

The Morphometric analysis of Pacinian Corpuscles in the thick skin of the Human Foot.

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ABSTRACT

Background: This research study investigates the impact of ageing on the shape and size of Pacinian corpuscles in the great toe of the human foot. By using histological sections of thick skin were taken from 60 samples of different age groups and five samples from the foetus. we have measured H&E-stained alternate sections of thick skin of different age groups. the Pacinian corpuscles were measured by using ImageJ software. **Results:** The morphometric parameters, including ranges of horizontal diameter (0.08 to 0.82 mm), vertical diameter (0.08 to 0.87 mm), outer perimeter (0.27 to 3.22), outer area (0.01 to 0.63 mm²), inner perimeter (0.08 to 0.26mm) and capsule thickness (0 to 0.06mm). we have observed that the shape of the Pacinian corpuscle varies from triangular, oval, fusiform, quadrilateral, dumbbell, cylindrical and circular in shape. We have also found that corpuscles were arranged in a cluster. **Conclusion:** the morphometric analysis results indicate that horizontal and vertical diameter, outer perimeter, area, and capsule thickness significantly increase with increasing age.

Keywords: Pacinian corpuscles; foot; distribution; human adults

INTRODUCTION

The Pacinian corpuscle was first reported in humans by Johannes Gottlieb Lehmann in 1741, while rediscovered by Filippo Pacini in 1835,1840 (1). Therefore, these lamellar structures are also called "Vater-Pacini" or Pacinian corpuscle (2). The first electron microscopic observational study was published in 1957 by Pease and Quilliam (3). In 1958 and 1959, Cauna and Mannan observed three visible regions in the corpuscle: outer core, inner core and intermediate growth zone (4), (1). In 1994, Bell et al. reported that the central part of the corpuscle lodges a knob-like structure called an axon terminal (2). A thick layer of the capsule encircles each corpuscle, and the capsule's thickness depends on the corpuscle's size, as observed by Pease and Quilliam 1957 (3). In humans, Halata 1975, suggested that the capsule consisted of 30 layers of flat cells with oval nuclei (5). The Pacinian corpuscles are circular or oval macroscopic structures. They are located at the junction of the dermis and hypodermis of thick skin. Morphometrically, the Pacinian corpuscle is about 1 to 2mm in length and approximately 0.1 to 0.7mm in diameter (6). Structurally, each corpuscle comprises the capsule, outer and inner core or zone, and central terminal zone (7). The capsule consists of type-II collagen fibres and concentrically arranged lamellae of flat cells (2). The outer core comprises approximately 30 units of concentric lamellae (6). Each concentric lamella consists of a single layer of flat cells resting on a thin layer of the basement membrane. The concentric

lamellae are separated from each other by fluid-filled spaces. These spaces contain a small amount of matrix, few microphases, type 2 collagen fibres, and blood capillaries. The outer core is continuous with the perineurium of the axon. The cells of perineurium are composed of squamous epithelial cells, having a flattened nucleus (7), (2). The inner core is present between the outer core and the central terminal zone. The inner core flat cells are two types of clear cells and dark cells (2). The central terminal zone contains a single unmyelinated axon. The axon is myelinated outside the corpuscle but becomes unmyelinated within the corpuscle (7), (2). Bell et al. 1994 reviewed that the Pacinian corpuscles are located in the sheath of the tendon, deep fascia, eardrum, middle ear cavity, peritoneum, capsule of the knee joint, fingertips, subcutaneous tissue of phalanges, olfactory bulb, the ureter, urinary bladder, urethra, prostate and genital organs and within the mesentery within the muscles and pancreas, close to the peripheral nerves, (2). They are also found in hand (Stark et al. 1998) (8), in the lymph node (Asiamelbourne 2006) (9), the skin of the thumb and fingers (Kobayashi et al. 2018) (10), in the Femoral sheath (Morishita et al. 2018) (11), skin and flexor tendon sheath of the foot (Jin et al. 2019) (12)

MATERIAL AND METHODS

Samples: Samples were taken for this study after Ethical due clearance from the Institutional Ethics Committee, Malwanchal University, Indore, Madhya Pradesh. In this study, we take pieces of the thick skin of the foot of human cadavers (60 in number) and fetuses (5 in number). The skin tissue of 0.5x0.5cm² in size was dissected from the plantar aspect of the foot (only from the big toe).

Grouping of Samples: The following groups of samples have been collected; Group P0- (15 Weeks to 20 Weeks) includes five samples; P1- (11 Years to 20 Years) includes eight samples; P2- (21 Years to 30 Years)-12 samples; P3- (31 Years to 40 Years)- 7 samples; P4- (41 Years to 50 Years)- 8 samples; P5- (51 Years to 60 Years)- 8 samples; P6- (61 Years to 70 Years)- 7 samples; P7- (71 Years to 80 Years)- 6 samples; P8- (81 Years to 90 Years)- 4 samples.

