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Comparative investigation of histological distribution of peripolar cells in renal parenchyma between wild rats (*Rattus norvegicus*) and lab rats (*Rattus norvegicus*)

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Abstract

Understanding the glomerular vascular pole's physiology and biodiversity is crucial for comprehending crescent development and peripolar regeneration. The current study looked into the primary histological differences between domestic and wild animals as well as the histological characteristics of the specialized cells in renal corpuscles. Two groups of six rats each were created from two strains of rats used in the experimental study. The wistar albino rats (*Rattus norvegicus*) were created at the animal house/pharmacology collage at Kerbala University, while the brown rats *(Rattus norvegicus)* were captured from agricultural areas and orchards in the Karbala governorate. For a general histological investigation, use the hematoxylin and eosin stains. Collagen fibers are examined with Masson trichrome and the Gomori trichrome stain. The peripolar cell lies adjacent to the visceral and parietal glomerular layers near the Bowman's capsule. Their outside surface is open to the urine space in a peripolar posture. In both lab and wild rats, the peripolar cells that were contain expanded with processes, type of these cells present within them were dendritic peripolar cells. These were one specific type of dendritic cells observed in rats. In lab rats, their cell bodies were pyramidal, but in wild rats, the shape of peripolar cells they were fusiform shape and spherical shapes. They often had greater microvilli than parietal epithelial cells. Most cells had a few non-branching extensions and wrapped tightly around the vascular pole. The gap that exists between afferent and efferent arteries contains a number of peripolar cells with extensions extending in opposite ways. These cells illuminate red whenever examined with Masson trichrome. The form of dendritic peripolar cells varied, indicating functional specialization. They may be essential for crescent formation and peripolar regeneration due to their localization and expansions surrounding the vascular pole.

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Introduction

Adaptations of distinct mammalian species to living in diverse settings may include varying combinations of cellular, physiological, behavioral, and ecological features (1-3). Several renal modifications that could be crucial in improving water conservation are discussed (4). These adaptations include changes in relative medullary thickness (4-6), length of the renal papilla, formation of pelvic fornices, Nephron count (1,7), the percentage of long-looped nephrons and nephron heterogeneity (8), confluence of collecting ducts and circulatory bundles in the outer medulla's inner stripe (9,10), the relative development of the three medullary zones and the thin descending limb epithelium (2,9,10). Perhaps the most popular study animals, especially for urinary physiology, is the rat. is an example of

a human illness. The best indicator of a rat's meal habit is how long it takes to eat, which is influenced by the size of the meal. Larger morsels are transported to a far location for continuous eating, while smaller fragments of nourishment (such as debris, grain meal, wheat, etc.) are eaten directly whenever they are discovered. Rats avoid open areas and prefer to feed near cover, with the exception of dominant rats, who are more likely to consume food directly at the source (11). The importance of the urinary system lies in the fact that it is responsible for many physiologic functions which are controlled by it, involves the generation of red blood cells, the control of blood pressure and volume, the absorption of calcium, the metabolism of toxins, and excretion. All mammalian species share these basic kidney functions as well as general gross and histologic anatomy (12). Peripolar cells have since been described in the toad and axolotl (13) and the current authors investigated them using light microscopy in the human kidney (14). Peripolar cells are particularly visible in the ovine kidney (15), while they are frequently sparse but vary in quantity in the human kidney (14). The identification of various cytoplasmic granules was a particularly obvious characteristic of the peripolar cell in every species examined (13,15). There are indications that they flow into the urinary area as secretory granules (16,17). Heterogeneous cells in the vascular pole of the renal corpuscles were designated as peripolar cells. Neither species' peripolar cells' placement in the renal cortex has been studied before (14). Despite their definition, these cells' morphological and physiological features remain mostly unidentified (18).

To provide basic knowledge about peripolar cell of rats' kidney and give histomorphological description of this cell, provide map for distribution of peripolar cell in glomerular space and calculate the number of this cell in wild and lab rats and how much the environment effect and adaption on structure of rat's kidney, for this aim, we have done this work.

Materials and methods

Ethical approve

This investigation was conducted in the anatomical facility of the University of Kerbala's College of Veterinary Medicine under reference number UOK.VET.AN.2024.099.

