentiation, or periglandular fibrosis in mares can lead to serious reproductive problems ranging from infertility to abortion.[8-10]

The present study planned to investigate the morphometric values in the uteri of Kyrgyz mares and to determine the correlation of the telocytes with pregnancy status.

Materials and Methods

The present study was conducted on 53 Kyrgyz mares aged 3-5 years located in Bishkek, Kyrgyzstan. The experimental protocols were reviewed and approved by the Kyrgyzstan-Turkey Manas University Animal Ethics Committee (Approval No: 2023/05). The animals included in the study were clinically healthy mares selected from among those living in Bishkek and its surroundings since birth. The tissues required for the study were obtained from animals slaughtered at the abattoir. The mares used as material were divided into 6 groups based on their pregnancy status and gestation periods. The groups were formed as follows: Group 1 (n=10) consisted of non-pregnant mares, Group 2 (n=10) consisted of two-month pregnant animals, Group 3 (n=9) consisted of three-month pregnant animals, Group 4 (n=5) consisted of four-month pregnant animals, Group 5 (n=10) consisted of five-month pregnant animals, and Group 6 Group (n=9) comprised six-month pregnant animals.

Uterine samples were collected postmortem from all mares. The tissues samples were fixed in 10 % buffered neutral formalin solution for 24 h, routinely processed, embedded in paraffin, and cross sections were stained with hematoxylin eosin (H&E) subsequently examined under a light microscope. Histomorphometric analyses of uteri from non-pregnant mares and mares at various stages of gestation were conducted using a digital imaging system consisting of a camera (Olympus DP72, Tokyo, Japan) integrated with image analysis software (cellSens Standard) on a light microscope (Olympus BX43). All measurements were performed in accordance with the methodology described by Silva *et al*.,[11] and the data published previously.[12] Briefly, endometrial thickness was assessed using a 4X objective lens by measuring the distance between the luminal endometrial epithelium and the submucosa in 10 randomly selected fields. Glandular density within the propria mucosa was determined by counting the number of glands in 10 randomly selected fields at 40X magnification. Glandular epithelial height and glandular diameter within the propria mucosa were evaluated using a 100X objective lens. The glandular epithelial height, defined as the distance from the basal lamina to the apical surface, was measured in 10 randomly selected fields. Glandular diameter was determined by recording two perpendicular measurements for each gland across 10 randomly selected fields, and the mean values were calculated.

Immunohistochemical staining method

Sections taken from paraffin blocks were also stained immunohistochemically using the Avidin-Biotin Peroxidase Complex (ABC) method. Positively charged slides were subjected to deparaffinization and rehydration, followed by antigen retrieval by boiling in a citrate buffer solution in a microwave oven for 20 min. The sections were then incubated in a 3% hydrogen peroxide solution for 10 min to inactivate endogenous peroxidase. To prevent non-specific antibody binding, sections were spotted with blocking serum (Ultra V Block) and incubated for 10 minutes. Sections were incubated with primary antibodies against CD117 (Mouse anti CD117 (C kit) monoclonal antibody, Invitrogen MA5-12944; Thermo Fisher Scientific, Waltham, MA, USA). Using an anti-rabbit, anti-mouse compatible ABC kit, they were first treated with a biotinylated secondary antibody (UltraVision Detection System Anti-Polyvalent, HRP/DAB; Thermo Fischer Scientific) and then with peroxidase-conjugated streptavidin for 30 min. Non-immune serum served as negative control, whereas malignant melanoma tissue sections obtained from our archive were used as positive controls. The sections were stained with 3-Amino-9-Ethylcarbazole (AEC) chromogen (Ultra Vision AEC Substrate System; Thermo Fischer Scientific). After counterstaining with Mayer's hematoxylin, the sections were covered with mounting

medium and examined under a light microscope. So far, no immunohistochemical marker specifically identifies telocytes. Nevertheless, CD117 has been reported to exhibit relatively higher specificity, particularly in organs of the female genital system,[7,13-16] and has therefore been utilized for telocyte identification and quantitative assessment.[13,14,17] In the present study, cells exhibiting CD117 immunopositivity and characteristic telocyte morphology, namely triangular, stellate, or spindle/needle-shaped profiles, were considered telocytes. For each case, CD117-positive telocytes were counted in five randomly selected microscopic fields.[18]

The data obtained were then statistically analyzed according to whether the mare was pregnant or not, and if pregnant, according to the month of pregnancy.