Tissue Fixation: The skin tissue was dissected out from the plantar aspect of the cadaveric foot and immersed in a fixative (10% buffered formalin solution). **Tissue Processing:** We trimmed the skin tissue and washed them with running tap water. Tissue dehydration starts with ascending grades of alcohol and is cleared in chloroform. The tissue embedding was done in wax, and made the paraffined block and microtomy done. We made the wax ribbon and transferred and spread it over the hot water bath, and picked it up on the glass slide. **Haematoxylin and Eosin staining:** we started with heat fixation and deparaffinised the tissue slides in xylene. The rehydration of the slides with descending grades of alcohol and stain with haematoxylin die. We wash under running tap water, and tissue differentiation is done with acid alcohol. The Tissue slides again proceed for dehydration with ascending grades of alcohol and counterstained with the eosin die. Finally, clear in xylene and mounted with DPX.

Microscopy and morphometry: We used a trinocular microscope attached to a digital camera. For image calibration, we use Image Focus Alpha software. The digital photomicrography is done at 10X magnification. we have taken photomicrographs of at least 3 to 5 alternate succeeding slides of each sample. The morphometry of Pacinian corpuscles is done on Fiji ImageJ2 software. For taking a precise measurement of the Pacinian corpuscle, we use an apple pencil to trace the outer and inner perimeter of the Pacinian corpuscles.

we select the straight line tool from the ImageJ software and draw the vertical and horizontal lines that must be passed from the central core of the corpuscle. For taking measurements of the thickness, we select the same tool from the outer boundary of the capsule to the inner edge of the capsule of the Pacinian corpuscle.

Limitations of the study: In this study, the sample collection will be restricted to the plantar aspect of the foot (only from the great toe). The cadavers with a diabetic foot ulcers will be excluded from this study.

Statistical Analysis: The statistical analysis involved normalising data from each sample and comparing multiple groups using one-way ANOVA. The correlation was determined by examining the p-value, with a significance set at $p > 0.05$.

RESULTS

Morphometric Parameters	Different Age Groups of Pacinian Corpuscle									p value
	P0	P1	P2	P3	P4	P5	P6	P7	P8	
Horizontal Diameter	Mean± SD 0.08±0.02	Mean± SD 0.27±0.04	Mean± SD 0.37±0.1	Mean± SD 0.44±0.18	Mean± SD 0.6±0.23	Mean± SD 0.52±0.16	Mean± SD 0.61±0.08	Mean± SD 0.78±0.27	Mean± SD 0.82±0.26	<0.001
Vertical Diameter	0.08±0.03	0.4±0.15	0.45±0.17	0.3±0.08	0.45±0.24	0.45±0.22	0.56±0.11	0.66±0.27	0.87±0.18	<0.001
Outer Perimeter	0.27±0.07	1.35±0.34	1.64±0.52	1.47±0.43	2.07±0.64	1.91±0.53	2.17±0.23	2.76±0.46	3.22±0.69	<0.001
Outer Area	0.01±0.01	0.09±0.04	0.14±0.07	0.11±0.06	0.21±0.11	0.22±0.13	0.26±0.04	0.4±0.16	0.63±0.26	<0.001
Inner Perimeter	0.08±0.02	0.15±0.03	0.17±0.04	0.2±0.04	0.18±0.04	0.19±0.07	0.21±0.08	0.21±0.02	0.26±0.06	<0.001
Inner Area	4.12±1.19	1.96±1.29	0.61±0.82	1.14±1.11	0.53±0.78	1.43±1.32	0.82±0.81	0.17±0.41	0.01±0.01	<0.001
Capsule Thickness	0±0	0.02±0.01	0.02±0.01	0.02±0.01	0.03±0.01	0.03±0.01	0.05±0.02	0.05±0.01	0.06±0.01	<0.001

Table 2: This table provides information about morphometric parameters of the Pacinian corpuscle. The data is presented for nine different age groups, labelled as P0 to P8, and each parameter is given as the mean and standard deviation (SD) for each age group. The table shows that there is a significant difference in morphometric parameters between the different age groups. If the p-value is less than 0.001, this suggests that the difference is statistically significant.