Animal model

Two strains of male rats, the average of body weight was about 180 grams in wild rats while in laboratory rats was about 359 grams, for experimental study divided in to two groups, each group includes six animals. The albino Wistar rats (*Rattus norvegicus)* were created at the animal house/pharmacology collage at Kerbala University, while the brown rats (*Rattus norvegicus*) were captured from farms and orchards in the Karbala Governorate. The rats were fed a standard diet of bread and tap water while being watched over by a specialist veterinarian. In order to provide a good and clean working environment, the right ventilation and nutrition conditions were adhered to.

Experimental design

A digital balance was used to weigh the animals while they were alive, and they were sacrificed at regular intervals after being anaesthetized with an intramuscular injection of a ketamine and xylazine mixture at doses of 80-100 mg/kg body weight ketamine and 10-12.5 mg/kg xylazine (19,20). After wards, abdominal cavity was opened and intestine moved to acquire access to the urinary system to examine the structure. The Histological section of kidneys was imaged with a digital camera (21,22).

Histological and histochemical preparation

The kidneys were subsequently preserved for around 48 hours in a 10% formalin solution. Small sections of kidney were sliced, conserved in 70% ethyl alcohol to preserve them, dehydrated in a series of alcohol grades, cleared in xylene, and then embedded as usual in paraffin wax. Sections of 5 µm thickness were mounted on clean glass slides. Hematoxylin and eosin stains are used for standard histological evaluation (23). The filaments of collagen were examined using Masson's trichrome stain (24). Gomori trichrome: this marking was be employed to identify collagen and smooth muscle fibers, and to find an increase in collagen fibers in connective tissue (25).

Quantitative statistics statistical analysis of peripolar cell

A minimum of fifty renal corpuscles with a visible vascular pole were imaged for each kidney. Each image was reviewed by three distinct observers to confirm that the peripolar cells were correctly identified. Peripolar cells are granular cells found in the glomerular capsule near the junction of the parietal and visceral layers. The following index was used to quantify peripolar cells in normal kidneys (14). Peripolar Cell Index (PPI): PPI (%) =number of vascular poles with at least one peripolar cell ÷ total number of vascular poles × 100.

Results

Renal corpuscle

The renal corpuscle consists of glomerulus and Bowman's capsule. A little cluster of microvascular with two distinct categories of cells is called a glomerulus. Specialized cells of the smooth muscle called mesangial cells are found in the spaces amongst capillaries (Figures 1 and 2). Collagen fiber appears through Masson's trichrome stain and was distributed in the basement membrane of the distal and proximal convoluted tubules as well as in the capillaries inside the glomerulus, the amount of collagen in the glomerulus of laboratory rats found on the basement membrane is greater and more widespread than that found in wild rats. (Figures 3 and 4).

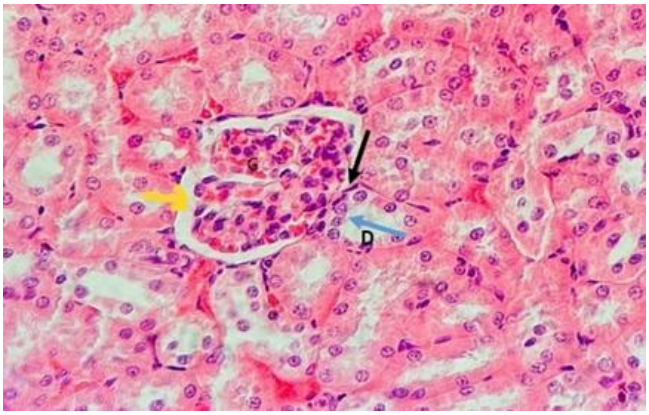

Figure 1: Microphotograph in of cortex of wild rat: showing glomeruli (G), Bowman capsule (yellow arrow) appears irregular or oval in shape in wild rat, Distal convoluted tubules (D), macula dense cell staining densely with hematoxylin (black arrow) and one peripolar cell in vascular bole (black arrow). H&E, 400x.

