

# Morphology and Morphometric study of Mammary Gland pre and Post Pubertal Development in Dromedary she camel (*Camelus dromedarius*) in Al-Muthanna Province

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**Abstract**— Camels play a vital role in the livestock sector in Al-Muthanna Governorate, The statistics of the Ministry of Agriculture/ Department of Planning 2008 revealed that the total numbers of camels in Iraq and in Al Muthanna province were (58293) and (7205) heads respectively. The latest statistics 2016-2017 revealed an increase in the numbers of camels in Al Muthanna (17500) head.(38) This underscores the importance of camel breeding in the governorate, where breeders benefit from their meat, hides, and other products. Camel milk is considered a major desert resource, often referred to as "white gold of the desert." Consequently, the study of mammary glands and their development before and after puberty is a neglected area of research in the governorate. This study aimed to investigate the morphological structure of the mammary gland during pre- and post-pubertal periods, the changes that have occurred to it, and to compare morphological and morphometric changes in the mammary glands during these periods.

This study successfully achieved its objectives by collecting 12 camel samples, divided into two groups of six samples each: six pre-pubescent and six post-pubescent. These samples underwent a morphological study (general description of the mammary glands, including gross study) and diagnostic imaging (radiography, computed tomography (CT), and ultrasound). A morphometric study was also conducted, involving numerous measurements of the teats and udder. The morphological study revealed that the pre-pubescent mammary glands are fully developed and complete in all their parts. These parts include two to three teat ducts, which connect to a teat cistern. This cistern, in turn, connects to the glandular cistern, which has a spongy consistency and contains cavities of varying sizes. These cavities decrease in size as they approach the parenchyma tissue. A clear change was observed in the morphometric measurements of both the teats and udder. found to be statistically significant using a t-test ( $p$ -value  $\leq 0.05$ ) with

the exception of: Diameter of teats at the apex, anterior left (mm), which had a significance value

of 0.457; and Diameter of the teats at the tip, left posterior (mm), with a significance value of 0.145; and Diameter of teats at the tip, right posterior (mm), with a significance value of 0.252. These values were considered not statistically significant and did not show a clear difference or tangible change during the pre- and post-pubertal periods. This confirms that the samples did not experience lactation even after puberty, based on the age range used in the study, which suggests that lactating females typically have noticeably rounded teat at the tip.

**Keywords** — the gland cistern, teat cistern, teat canal, and parenchymal tissue.

## INTRODUCTION

Camels can be defined as pseudo-rumen chorionic mammals. They are classified as mammals with double toes and lined feet, belonging to the family Camelidae , The classification can be divided into in New World dromedary, Bactrian, lamas, alpacas, vicuñas, and guanacos. The classification can be divided into two types Old World camels are placed fundamentally into two species: *Camelus bactrianus* (Bactrian) with two humps *Camelus dromedary* (Arabian) with one hump(1,2).

Camel is adapted to survive rough conditions physiologically and anatomically and plays a significant role in the life of people in the desert, semi-desert, and even irrigated lands. The total number of camels worldwide is approximately 25.89 million, 89% of which are dromedary camels, and the remaining 11% are Bactrian camels (found in the cold deserts of Asia). More than 80% of the world's camels are found in Africa. According to a 1978 Iraqi government survey, there were 70,000 camels.(FAO,2005) Nowadays, Iraq owned a total of 58,000 camels(3,4)

In Iraq, the percentages of camelids are (51%), (47%) and (2%) distributed in Al Jazira, Northern and southern Badia respectively. The camels are raised by different Iraqi tribes living and moving in between different Badia, moreover they are crossing the desert to reach another countries like Shamar, Dulaim tribes in the Al Jazira and Northern Badia that cross and reach east Syria. Camels are an important source of milk, meat, and their dung is used for fires. They are also used for riding and transport purposes (5,6).

the mammary gland of female camels consists of left and right halves separated from each other by the median suspensory ligaments. A visible groove can be seen grossly between the two halves. Each half is divided by invisible separation into two quarters (7,8) forming four quarters; two front and two rear quarters. Each quarter has its own teat (9,10). and four teats. the teats have typically two or sometimes three teat canals, and rarely just one (11,12)