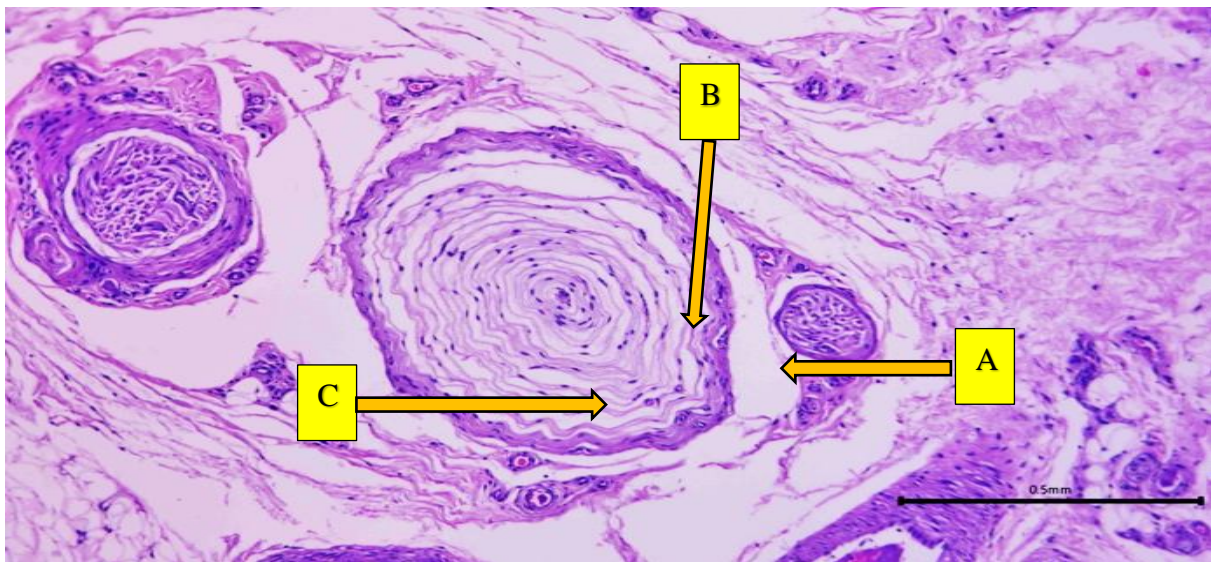


Image: The photomicrographs of H&E stained sections of thick skin under 10X magnification show the structure of Pacinian corpuscles. (A) a capsule of the corpuscle, (B) concentric lamellae, (C) inner core of corpuscle.