Statistical analyses

In this study, statistical analyses were performed to determine the relationships between the examined endometrial thickness (µm), gland density (number), gland epithelial height (µm), and gland diameter (µm), the number of telocytes in the proprium (number), the number of telocytes in the myometrium (number), and the total number of telocytes in the uterus (number) were calculated using Spearman and Pearson correlation coefficients, and the significance of these coefficients was determined.[19,20] The significance level in statistical tests was set at $p<0.05$. Calculations and statistical analyses were carried out using SPSS (version 22.0; SPSS Inc., Chicago, IL, USA).

Results

Immunohistochemical staining revealed spindle shaped, telocyte-like CD117-specific positive cells in the periglandular and perivascular areas of the uterine propria mucosa (Figure 1A). Also in the muscular layer, CD117-positive cells were also found in the muscle layer of the uterus (Figure 1B). In this study, the correlation coefficients between the morphometric values of the uterus and the telocyte counts are presented in Table 1. Considering the correlation coefficients between the morphometric values of the uterus and the number of telocytes, the relationships between endometrial thickness and glandular epithelial height in mares and the number of telocytes in the propria were generally not found to be statistically significant ($p>0.05$). However, a positive correlation ($p<0.01$) (0.204) was determined between gland density in the uterus and telocyte counts in the propria mucosa. When the relationship between these two parameters was examined separately for each group, contrary to the finding determined in the general evaluation, a negative significant ($p<0.01$) correlation (0.458) was found only in group 1, which consisted of non-pregnant mares. For the other groups, the correlations between these two parameters were not significant ($p>0.05$). Negative and significant ($p<0.01$) correlations (-0.215 and -0.464, respectively) were detected between gland diameters and telocyte counts in the proprium, both overall and in mares in the 5th group. When examining the relationships between the morphometric values of the uterus and the num-

Table 1. Correlation coefficients between the morphometric values of the uterus and telocyte counts.

Groups		Telocyte counts (number)		
		Propria	Myometrium	Uterus
1	Endometrial thickness (µm)	0.018	-0.128	-0.043
	Glandular density (count)	-0.458**	-0.124	-0.408**
	Glandular epithelial height (µm)	-0.272	-0.577**	-0.510**
	Glandular diameter (µm)	-0.278	-0.194	-0.341*
2	Endometrial thickness (µm)	-0.008	0.132	0.135
	Glandular density (count)	-0.049	-0.169	-0.115
	Glandular epithelial height (µm)	0.114	0.044	0.139
	Glandular diameter (µm)	0.253	-0.044	0.143
3	Endometrial thickness (µm)	0.041	-0.048	0.083
	Glandular density (count)	0.233	-0.278**	0.038
	Glandular epithelial height (µm)	-0.030	0.076	0.062
	Glandular diameter (µm)	0.023	0.344**	0.135
4	Endometrial thickness (µm)	-0.063	0.143	0.087
	Glandular density (count)	-0.085	0.226	0.142
	Glandular epithelial height (µm)	0.097	0.083	0.143
	Glandular diameter (µm)	0.017	0.109	0.095
5	Endometrial thickness (µm)	-0.061	-0.253	-0.152
	Glandular density (count)	-0.024	0.006	0.023
	Glandular epithelial height (µm)	0.127	-0.008	0.071
	Glandular diameter (µm)	-0.464**	-0.388**	-0.500**
6	Endometrial thickness (µm)	0.193	0.296**	0.316**
	Glandular density (count)	-0.015	-0.083	-0.070
	Glandular epithelial height (µm)	0.024	-0.011	0.018
	Glandular diameter (µm)	0.173	0.300*	0.291*
General	Endometrial thickness (µm)	-0.021	0.020	0.032
	Glandular density (count)	0.204**	0.111**	0.194**
	Glandular epithelial height (µm)	-0.051	-0.010	0.001
	Glandular diameter (µm)	-0.215**	-0.102	-0.193**

*$p<0.05$, **$p<0.01$.