Each teat canal leads to a separate milk cistern. This means that the camel's mammary gland possesses 8 (4 x 2) independent milk units. One unit consists of the alveoles, the milk ducts, the gland cisterns, the teat systems and the teat canals. (7) This means Each teat canal is associated with one separate tributary glandular complex. (13,14). High-performing dairy camels are supposed to have a symmetrically shaped udder with evenly formed teats and a prominent udder vein. However, udder conformation varies depending on different regional types, age, and stage of lactation (13,15)

Given the scarcity of studies concerning the morphology and morphometrics of camels in Al-Muthanna Governorate, this study aimed to investigate the morphological structure of the mammary gland during pre- and post-pubertal periods and the changes that have occurred to it, and to compare histological, morphological, and morphometric changes in the mammary glands during these periods.

## MATERIALS AND METHODS

During this study, the morphological description of the mammary glands in camels before slaughter was used to illustrate the morphological changes of the glands. A measuring tape, Vernier Caliper, and a sensitive digital balance were used to record the morphometric measurements of the udder and teats after taking the mammary glands from the slaughtered camels. It is worth mentioning that the weight of the mammary glands was the only measurement taken after slaughter, while all other measurements were taken before slaughter, meaning the animals were standing.

After slaughter, the camels' mammary glands were removed, washed with saline solution, and placed in polystyrene foam boxes on ice and then stored at 4°C until testing. Tomohexol, a contrast agent used in radiological analyses, was used.

Diagnostic imaging of the mammary glands was used, which included three tests—radiography, computed

tomography (CT), and ultrasound—to differentiate and study their internal structures.

The samples were then subjected to Gross Anatomy to study the developments that occurred in the mammary glands before and after puberty.

## Experimental design

During this study, samples were collected from a slaughterhouse and various locations in Al-Muthanna Governorate. These samples were intended for slaughter, meaning they were meant for human consumption or regular commercial slaughter. The animals were not killed specifically for research purposes; the samples were collected after slaughter, in accordance with local regulations. A total of 12 samples were collected from the mammary glands of Arabian camels (*Camelus dromedarius*). The study ran from October 2025 to February 2026 and relied on determining the age of sexual maturity in camels using an age-based formula. The samples were divided into two groups of six each: a pre-pubescent group (1-3 years old) and a post-pubescent group (4-6 years old). The samples underwent clinical examination to ensure they were free of disease. A Canon/Japan digital camera with a resolution of 14.2 megapixels was used to capture images of the mammary glands to illustrate the overall study. The measurements pertaining to the mammary glands included the following:

### A - Udder measurements:

Weight of the udder (g) WU / Udder depth UD (cm) / Udder length UL (cm) / Udder circumference (cm) UC / Udder height at the front quarters (cm) / Udder height at the hind quarters (cm) UHFQ / UHHQ

### B - Teat measurements:

Teat length (mm) TL / Teat diameter at base (mm) TDB / Teat diameter at the apex (mm) TDA / Distance between the front threads (mm) DFT / Distance between the back teats (mm) DBT / Distance between the left teats (mm) DLT / Distance between the right teats (mm) DRT / Length of left front tees (mm) LLFT / Length of right front tees (mm) LRFT / Length of the left posterior threads (mm) LLPT / Length of the right posterior teats (mm) LRPT / Diameter of teats at the apex, anterior left (mm) DTAAL / Diameter of teats at the apex, anterior right (mm) DTAAR / Diameter of the teats at the tip, left behind (mm) DTTLB / Diameter of teats at the tip, right behind (mm) DTTRB

After removing the six samples from the mammary glands of camels immediately after slaughter (three pre-pubescent and three post-pubescent), they were placed in polystyrene foam boxes on ice and then stored at 4°C until testing. Tomohexol, a contrast agent used in radiological analyses, was used. Three tests—radiography, computed tomography (CT), and ultrasound—were employed to examine the mammary glands. A Canon (Japan) digital camera was used to take the images. (16)

It should be noted that these procedures were carried out under the supervision and monitoring of a specialist physician, Dr. Raja Aziz Jabbar, a radiologist and member of the Iraqi Board of Radiology.