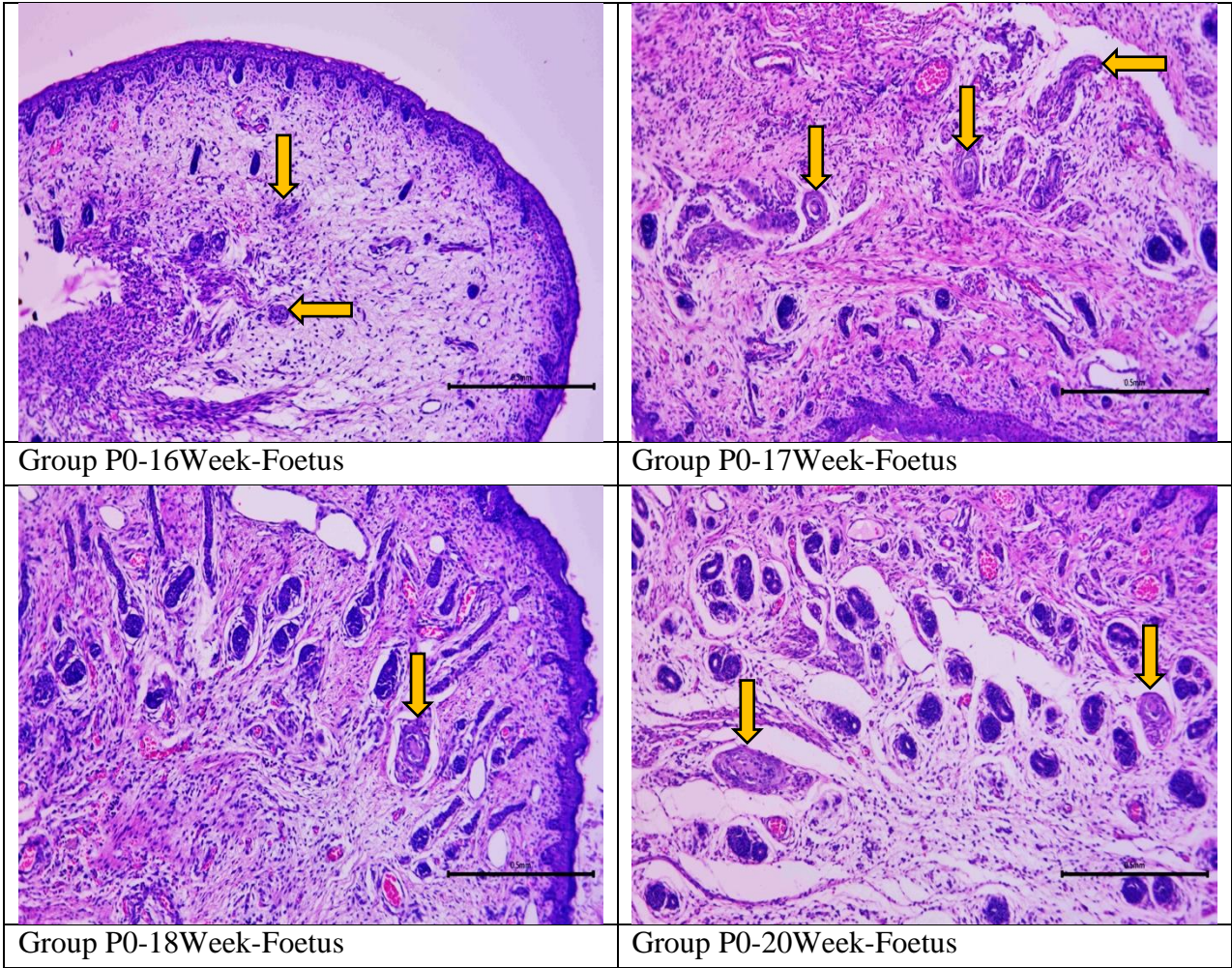
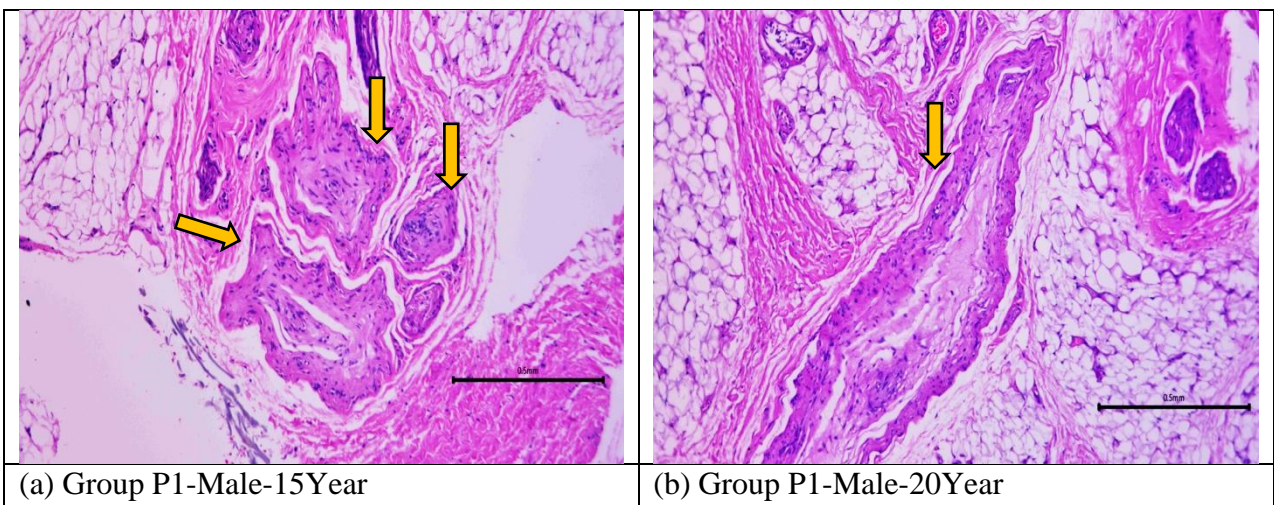
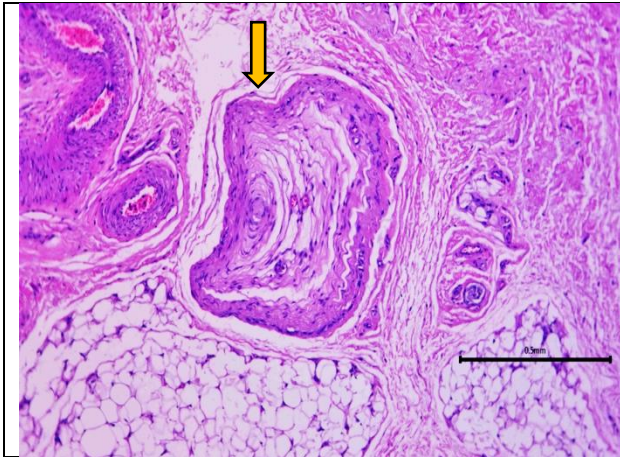
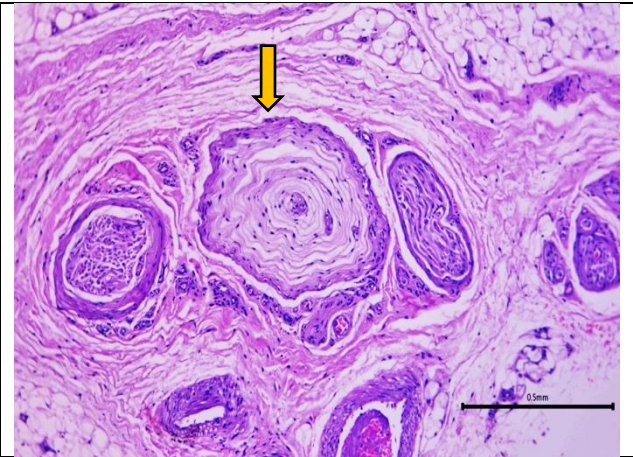


Image panel 1: The photomicrographs of H&E stained sections of foetus thick skin under 10X magnification showing the development of Pacinian corpuscles from 16 weeks to 20 weeks.