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ber of telocytes in the myometrium in general, only a positive significant correlation (p<0.01) between gland density and telocyte count (0.111) was calculated. When examined by group, a negative relationship was determined in Group 3 (-0.278, p>0.01). In terms of epithelial height, a negative significant correlation was determined only in Group 1. When considering gland diameters and telocyte counts in the myometrium, positive correlations (0.344 and 0.300, respectively) were found in Groups 3 and 6, while a negative correlation (-0.388) was found in Group 5, all statistically significant (p<0.05-p<0.01). In terms of endometrial thickness, a statistically positive correlation between these two parameters was only determined in Group 6 (0.296, p<0.01). A significant (p<0.01) negative correlation was determined between the total telocyte counts in the uterus and the gland density and gland epithelial height of non-pregnant mares (-0.408, 0.510, respectively), while in pregnant mares, a similar negative correlation (p<0.01) was determined only for gland diameter (-0.500) in 5-month pregnant mares. However, a significant (p<0.01 and p<0.05, respectively) positive correlation (0.316 and 0.291, respectively) between total telocyte numbers in the uterus and endometrial thickness and gland diameter was only observed in 6-month pregnant mares.

The correlation coefficients between the numbers of telocytes in the uterine propria and myometrium and between their morphometric values are presented in Table 2. A significant (p<0.01, p<0.05, respectively) positive correlation (0.362, 0.330, respectively) between the numbers of telocytes in the uterine propria and myometrium was determined only in 5- and 6-month pregnant mares. A significant (p<0.01) positive correlation (0.352) was determined between endometrial thickness and gland density in 2-month pregnant mares, while a significant (p<0.05) negative correlation (-0.330) was observed in 4-month pregnant mares. A significant (p<0.05) positive correlation (0.271) between glandular epithelial height and endometrial thickness was observed only in 3-month pregnant mares. A significant (p<0.05) positive correlation (0.3290) was determined between gland diameter and gland density in non-pregnant mares, while a significant (p<0.01) negative correlation (-0.353) was determined in 3-month pregnant mares. Furthermore, a significant (p<0.05) negative (-0.311) correlation between gland diameter and endometrial thickness was found in 3-month pregnant mares, while a significant (p<0.01) positive (0.398) correlation was found in 6-month pregnant mares. When evaluated generally without considering groups, significant positive correlations were observed between the number of telocytes in the uterine propria and myometrium, endometrial thickness and glandular epithelial height, and endometrial thickness and glandular diameters (0.298, 0.179, 0.225 and 0.130, respectively), while significant negative correlations were observed between endometrial thickness and gland density, gland density and gland epithelial height, and gland epithelial height and gland diameter (-0.155, -0.155, and -0.490, respectively) were determined.

Discussion

Telocytes are a unique type of interstitial cell that is attracting increasing attention due to their distinctive morphology and potential roles in tissue homeostasis, regeneration, and intercellular communication.[21] The most distinctive feature of telocytes is their unique morphology, characterized by a small cell body and extremely long, thin cytoplasmic extensions known as telopods, a feature that can only be revealed by electron microscopy. Therefore, transmission electron microscopy remains the gold standard for the identification of telocytes.[22,23] Immunohistochemically, telocytes commonly express CD117, CD34, α-smooth muscle actin, estrogen receptor and progesterone receptor and vimentin, although none of these markers are exclusive to telocytes.[7,13-16] Among these immunohistochemical markers, CD117 has been reported to be particularly useful in certain organs, notably those of the female genital system,[13,14,17] where it facilitates the visualization and quantification of telocytes as seen in this study. It has been reported that telocytes are present in the endometrium and myometrium of the rat uterus and that they ensure the continuation of pregnancy by regulating uterine con-