### STATISTICAL ANALYSIS

The statistical analysis of the data in this study was performed using SPSS version 26, and the results were presented as mean  $\pm$  standard error (Mean  $\pm$  SE). Differences between the pre-pubertal and post-pubertal groups were assessed using an independent samples t-test. For comparisons between more than two groups, A p-value  $\leq$  0.05 was considered statistically significant . (17).

### RESULT AND DISCUSSION

#### Morphological results

The mammary glands in camels are located in the inguinal region, the udder is divided into two halves, each containing two quarters, and each quarter has a teat.

Morphologically, a radical difference was observed between the mammary glands of camels before and after puberty in terms of size. After puberty, camels had a relatively large udder covered with hair, with the hair thinning towards the teats. This contrasted with pre-puberty camels, which had sparse hair. The udder and teats of camels became larger and more pendulous as the camel aged. A difference in shape was also noted: pre-puberty camels had a relatively flat udder, while after puberty, the udder was relatively spherical. (Continued in Figure 1)

A difference was observed between the distance between the anterior and posterior teats, with the anterior teats being larger than the posterior teats, both before and after puberty. A difference was also observed between the anterior and posterior quarters of the mammary glands in Arabian camels after puberty, with the posterior quarters being larger and pendulous. This difference can be observed with the naked eye. It is also worth mentioning the number of milk ducts in the teat, which ranged from two to three; no teats with only one duct were found. Finally, it should be noted that the mammary glands in camels They differ from one another even if the camels are of the same breed and from the same herd. Another noteworthy point is that the mammary glands are affected by physiological conditions and diseases. Regarding the teats, it was observed that they have a pointed, conical shape, increasing in size after puberty and changing color from light black to dark brown. (Continued in Figure 2)

One of the findings when selecting mammary gland samples was that most camels in Al-Muthanna Governorate are classified as dual-purpose camels. This classification is based on the work of Wardeh in 2004. These results are consistent with several studies, including the research of Al Salihi et al. (2023), which compared lactating and non-lactating camels. While they agreed on the color and shape of the teats, they differed in the number of teat ducts, with the study noting that the camels had two teat ducts.



**Figure 1.** Morphological images the udder of Arabian camels before puberty in terms of position, sagging, and difference in distance between the front and back teats.



**Figure 2.** Morphological images showing the udder of Arabian camels after puberty, illustrating its position, sagging, larger hindquarters compared to the forequarters, and the distance between the fore and hind teats.

#### Morphometric results

Measurements of the udder and teats of Arabian camels revealed a significant difference between the mammary glands before and after puberty. The udder measurements showed a clear difference: the average udder weight before puberty was  $869.5 \pm 200$  g, while the average udder weight after puberty was  $2529 \pm 781.7$  g. These measurements demonstrate the significant increase in udder weight between puberty and before, more than doubling it. This illustrates the development that occurred between these two periods. These results were consistent with his (30,31) ( See Table 1)

The development is not limited to weight alone; the udder measurements before puberty were: udder depth (cm)  $8.683 \pm 0.752$  cm, udder circumference (cm)  $14.893 \pm 1.839$  cm, udder height at the front quarters (cm)  $6.474 \pm 1.283$  cm, and udder height at the hind quarters (cm)  $7.962 \pm 1.479$  cm and Udder length (cm)  $8.983 \pm 1.057$  cm and Udder height (cm)  $8.417 \pm 1.668$  cm. ( See Table 1)

In contrast, the udder measurements after puberty were: Udder depth (cm)  $11.42 \pm 1.73$  cm, Udder circumference (cm)  $27.67 \pm 7.47$  cm, Udder height at the front quarters (cm)  $10.59 \pm 2.30$  cm, Udder height at the hind quarters (cm)  $10.78 \pm 2.14$  cm, Udder length (cm)  $23.0 \pm 3.03$  cm, Udder height (cm)  $8.78 \pm 1.69$  cm. ( See Table 1)

We observe from the following measurements of the samples that the hind quarters are higher (hang more) than the front quarters, with a noticeable increase in weight, depth, height, and circumference. The udder length in post-pubertal samples was greater than in pre-pubertal

samples. These results were consistent with those of (32,33,34,35,36). ( See Table 1)

Based on the statistical analysis, which used the t-test to clarify the difference between the two groups compared, namely before and after puberty, it was found that all measurements related to the udders had a statistically significant difference, i.e., they were statistically significant at (p-value  $\leq 0.05$ ), These results are consistent with those of (32,36) ( See Table 1)

Regarding the average teat measurements, a difference was observed between pre- and post-pubertal samples.