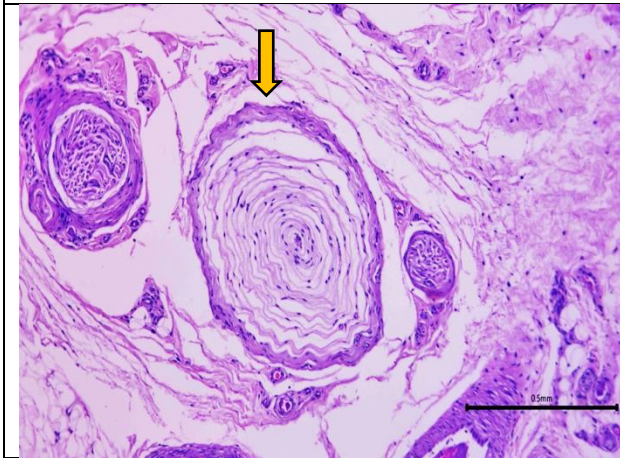




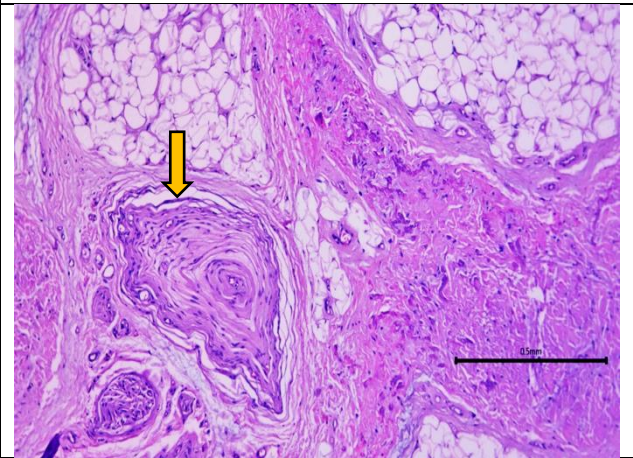
(c) Group P2-Male-27Year



(d) Group P2-Female-22Year

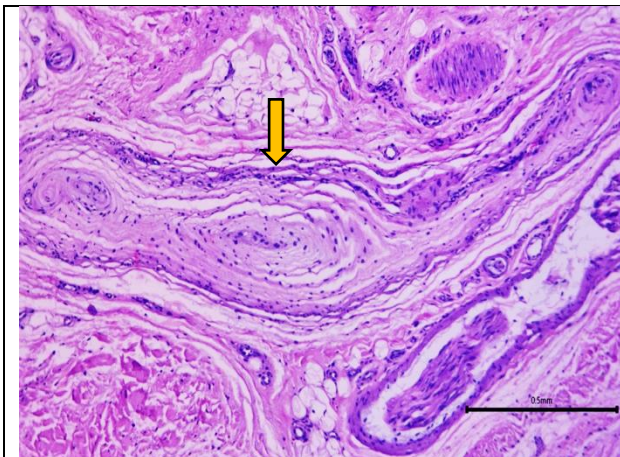


(e) Group P3-Female-36Year

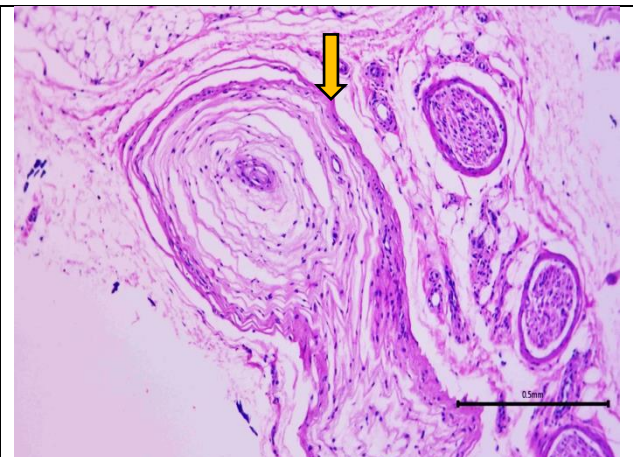


(f) Group P3-Male-35Year

Image panel 2: The photomicrographs of H&E stained sections of group P1, P2, and P3 thick skin under 10X magnification showing the shape and distribution of Pacinian corpuscles (arrow marked structures). Image (a) quadrilateral in shape, arranged in a cluster, (b) fusiform in shape, (c) quadrilateral, (d) circular in shape, arranged in a cluster, (e) oval in shape, (f) triangular in shape.