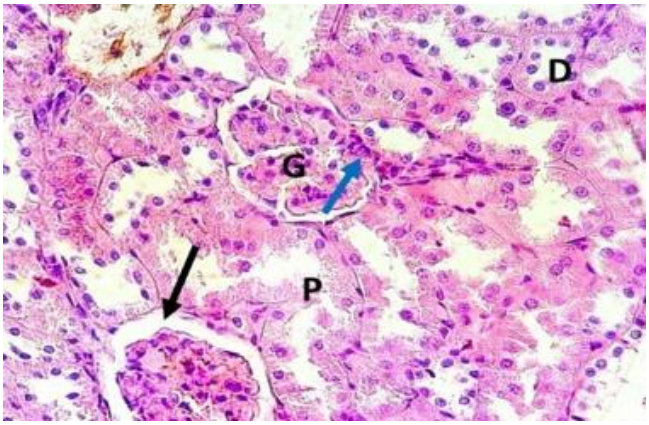

Figure 2: Microphotograph of cortex of lab rat: show glomeruli (G), Bowman space (black arrow), proximal convoluted tubules (P), Distal convoluted tubules (D) and macula dense of juxtaglomerular apparats (blue arrow). H&E, 400x.

Peripolar cells

The H and E dye was not performing the best for detecting the peripolar cells, even if it provides sufficient visibility of the kidney's different histological aspects. The small, oval, and prolonged nuclei of these cells marked with H and E were their defining feature. A cell's identity can be recognized by its position in the vascular pole using Masson's Trichrome stain. The position and red nucleus of the peripolar cell make it easy to identify with Gomori trichrome. These cells were situated near the vascular pole at basement membrane of Bowman's capsule and juxtaglomerular cells, with its free surface exposed to the urine space in a peripolar posture (Figures 5 and 6). Dendritic peripolar cells were the type of peripolar cell that was extended with cell processes in both lab and wild rats. The only sort of dendritic cells seen in rats were these. Their cell bodies were pyramidal in shape in lab rats; while, fusiform and ovoid in wild rats. Compared to parietal epithelial cells, their microvilli were frequently longer. The majority of cells had one or two non-branching processes and wrapped around the vascular pole. Certain peripolar cells, which were reddish in color when stained with Masson trichrome, are found within the cleft separating the afferent and efferent arteries, with branches running in opposite directions.

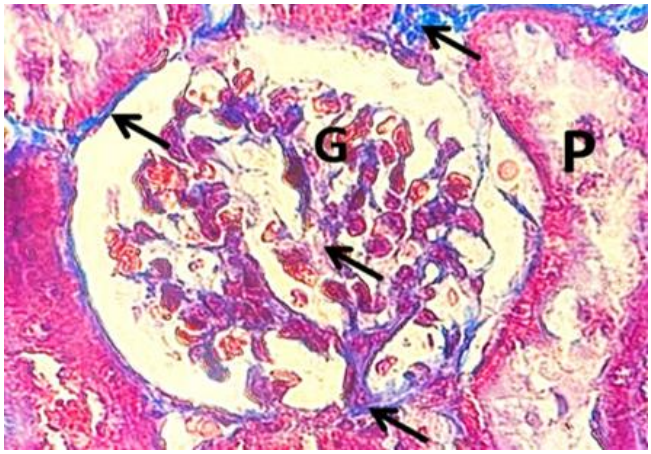

Figure 3: Microphotograph of renal cortex of wild rats showing distribution of collagen fiber on basement membrane of glomeruli, on wall of capillary inside the glomeruli (black arrow), glomeruli (G), proximal convoluted tubules (P). Masson trichrome stain.1000x.

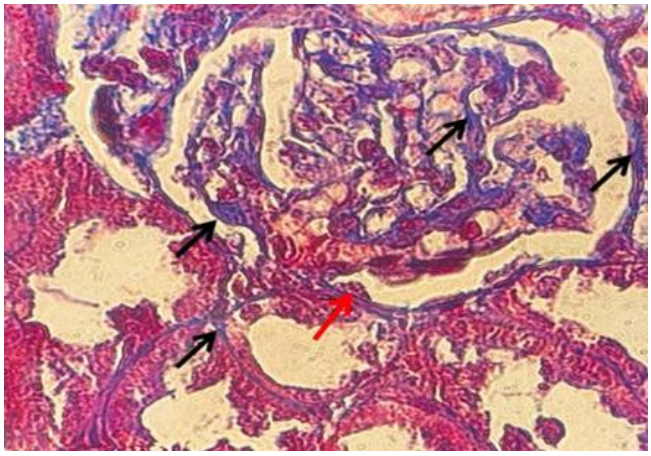

Figure 4: Microphotograph of renal cortex of lab rats showing distribution of collagen fiber on basement membrane of glomeruli, distal and proximal convoluted tubules also on wall of capillary inside the glomeruli (black arrow), one peripolar cell rest on Bowman capsule at vascular pole (red arrow). Masson trichrome stain. 1000x.