Pre-pubertal measurements included: teat length (mm)  $29.167 \pm 8.352$  mm, teat diameter at base (mm)  $17.56 \pm 1.882$  mm, teat diameter at the apex (mm)  $9.413 \pm 1.091$  mm, distance between the front teats (mm)  $29.80 \pm 5.65$  mm, distance between the back teats (mm)  $23.88 \pm 3.85$  mm, distance between the left teats (mm)  $13.99 \pm 3.13$  mm, distance between the right teats (mm)  $18.23 \pm 3.99$  mm, length of the left front teats (mm)  $19.99 \pm 2.27$  mm, and length of the right teats . Front teats (mm)  $17.71 \pm 1.15$  mm, Length of the left posterior teat (mm)  $22.27 \pm 2.23$  mm, Length of the right posterior teat (mm)  $22.24 \pm 3.89$  mm, Diameter of teats at the apex, anterior left (mm)  $14.90 \pm 2.78$  mm, Diameter of teats at the apex, anterior right (mm)  $13.59 \pm 4.06$  mm, Diameter of the teats at the tip, left posterior (mm)  $16.61 \pm 4.44$  mm, Diameter of teats at the tip, right posterior (mm)  $16.73 \pm 7.71$  mm. ( See Table 2)

As for the average post-pubertal measurements, the teat length (mm) was  $40.93 \pm 7.52$  mm and the teat diameter at base (mm) was  $25.95 \pm 5.20$  mm. And teats diameter at the apex (mm)  $14.49 \pm 3.66$  mm and .Distance between the front teats (mm)  $86.51 \pm 29.29$  mm and Distance between the back teats (mm)  $78.81 \pm 24.60$  mm and The distance between the left teats (mm)  $46.52 \pm 9.82$  mm and .The distance between the right teats (mm)  $37.36 \pm 9.13$  mm and Length of the left front teats (mm)  $48.81 \pm 12.17$  mm and Length of the right front teats (mm)  $44.57 \pm 9.71$  mm and Length of the left posterior teat (mm)  $51.81 \pm 15.40$  mm and Length of the right posterior teat (mm)  $52.96 \pm 12.20$  mm and Diameter. of teats at the apex, anterior left (mm)  $15.97 \pm 1.94$  mm and .Diameter of teats at the apex, anterior right (mm)  $20.06 \pm 1.71$  mm and .Diameter of the teats at the tip, left posterior (mm)  $19.77 \pm 2.07$  mm and Diameter of teats at the tip, right posterior (mm)  $20.70 \pm 1.90$  mm The morphometric data revealed that test length at Post-puberty increased twice the size of Pre-puberty heifer The Teat length increased in which might be attributed to the functional activity. These results were consistent with those of (32,37,9,34,35,36) The data in the morphometric measurements section were reported as follows (Mean  $\pm$  SD)

Regarding nipple measurements, all values were found to be statistically significant using a t-test (p-value  $\leq 0.05$ ) with the exception of: Diameter of teats at the apex, anterior left (mm), which had a significance value of 0.457; and Diameter of the teats at the tip, left posterior (mm), with a significance value of 0.145; and Diameter of

teats at the tip, right posterior (mm), with a significance value of 0.252. These values were considered not statistically significant and did not show a clear difference or tangible change during the pre- and post-pubertal periods. This confirms that the samples did not experience lactation even after puberty, based on the age range used in the study, which suggests that lactating females typically have noticeably rounded teat at the tip. The length of the teat varies greatly, as mentioned in the research of (9). ( See Table 2)

**Table 1.** Gross measurements between of pre-puberty and post-puberty camel udder

Gross Measurements	Mean $\pm$ SE pre	Mean $\pm$ SE post	T-Test	Sig
1. WU	869.5 $\pm$ 81.7 g	2529 $\pm$ 319.2 g	5.04	0.01*
2. UD	8.683 $\pm$ 0.307 cm	11.42 $\pm$ 0.71 cm	3.55	0.01*
3. UC	14.893 $\pm$ 0.751 cm	27.67 $\pm$ 3.05 cm	4.07	0.01*
4. UHFQ	6.474 $\pm$ 0.524 cm	10.59 $\pm$ 0.94 cm	3.83	0.01*
5. UHHQ	7.962 $\pm$ 0.604 cm	10.78 $\pm$ 0.87 cm	2.65	0.05*
6. UL	8.983 $\pm$ 0.432 cm	23.0 $\pm$ 1.24 cm	10.7	0.01*