(a) Group P4-Male-45Year



(b) Group P4-Female-45Year

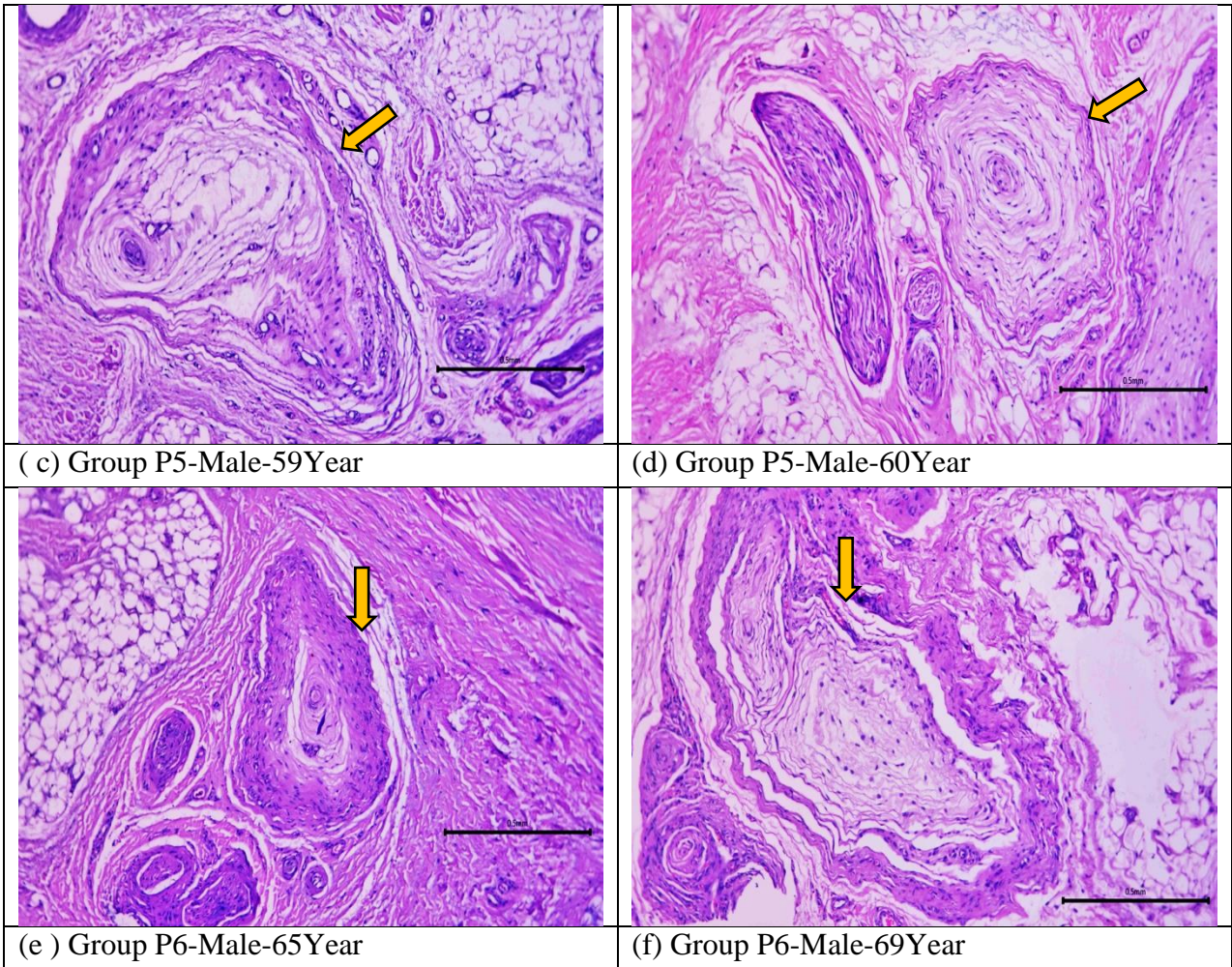
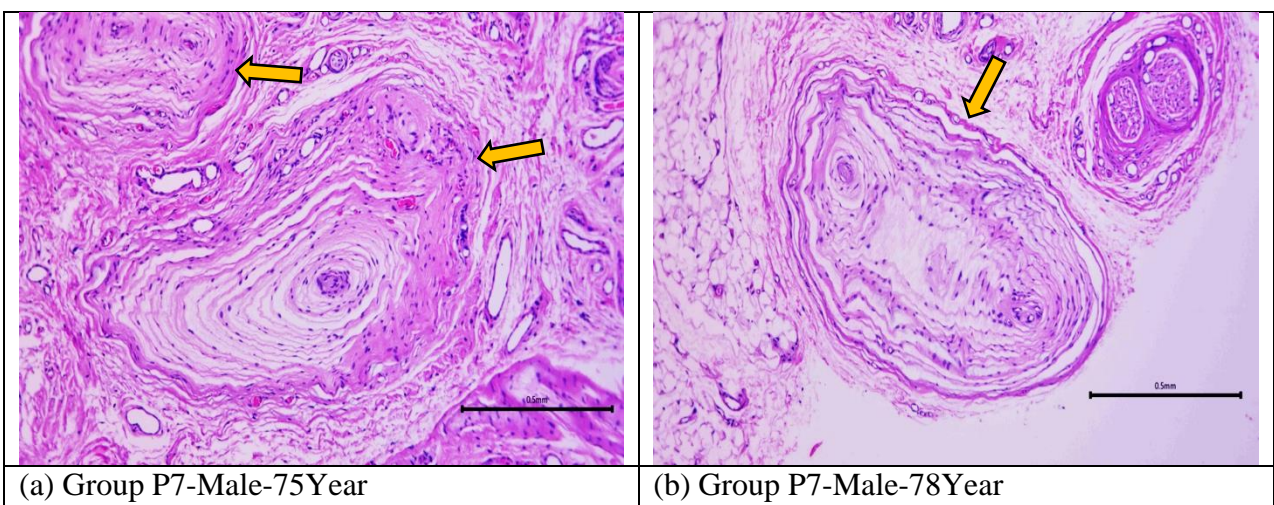