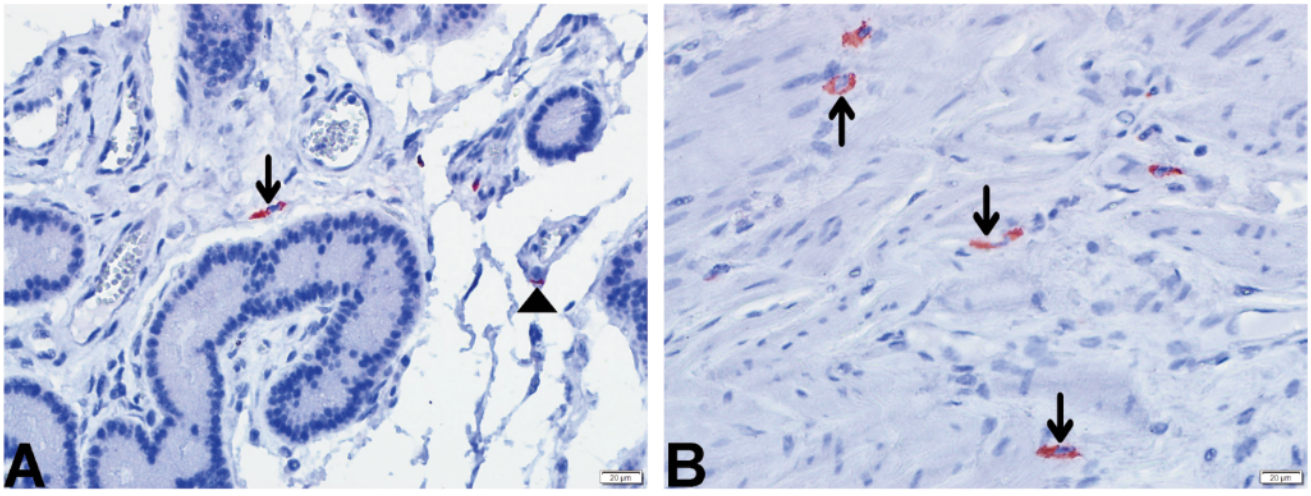


Figure 1. Representative microscopic images of mare uteri immunohistochemically stained with the CD117 antibody. **A**) In a four-month-pregnant mare, telocyte-like, spindle-shaped cells showing specific CD117 immunoreactivity are observed in the periglandular (arrow) and perivascular (arrowhead) regions of the endometrial propria mucosa. **B**) In a non-pregnant mare, CD117-positive cells (arrows) are localized within the muscularis layer of the uterus. ABC method, AEC chromogen, Mayer contrasting staining.

tractions and preventing premature birth.[2] A study analyzing the distribution and morphological changes of telocytes in the endometrium of the rabbit uterus during different stages of pregnancy reported that these cells gradually increase with the progression of pregnancy. The same study suggested that telocytes interact with glandular epithelium, blood vessels, and immune cells such as lymphocytes, neutrophils, and macrophages, as well as decidual cells.[24] Consequently, they may play an important role in maternal placenta formation, particularly in decidualization, in regulating uterine gland development, and in the neovascularization of maternal uterine blood vessels. It is suggested that the increase in the number of telocytes in the endometrium during pregnancy contributes to pregnancy-related endometrial changes, such as the decidual reaction. On the other hand, it is suggested that the decrease in the number of myometrial telocytes during pregnancy prevents pathological contractions and premature birth.[17] A study has demonstrated that endometrial telocytes influence various physiological properties of endometrial stromal cells, such as proliferation, adhesion, and motility.[25] Another study indicated that myometrial telocytes may play a role in regulating myometrial contractility.[26] A study presenting the first data on the pregnancy-related morphological characteristics of uterine glands in Kyrgyz mares reported significant changes in the histological structure of the endometrium throughout pregnancy. As pregnancy progressed, endometrial thickness, glandular epithelial height and diameter increased, while glandular density decreased. The same study suggested that these changes are physiological adaptations related to embryo nutrition and the adaptation of the uterine environment to pregnancy.[12] Risvanli *et al*.[18] reported that pregnant mares have more telocytes in their genital organs than non-pregnant mares, and that this number increases further as pregnancy progresses. They suggested that further publications on the roles telocytes play in pregnancy in mares and other species would be beneficial. Despite all the investigations performed, no publications have been found regarding the determination of the correlation between the morphometric values in the uteri of pregnant mares and telocytes according to pregnancy status. The presented study revealed that significant changes occurred in telocyte counts and uterine morphometric parameters in the uteri of Kyrgyz mares during pregnancy. The fact that telocytes show meaningful correlations with structural features such as gland density, gland diameter, and endometrial thickness, particularly during certain stages of pregnancy, sug-

Table 2. Correlation coefficients between telocyte counts in the uterine propria and myometrium and between their morphometric values.