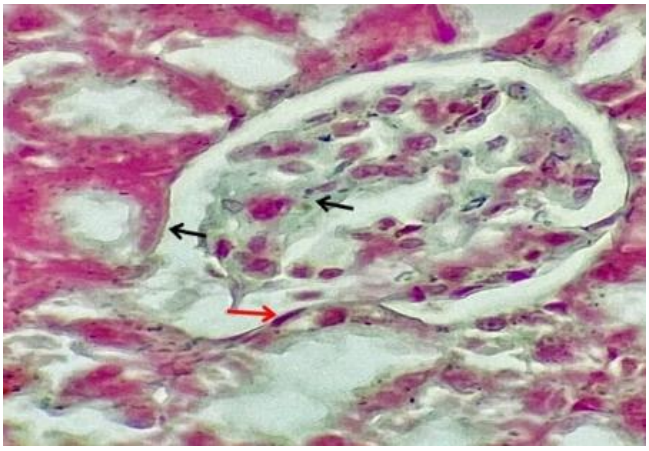

Figure 5: Microphotograph of renal cortex of wild rats showing distribution of collagen fiber on basement membrane of glomeruli also on wall of capillary inside the glomeruli (black arrow), one peripolar cell rest on Bowman capsule at vascular pole with elongated nuclei (red arrow). Gomori trichrome stain. 700x.

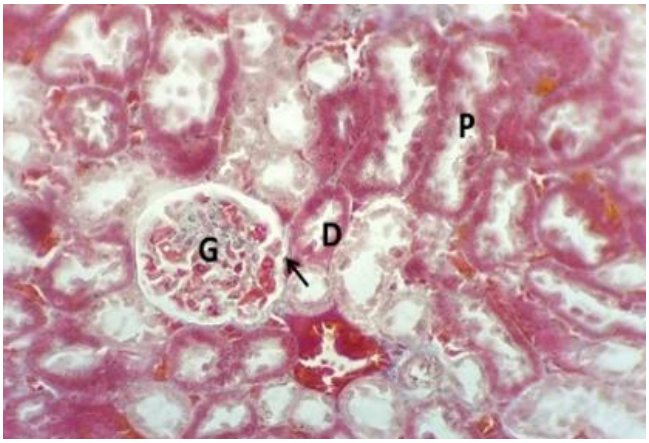

Figure 6: Microphotograph of renal cortex of lab rats showing distribution of collagen fiber on basement membrane of glomeruli also on wall of capillary inside the glomeruli, one peripolar cell rest on Bowman capsule at vascular pole with elongated nuclei (black arrow), glomeruli (G), distal convoluted tubule(D)and proximal convoluted tubules (P). Gomori trichrome stain. 400x.

They did not seem to be in continuity with either the Podocytes or the parietal cells, but rather lay between them. Their long axes were not always oriented at right angles to the arterioles; their orientation varied. They were put to the vessels and were sessile, but they weren't wrapped around them. Usually there was just one cell, but when there were several, they surrounded the vascular pole in a ring. The afferent arteriole was more frequently associated with them than the efferent arteriole.

No more than one peripolar cell was identified at any vascular pole. In both animal's peripolar cell was without cytoplasmic granules. According to Table 1, the number of these cells in wild rats was determined to be at least one cell in each of the 50 vascular poles; however, in some cases, these poles did not contain any cells, and in some cases, they contained more than one cell, but not more than three. There was no statistically significant difference between the number of cells in wild and laboratory rats ($P>0.05$), and the difference between the two groups was considered slight, but the percentage of peripolar cells present was slightly higher in wild rats 58% than in laboratory rats 54%, and this percentage is considered large when compared to the presence of cells that were at least one cell in each visceral pole.

In laboratory rats, the number of these cells was also determined to be at least one cell in each of the 50 vascular poles, and in some cases, there were no peripolar cells. These cells located at the gate of vascular pole and extend from it processes that appeared elongated or stellate morphology (Figures 7 and 8).