Image panel 3: The photomicrographs of H&E stained sections of group P4, P5, and P6 thick skin under 10X magnification showing the shape and distribution of Pacinian corpuscles (arrow marked structures). Image (a) cylindrical in shape, (b) Dumble in shape, (c) Large triangular in shape, (d) quadrilateral and arranged in a cluster, (e) triangular in shape, arranged in a cluster, (f) large oval in shape, wavy in nature.



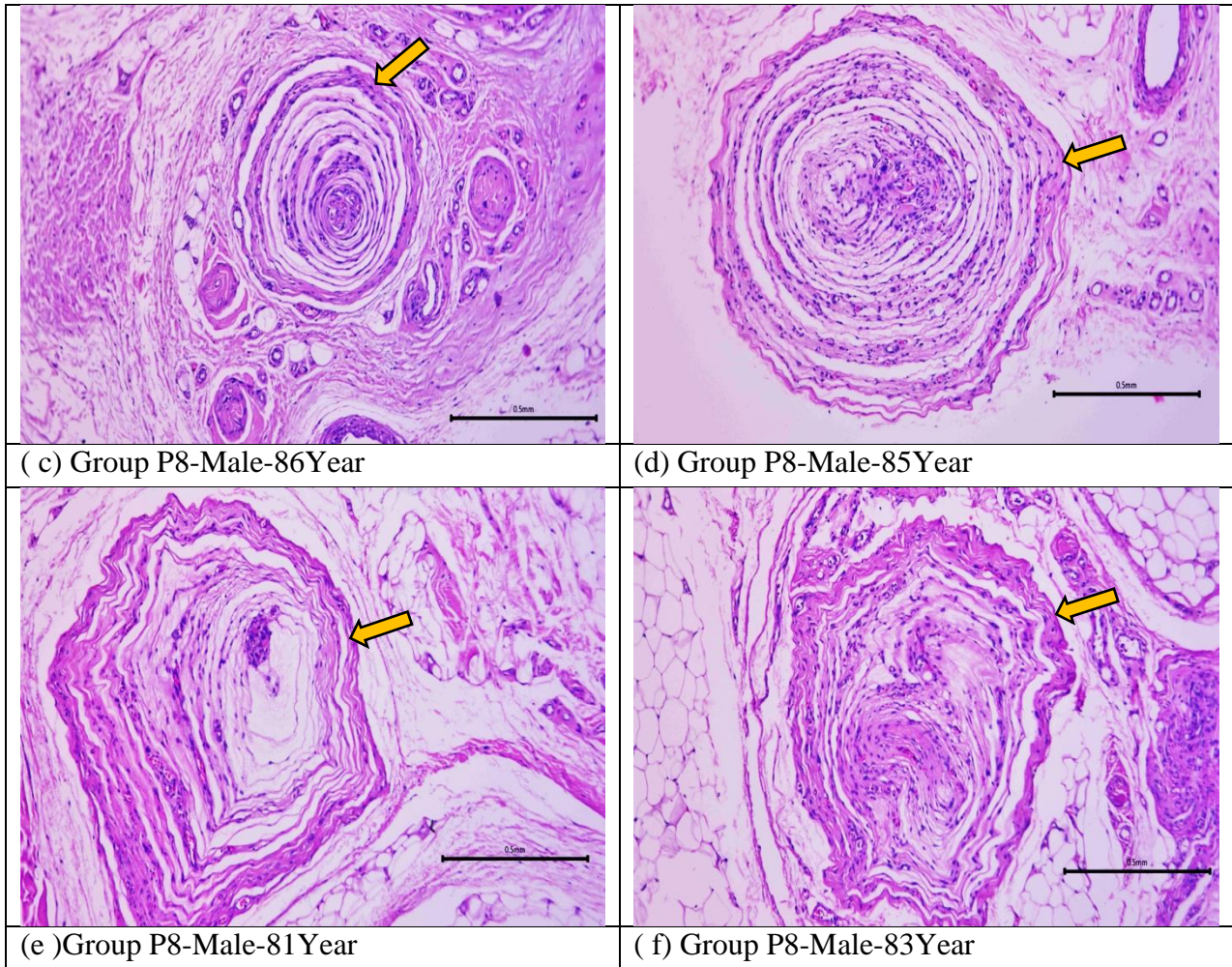


Image panel 4: The photomicrographs of H&E stained sections of group P7 and P8, thick skin under 10X magnification showing the shape and distribution of Pacinian corpuscles (arrow marked structures). Image (a) Large oval in shape arranged in a cluster, (b) oval in shape with two central cores, (c) Large triangular in shape, arranged in a cluster, (d) Large and circular, (e) Large quadrilateral in shape, (f) large oval in shape with two central core, wavy in nature.