	Myometrial telocyte (count)	Glandular density (count)	Glandular epithelial height (µm)	Glandular diameter (µm)
Group 1				
Propria telocyte count	0.205			
Endometrial thickness (µm)		0.136	0.248	-0.148
Glandular density (count)			0.041	0.329*
Glandular epithelial height (µm)				0.213
Group 2				
Propria telocyte count (number)	-0.131			
Endometrial thickness (µm)		0.352**	-0.005	-0.087
Glandular density (count)			0.146	-0.063
Glandular epithelial height (µm)				0.026
Group 3				
Propria telocyte count	-0.218			
Endometrial thickness (µm)		0.156	0.271*	-0.311*
Glandular density (count)			-0.224	-0.353**
Glandular epithelial height (µm)				-0.070
Group 4				
Propria telocyte count	-0.149			
Endometrial thickness (µm)		-0.330*	0.149	0.160
Glandular density (count)			0.020	0.074
Glandular epithelial height (µm)				-0.092
Group 5				
Propria telocyte count	0.362**			
Endometrial thickness (µm)		0.144	0.050	0.030
Glandular density (count)			-0.162	-0.164
Glandular epithelial height (µm)				-0.017
Group 6				
Propria telocyte count	0.330*			
Endometrial thickness (µm)		-0.105	0.057	0.398**
Glandular density (count)			-0.014	-0.127
Glandular epithelial height (µm)				0.049
General				
Propria telocyte count	0.298**			
Endometrial thickness (µm)		-0.155**	0.179**	0.225**
Glandular density (count)			-0.155**	-0.490**
Glandular epithelial height (µm)				0.30*

*p<0.05, **p<0.01.

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gests that these cells contribute to the remodeling of the uterus, the maintenance of tissue integrity, and the continuation of pregnancy throughout gestation. Furthermore, the increasing correlation between telocytes in the proprium and myometrium during the later months of pregnancy supports the idea that telocytes play an active role in pregnancy-specific physiological adaptations.

Previous studies in other species suggest that uterine telocytes may change during late pregnancy and after parturition. In rats, myometrial telocytes decrease during pregnancy and increase again postpartum, suggesting a possible role in uterine contractility and involution.[17,27] In humans, telocytes have also been associated with the regulation of myometrial activity during pregnancy and labour.[28] However, comparable data for mares, particularly after the sixth month of gestation and around parturition, are lacking. Therefore, the behavior of telocytes during late equine pregnancy and their possible role in uterus-placenta remodeling before parturition remains to be elucidated.

In conclusion, it is believed that telocytes may be an important cellular component in the regulation of equine pregnancy and should therefore be considered as a new target cell group in future research on reproductive biology and fertility.