Table 1: Quantification of vascular poles and peripolar cells in wild and lab rat's kidney

Rat	Vascular poles numbers	Peripolar cells numbers with vascular	Peripolar cells numbers	Ratio of peripolar cell
Wild	50	29±1	34±1	58%
Lab	50	27±1	31±1	54%

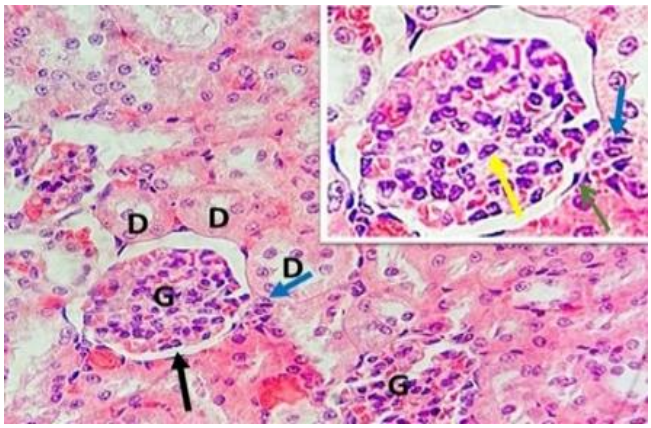

Figure 7: Microphotograph of cortex of wild rat kidney: showing glomeruli (G), Distal convoluted tubules (D), macula densa cell of juxtaglomerular apparats (blue arrow) and Podocytes with large body cell cover the tuft of capillaries (yellow arrow). one peripolar cell rest on partial layer of bowman capsule (green arrow). H&E, 400x.

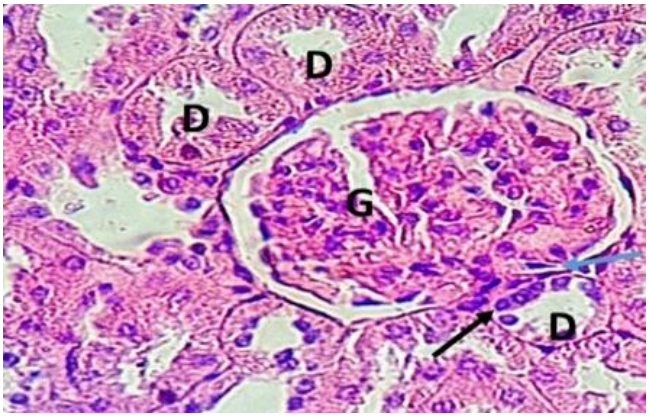

Figure 8: Microphotograph of cortex of lab rat: showing glomeruli (G), Distal convoluted tubules (D), macula dense cell of juxtaglomerular apparats (black arrow), these cells appear few in number, distributed and have relatively large cells compared to wild rats. Tow peripolar cell pyramidal cell bodies. cell in vascular bole with elongated nuclei and (blue arrow). H&E, 600x.

Discussion

The peripolar cell is a granulated epithelial cell that is positioned within the glomerulus in the reflection of Bowman's capsule between the visceral and partial layer, but not in all glomeruli (25). A unique kind of fragmented epithelial cell found in the glomerulus, the peripolar cell is situated at the focal point of contemplation that separates the visceral and parietal layers of Bowman's capsule. This area, which is also known as the renal corpuscle's vascular pole, may serve as Barrier Integrity to preserve the architecture and selective permeation of Bowman's capsule or it may have a specific structural and potentially regulatory role in glomerular activity.

The only type of dendritic cells seen in both laboratory and wild rats, according to the current study, are dendritic peripolar cells. One characteristic which encourages the designation of these kinds of cells as dendritic is the identification of prolonged cell processes. Interestingly, the two groups differed in the shape of their cell bodies: in wild rats, most of them had fusiform shape and rare of them had round cell bodies, while laboratory rats had pyramidal cell bodies. The soma's shape variations between laboratory-bred and wild populations may be the result of developmental or adaptation differences driven by genetic or environmental variables. Notwithstanding these architectural variations, the lack of cytoplasmic granules in the peripolar cells remained a characteristic shared by the two groups. The peripolar cells type in rats is characterized by granule-free cytoplasm (26,27). The consistent lack of granules points to a conserved functional role for dendritic peripolar cells that is unaffected by environmental factors or lifestyle variations across lab and real-world populations.