Discussions

The size of Pacinian corpuscles:

We identified the Pacinian corpuscles in the H&E stained sections of foetal samples (big toe) of age groups 16th, 17th, 18th and 20th week. We could not find PC in the 15-week foetus. We have measured the PC in the foetus group (P0); the horizontal and vertical diameter is about 0.08mm, the outer perimeter is about 0.27mm, and the outer area is 0.01mm. Kim et al.2017 measured the length of Pacinian corpuscles in human foetal samples from the finger region, which was approximately 0.2 to 1.0mm and 0.05 to 0.3mm in diameter (13). Komei et al.2017 examined PC in the distal segment of the thumb and finger of the human foetus. They measured the PC approximately 0.2 to 1.6 mm in length and 0.05 to 0.3 in diameter.

We identified the PC in the H&E stained sections of thick skin, dissected out from the big toe of **the group (P1)**. The measured horizontal diameter (HD), vertical diameter (VD), outer perimeter (OP), outer area (OA), inner perimeter (IP) and capsule thickness (TC) are 0.27mm,0.4mm,1.35mm,0.09mm square, 0.15mm and 0.02mm, respectively. The PC length in an adult hand was mentioned as 1 to 1.5mm in Freitag et al.1994 (14).

In group (P2), we measured HD, VD, OP, OA, IP and TC, which are as follows 0.39mm,0.47mm,1.71mm,0.15mm square, 0.18mm and 0.02mm, respectively. The length of Pacinian corpuscles of adult hand estimated by George et al.2018 was 2 to 3mm and 0.8 to 2.2 mm in diameter.

In the group (P3), we took the measurement of HD, VD, OP, OA, IP and TC of Pacinian corpuscles; they are 0.41mm, 0.29mm,1.4mm, 0.1mm square, 0.19mm and 0.03mm subsequently. Jin et al.2019, observed that the length of Pacinian corpuscles was about 0.2 to 0.7mm, and the diameter was 0.05 to 0.3mm in the human adult foot (12). **In our group (P4)**, we measured various aspects of the Pacinian corpuscles. The results showed that the horizontal diameter was 0.6mm, the vertical diameter was 0.45mm, the outer perimeter was 2.07mm, the outer area was 0.21mm square, the inner perimeter was 0.18mm, and the capsule thickness was 0.03mm. According to a study by Henele and Kolliker 1944, the length of Pacinian corpuscles in human adult samples is typically between 0.8 and 1.2mm, with a breadth ranging from 0.45 to 0.6mm. The measurements we took of **the group (P5)** showed that the horizontal diameter was 0.52mm, the vertical diameter was 0.45mm, the outer perimeter was 1.91mm, the outer area was 0.22mm square, the inner perimeter was 0.19mm, and the capsule thickness was 0.03mm. In the study by Komei et al. (2017), morphometric data were reported for PCs in the distal segments of the fingers and thumbs of elderly individuals. The thickness of the PCs was in the range of 0.2 to 0.5mm, and the length was 1.0 to 2.5mm in the elderly. The data collected from **group P6** revealed that the HD, VD, OP, OA, IP and TC were determined to be 0.61mm,0.56mm,2.17mm,0.26mm square,0.21mm and 0.05mm, respectively. An observational study by Rhodes et al.2018 reported that corpuscles were 0.1 to 0.7mm in diameter (15). The findings from **group P7** showed that the horizontal diameter was measured to be 0.79mm, and the vertical diameter was recorded at 0.66mm. The outer perimeter was determined to be 2.76mm, with an outer area of 0.4mm squared. Additionally, the inner perimeter was 0.21mm, and the thickness of the capsule was established as 0.05mm. According to a study conducted by Lang et al.1984, the length of the PCs in hand was in the range of 1.6-5mm in the elderly individual. The Pacinian corpuscles located in the big toe of **group P8** were determined. The dimensions we took note of include the horizontal diameter (0.82mm), vertical diameter (0.87mm), outer perimeter (3.22mm), outer area (0.63mm square), inner perimeter (0.26mm), and capsule thickness (0.06mm). Stark et al.1998 observed that the length of Pacinian corpuscles was 1.6 to 5mm (16). We also observed that the distribution of Pacinian corpuscles in the big toe of an individual foot exhibits a solitary and cluster arrangement which consists of 3 to 5 corpuscles. Kim et al.2017 also found the cluster arrangement of Pacinian corpuscles in hand, which comprised 4 to 20 corpuscles (13).

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