**Table 2.** Gross measurements between of pre-puberty and post-puberty camel teats

Gross Measurements	Mean $\pm$ SE pre	Mean $\pm$ SE post	T-Test	Sig
1-TL	29.167 $\pm$ 3.41 mm	40.93 $\pm$ 3.07 mm	2.56	0.05*
2- TDB	17.56 $\pm$ 0.769 mm	25.95 $\pm$ 2.12 mm	3.71	0.01*
3- TDA	9.413 $\pm$ 0.445 mm	14.49 $\pm$ 1.49 mm	3.26	0.01*
4- DFT	29.80 $\pm$ 2.31 mm	86.51 $\pm$ 11.96 mm	4.65	0.01*
5- DBT	23.88 $\pm$ 1.57 mm	78.81 $\pm$ 10.04 mm	5.41	0.01*
6- DLT	13.99 $\pm$ 1.28 mm	46.52 $\pm$ 4.01 mm	7.73	0.01*
7- DRT	18.23 $\pm$ 1.63 mm	37.36 $\pm$ 3.73 mm	4.70	0.01*
8- LLFT	19.99 $\pm$ 0.93 mm	48.81 $\pm$ 4.97 mm	5.71	0.01*
9- LRFT	17.71 $\pm$ 0.47 mm	44.57 $\pm$ 3.96 mm	6.73	0.01*
10- LLPT	22.27 $\pm$ 0.91 mm	51.81 $\pm$ 6.29 mm	4.65	0.001*
11- LRPT	22.24 $\pm$ 1.59 mm	52.96 $\pm$ 4.98 mm	5.87	0.01*
12- DTAAL	14.90 $\pm$ 1.14 mm	15.97 $\pm$ 0.79 mm	0.773	NS
13- DTAAR	13.59 $\pm$ 1.66 mm	20.06 $\pm$ 0.70 mm	3.60	0.01*
14- DTTLB	16.61 $\pm$ 1.81 mm	19.77 $\pm$ 0.85 mm	1.58	NS
15- DTTRB	16.73 $\pm$ 3.15 mm	20.70 $\pm$ 0.78 mm	1.22	NS

Values represent: (Mean  $\pm$  SE). (\*) significant differences and NS: Not statistically significant (p-value  $\leq 0.05$ ) between different parameter .

## Diagnostic imaging and Gross anatomy results

### Gross anatomy Pre-puberty :

After removal, the mammary glands of camels exhibit a large and branching network of blood vessels. However, these vessels are smaller and less dilated than in camels after puberty. Another notable feature is the presence of elastic ligaments at the back of the udder, specifically the median suspensory ligament. from the Linea alba to prepubic tendon These ligaments act as mechanical supports for the udder, and from them extend the lateral suspensory ligaments. These ligaments separate the right and left halves of the udder with a cavity visible to the naked eye. These results are consistent with those of (19,3) Most teats in both pre-pubertal and post-pubertal camels have two or three milk duct openings. No teat with only one duct has been observed. The duct openings are visible to the naked eye. After the nipple opens, the nipple ducts are clearly visible to the naked eye. They have two openings: a superior opening with the cistern and a inferior opening with the external nipple slit. The nipple ducts are completely separate from each other. These results are consistent with the research of (34,3,23,12)

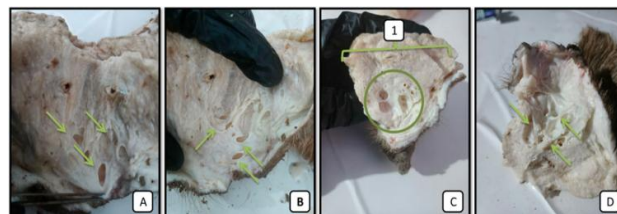
The glandular cistern has a spongy structure composed of separate units separated by elastic septa. It is not a single chamber but rather consists of separate compartments. These compartments gradually decrease in size as they approach the visceral tissue. No difference was observed between the anterior and posterior quadrants in prepubertal specimens. The visceral tissues had a yellowish fatty consistency, unlike those after puberty. These results are consistent with the research of (16,12,30,21)( Continued in Figure 3)