References

1. Abd-Elhafeez HH, Soliman SA. New description of telocyte sheaths in the bovine uterine tube: An immunohistochemical and scanning microscopic study. Cells Tissues Organs 2017;203:295-315.
2. Al-Zahraa AF, Mahmoud ES, ElNabawy RM. Uterine rat telocyte structure and organization: An immunohistochemical and ultrastructural study. Egypt J Histol 2023;46:1342-52.
3. Babadag S, Çelebi-Saltik B. A cellular regulator of the niche: Telocyte. Tissue Barriers 2023;11:2131955.
4. Campeanu RA, Radu BM, Cretoiu SM, Banciu DD, Banciu A, Cretoiu D, et al. Near-infrared low-level laser stimulation of telocytes from human myometrium. Lasers Med Sci 2014;29:1867-74.
5. Cretoiu D, Ciontea SM. Popescu LM, Ceafalan L, Ardeleanu C. Interstitial Cajal-like cells as steroid hormone sensors in human myometrium: Immunocytochemical approach. J Cell Mol Med 2006;10:789-95.
6. Roatesi I, Radu BM, Cretoiu D, Cretoiu SM. Uterine telocytes: A review of current knowledge. Biol Reprod 2015:93;10.
7. Klein M, Csöbönyeiová M, Danišovič Ľ, Lapides L, Varga I. Telocytes in the female reproductive system: Up-to-date knowledge, challenges and possible clinical applications. Life 2022;12:267.
8. Schoon HA, Schoon D, Wiegandt I, Bartmann CP, Aupperle H. Endometrial maldifferentiation - A clinically significant diagnosis in equine reproduction? Pferdeheilkunde 1999;15:555-9.
9. Schoon HA, Wiegandt I, Schoon D, Aupperle H, Bartmann CP. Functional disturbances in the endometrium of barren mares: A histological and immunohistological study. J Reprod Fertil Suppl 2000;56:381-91.
10. Gray CA, Taylor KM, Ramsey WS, Hill JR, Bazer FW, Bartol FF, et al. Endometrial glands are required for preimplantation conceptus elongation and survival. Biol Reprod 2001;64:1608-13.
11. Silva ESM, Leite RO, Maciel LFS, Francia C, Padovani CR, Oliveira-Filho JP, et al. Endometrial histomorphometry of anestrous mares under the influence of different embryo transfer hormonal protocols. J Equine Vet Sci 2019;81:102792.
12. Risvanli A, Salykov R, Timurkaan N, Seker I, Ekinci E. Changes in uterine glandular histology in Kyrgyz breed mares according to pregnancy status. Anat Histol Embryol 2026;55:e70078.
13. Klein M, Urban L, Deckov I, Danisovic S, Polak S, Danihel L, et al. Distribution of telocytes in the corpus and cervix of human uterus. Biologia 2017;72:1217-23.
14. Othman ER, Elgamal DA, Refaiy AM, Abdelaal II, Abdel-Mola AF, Al-Hendy A. Identification and potential role of telocytes in human uterine leiomyoma. Contracept Reprod Med 2016;1:12.
15. Urban L, Miko M, Kajanova M, Bozikova S, Mrazova H, Varga I. Telocytes (interstitial Cajal-like cells) in human fallopian tubes. Bratisl Med J 2016;117:263-7.
16. Varga I, Kyselovič J, Danišovič Ľ, Gálfiová P, Kachlík D, Polák Š, et al. Recently discovered interstitial cells termed telocytes: Distinguishing cell-biological and histological facts from fictions. Biologia 2019;74:195-203.
17. Salama NM. Immunohistochemical characterization of telocytes in rat uterus in different reproductive states. Egypt J Histol 2013;36:185-94.
18. Risvanli A, Hatipoglu F, Salykov R, Timurkaan N, Kadiralieva N, Kasymalieva KK, et al. Evaluation of telocytes in the ovary, oviduct, and uterus of Kyrgyz mares according to pregnancy status. Anat Histol Embryol 2025;54:e70024.
19. Akgül A. Statistical analysis techniques in medical research. Ankara, Yök Publications; 1997.
20. Özdamar, K. Biostatistics with SPSS, 5th ed. Ankara, Kaan Press; 2003.
21. Cretoiu SM, Cretoiu D, Simionescu A, Popescu LM. Telocytes in human fallopian tube and uterus express estrogen and progesterone receptors. Sex Steroid 2012;217:114-20.
22. Cretoiu SM, Radu BM, Banciu A, Banciu DD, Cretoiu D, Ceafalan LC, et al. Isolated human uterine telocytes: Immunocytochemistry and electrophysiology of T-type calcium channels. Histochem Cell Biol 2015;143:83-94.
23. Soliman SA, Abd-Elhafeez HH, Abou-Elhamd AS, Kamel BM, Abdellah N, Mustafa FEZA. Role of uterine telocytes during pregnancy. Microsc Microanal 2023;29:283-302.
24. Tang XL, Zhang FL, Jiang XJ, Yang XJ. Telocytes enhanced the proliferation, adhesion and motility of endometrial stromal cells as mediated by the ERK pathway in vitro. Am J Transl Res 2019;11:572-85.
25. Banciu A, Banciu DD, Mustaciosu CC, Radu M, Cretoiu D, Xiao J, et al. Beta-estradiol regulates voltage-gated calcium channels and estrogen receptors in telocytes from human myometrium. Int J Mol Sci 2018;19:1413.
26. Aleksandrovych V, Walocha JA, Gil K. Telocytes in female reproductive system (human and animal). J Cell Mol Med 2016;20:994-1000.
27. Cretoiu SM, Cretoiu D, Marin A, Radu BM, Popescu LM. Telocytes: ultrastructural, immunohistochemical and electrophysiological characteristics in human myometrium. Reproduction 2013;145:357-70.

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