There was little difference among both groups, as seen by the nearly identical quantity of peripolar cells seen in laboratory and wild rats. irrespective of the environment or exposure to various outside situations, this study implies that the number and location of peripolar cells may be a retained property among rat populations. The distribution of peripolar cells in sheep, which is consistent with our result (18). The fact suggesting these results are consistent across breeds raises the possibility that peripolar cells play a key function in renal physiology, most likely in the control of glomerular filtration rates or local paracrine communications in the juxtaglomerular apparatus. The comparability across lab and wild rats further suggests that both the structural and functional characteristics of these particular kidney cells are not much changed by the carefully monitored conditions of laboratory settings. The stable miniature anatomy of the nephron, which is genetically determined and resistant to extrinsic influences like food, stress, or infection exposure (28,29).

The current study finding the peripolar cells located at the gate of vascular pole of renal corpuscles, this location gives the very important role for these cells, their location near the afferent arteriole suggests they may help regulate blood flow into the glomerulus, potentially modulating vascular tone via paracrine signals or mechanical support. In addition, like other pericyte-like cells, peripolar cells likely help maintain the architecture of the glomerular entrance and exit routes, stabilizing capillaries (30,31).

Conclusion

The study highlighted the structural variety of peripolar cells by revealing clear morphological differences between lab and wild rats. The form and density of dendritic peripolar cells varied, indicating functional specialization. They may be essential for crescent formation and peripolar regeneration due to their localization and expansions surrounding the vascular pole.

Acknowledgment

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Conflict of interest

The author claims that there isn't any obvious disagreement at all.

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دراسة نسجية مقارنة لتوزيع الخلايا القطبية في نسيج الكلى بين الجرذان البرية والمختبرية

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الخلاصة

إن فهم فسيولوجيا القطب الوعائي الكبيبي وتنوعه البيولوجي أمر بالغ الأهمية لفهم التطور والتجدد حول القطب. تناولت الدراسة الحالية الاختلافات النسيجية بين الجرذان الأليفة والبرية، بالإضافة إلى الخصائص النسيجية للخلايا المتخصصة في الكبيبة الكلوية. تم إنشاء مجموعتين من الجرذان كل مجموعة تحتوي على ست حيوانات. الجرذان المختبرية تم الحصول عليها من البيت الحيواني في كلية الصيدلة/ جامعة كربلاء بينما الجرذان البرية تم اصطيادها في بساتين محافظة كربلاء. لإجراء فحص نسيجي عام، استخدمنا صبغة الهيماتوكسيلين والايوسين، ولفحص توزيع وكمية ألياف الكولاجين استخدمت صبغة ماسون الثلاثية. وكذلك استخدمت فحص بصبغة جوموري ثلاثي الألوان لتشخيص الخلية القطبية. تقع الخلية حول القطب

على الغشاء القاعدي لكبسولة بومان، بين الظهارة الكبيبية الجدارية والحشوية، ويكون سطحها الحر مكشوفًا لحيز البول في وضع حول القطب. في كل من جرذان المختبر والجرذان البرية، كانت الخلايا القطبية التي وجدت تحتوي على نتوءات. كانت هذه الخلايا نوعًا محددًا من الخلايا الشجيرية التي لوحظت لدى الجرذان، كانت أجسام الخلايا هرمية الشكل في الجرذان المختبرية، بينما في الجرذان البرية كانت مغزلية الشكل وكروية. غالبًا ما كانت تحتوي على زغيبات أكبر من الخلايا الظهارية الجدارية. كان لدى معظم الخلايا بعض الامتدادات غير المتفرعة وتلتف بإحكام حول القطب الوعائي. توجد العديد من الخلايا القطبية، التي تتحول إلى اللون الأحمر عند صبغها بماسون ثلاثي الألوان، في مدخل القطب الوعائي بين الشرايين الواردة والصادرة، مع امتدادات في اتجاهين متعاكسين. أبرزت الدراسة التنوع الهيكلي للخلايا حول القطب، من خلال الكشف عن اختلافات مورفولوجية واضحة بين الجرذان المخبرية والبرية. تباين شكل وكثافة الخلايا الشجيرية حول القطب، مما يشير إلى تخصص وظيفي. وقد تكون هذه الخلايا ضرورية لتكوين حلقة وتجديد الخلايا حول القطب، نظرًا لتموضعها ووجودها. في محيط القطب الوعائي.