### Gross anatomy Post-puberty

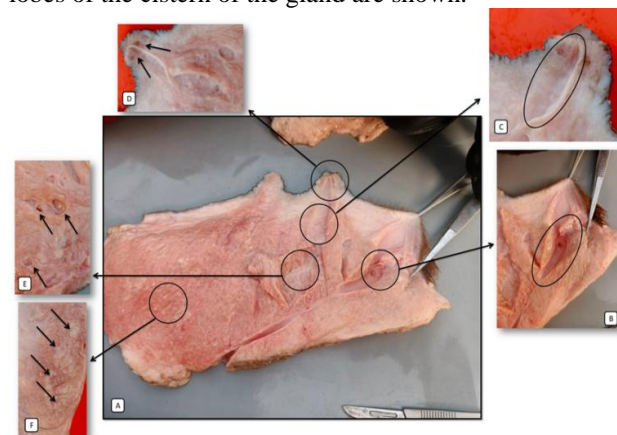
After puberty, growth in the ligaments was observed, along with dilation and branching of the blood vessels, and widening of the nipple duct and Teat cistern . A clear distinction emerged between the anterior and posterior quadrants. The posterior quadrant was wider in terms of both the follicle and gland compared to the anterior quadrant, and the posterior quadrant was larger in volume than the anterior quadrant. These results are consistent with the research of (35,9,21,22)The ducts were characterized by a mucous lining the walls of the nipple ducts, Teat cistern , and Gland cistern.

The visceral tissue was dilated, ranging in color from light red to dark pink, and had a lobular texture, unlike the adipose tissue present in the prepubertal stage. These results are consistent with the research of (12,23) One of the results of comparing mammary glands before and after puberty is that the difference does not depend on the basic parts of the mammary glands. That is, the glands contain a complete milk duct, but this duct is not yet specialized and is not fully developed. What we mean is the complete presence of the parts, which include the external nipple slits, nipple ducts, nipple cistern, glandular cistern, visceral tissue, milk ducts, and ligaments, including the median suspensory ligament and lateral suspensory ligaments. However, all these structures are in an

immature and underdeveloped state. That is, the milk ducts, nipple cistern, gland, and external nipple slits are small, undifferentiated, and have few branches. After puberty, no new parts appear. Instead, we observe greater specialization and development in the mammary glands to provide greater efficiency in milk production. We can observe the widening of the external slits, ducts, and cisterns, and a very noticeable development in the parts. (12,21,16) (See Figure 4)



**Figure 3.** Cross section. The images show the Gland cistern in the udder of camels before puberty : A- Teat cistern cavities, which appear to vary in size. B- The septa, which separate each cavity to form the lobes. C- The cistern of the gland is shown to be connected to the parenchyma tissue, which appears as a white, fatty substance and is designated by the number (1). D-The lobes of the cistern of the gland are shown.



**Figure 4.** Cross section. The image above shows a cross-section of the mammary glands of an adult camel: A- The complete cross-section of the udder of an adult camel B- A blood vessel supplying the parenchyma tissue of the udder is visible C- The teat cistern is visible within a circle D- The teat ducts are visible, with each duct pointing to a specific duct E- The glandular cistern is visible, with each duct pointing to a cavity within the cistern F- The parenchyma tissue of the mammary glands is visible

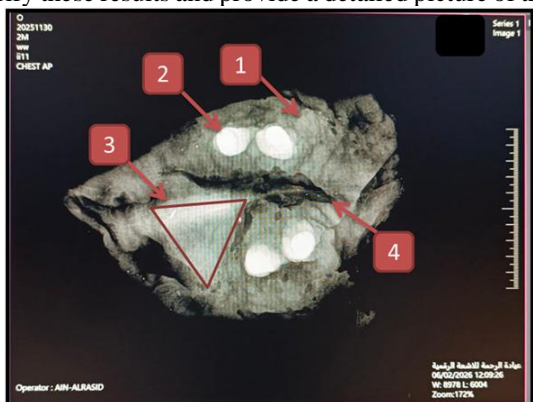
### Radiography Pre-puberty and Post-puberty results

Among the observations to note during the radiological examinations, two methods were used: with and without contrast. Prepubertal X-rays highlighted the median and lateral suspensory ligaments. The septa were clearly connected to the ligaments, but the teat cistern and gland were not visible without contrast injection. The ligaments were larger before puberty compared to after, possibly due to the size of the udder. After contrast injection, only the

teat cistern and gland were visible in the areas and spaces containing the contrast,  
( See Figure 5)

Even after puberty, radiography distinguished areas with more contrast than others. It did not provide detailed images of the specimen except for the spaces containing the contrast material. However, it did identify the ligaments, which resemble an inverted triangle with a groove extending from it, dividing the udder in half.

It should be noted that radiography (X-ray imaging) did not provide much detail about the mammary glands, as the details were very limited, restricted to the glandular cistern and nipple cistern. This means that radiographic imaging is not practical due to the interference of soft tissues and is not expected to yield results in addition to the mammary glands of camels. These results are consistent with the research of (16,3) This paragraph does not state that radiography is useless, but it does state that it is limited in showing full details of the camel's mammary glands and is not expected to provide comprehensive details in future research. The reason for its limitations is the overlap of soft tissues with each other in the mammary glands, and the reason for its use is to clarify these results and provide a detailed picture of them.



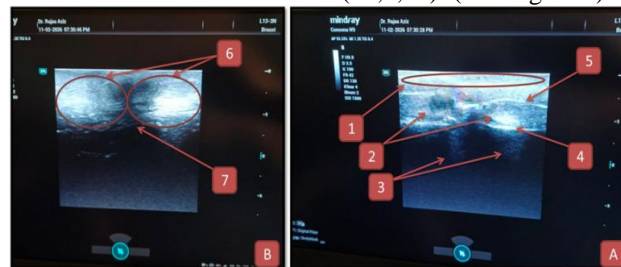
**Figure 5.** The image shows a digital radiography of a camel's udder before puberty: 1-The contrast material is distributed in well-defined pools or "puddles" representing the gland cisterns. 2-The contrast material reveals the four teat sisters separately. 3-The median suspensory ligament appears as a bright triangle in the images. 4- In the center of the image, an irregularly shaped mass of medium density (gray) tissue is visible, representing the udder tissue, mammary glands, and surrounding adipose tissue.

### **Ultrasound ( Ultrasonography ) Pre-puberty and Post-puberty results :**

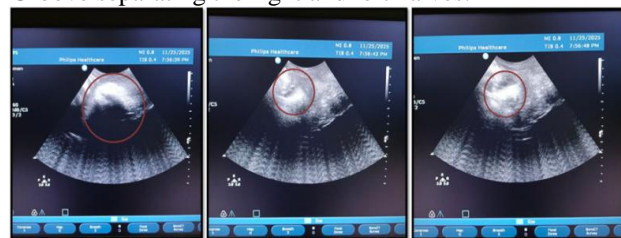
Prepubertal ultrasound revealed different levels of connection between the right and left halves of the mammary gland, distinct from that observed after puberty. The shape of the connection resembled a cross ( $\infty$ ), and this was observed in samples aged one to three years. Researchers hypothesized that this was due to the development of the mammary glands and the separation of the right and left halves. (See Figure 6)

Using ultrasound, the internal structural composition of mammary glands can be determined, including the hypochoic parenchyma and udder cistern. It can also be observed that the glandular tissue appears homogeneous with moderate echogenicity. In addition, ultrasound was able to distinguish the internal spongy structure of the glandular cistern, which is distinguished from other ruminants, including cows, as it is not a single cavity but rather a complex network of ducts. These results are consistent with the research of (13,3,16)

The nipple appeared on ultrasound as a three-layered structure: a hyperechoic outer layer, meaning the outermost layer of the organ strongly reflects sound waves and appears brighter than its surroundings; a thick hypochoic middle layer; and a more echogenic inner layer. The teat canal appeared as an anechoic line ending in a small, rounded anechoic teat cistern. with two hypochoic teat cisterns in the middle. These results are consistent with the research of (13,3,16). (See Figure 7)



**Figure 6.** Lateral and anterior ultrasound images of the mammary gland of a prepubescent camel after contrast injection showing: 1- Parenchymal tissue, 2- Central region and gland cistern, 3- Anterior and posterior teats, 4- Skin line, 5- Septa between the quadrants, 6- Gland cisterns of the right and left anterior quadrants, and 7- Groove separating the right and left halves.

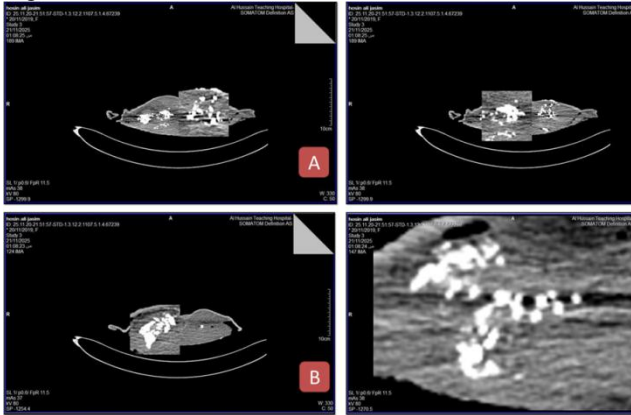


**Figure 7.** The images illustrate ultrasonography of the mammary glands of post-pubertal camels after contrast injection. The red circles indicate the glandular cistern, which appears as a hyperechoic area due to being filled with contrast material, thus providing a clear and detailed view. These quadrants are surrounded by areas containing small lobes filled with contrast material, indicating the milk ducts.

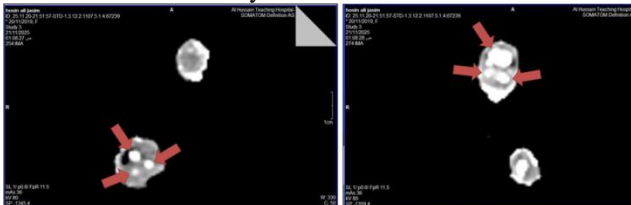
### **computed tomography (CT) Pre-puberty and Post-puberty results**

Before puberty, CT scans revealed the presence of milk ducts, but they were few in number and limited in branching, unlike after puberty. However, in post-pubertal CT scans, Through it, the precise internal division of each udder quarter can be distinguished, and this division can

be determined through the distribution of lobules and internal ducts of the tissue. The cistern and nipple ducts were also visible, indicating their separation. The nipples were conical and pointed at the apex, connected to the tubular cistern. The visceral tissue was more abundant than before puberty. After contrast injection, the glandular cistern became clearly visible and appeared lobulated. It should be noted that, to the best of our knowledge and based on our review of research, we have not found any studies that used computed tomography (CT) on the mammary glands of Arabian camels; therefore, we were unable to compare our results with other findings. (See Figure 8)



**Figure 8.** Images of a camel's udder after puberty, using contrast material and a computed tomography (CT) scanner. The image shows the glandular cistern in each quarter of the segmented udder, which does not appear bright white due to being filled with contrast material. This can be observed by red arrows.



**Figure 9.** Images of camel teats after puberty, using contrast medium and a computed tomography (CT) scanner. The images show the milk ducts of the camel teat, proving that the teat can consist of three ducts, are connected. (Tea cisternal)

### CONCLUSION

The mammary glands are located in the inguinal region of the abdominal wall, consisting of two halves, right and left, each half divided into two quarters, thus forming four teats. and The mammary glands are attached to the udder by the suspensory ligaments, which fix the udder to the abdominal wall. A groove extends from these ligaments, separating the right and left halves, and can be observed with the naked eye and An increase in the weight, depth, length, and circumference of the udder is more noticeable Post-pubertal than before. and The posterior quarters sag more than the anterior quarters Post-pubertal and Teat measurements increase more Post-

pubertal than before and The distance between the anterior teats is greater than the distance between the posterior teats, both before and Post-pubertal and Camel teats contain 2-3 ducts; these ducts are connected to the teat cistern.

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N/A

### Conflict of Interest

The authors declare no conflict of interest.

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