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Original Research Article

MORPHOLOGICAL AND MORPHOMETRIC STUDY OF THE MITRAL VALVE LEAFLETS IN ADULT HUMAN CADAVERIC HEARTS: A CROSS-SECTIONAL ANATOMICAL STUDY

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ABSTRACT

Background: The mitral valve plays an essential role in maintaining one-way blood flow from the left atrium to the left ventricle. Variations in the size and structure of its leaflets are play important role for understanding the cardiac imaging, mitral valve repair, and prosthetic valve replacement. Therefore, detailed knowledge of mitral valve morphology and morphometry is important for anatomists, cardiologists, and cardiac surgeons. The aim is to study the morphometric and morphological variations of the mitral valve leaflets in adult human cadaveric hearts.

Materials and Methods: A cross-sectional cadaveric study was conducted in the Department of Anatomy, GCS Medical College, Ahmedabad, on 50 adult human cadaveric hearts with intact mitral valve complexes. Hearts with congenital anomalies, previous cardiac surgery, severe calcification, infective endocarditis, or decomposition were excluded. After standard dissection, the left atrium and left ventricle were opened to expose the mitral valve. The width and height of the anterior and posterior leaflets were measured using a digital Vernier calliper. The number of leaflets and the number and distribution of scallops were recorded. Data were tabulated and statistically analysed.

Results: The mean width of the anterior and posterior leaflets was 19.61 ± 3.54 mm and 21.15 ± 3.45 mm, respectively. The mean height of the anterior leaflet was 13.89 ± 2.02 mm, while that of the posterior leaflet was 9.27 ± 3.45 mm. Bicuspid morphology was the predominant pattern, observed in 44 (88%) specimens, whereas tricuspid and tetracuspid configurations were found in 5 (10%) and 1 (2%) specimens, respectively. The posterior leaflet demonstrated greater morphological variability in scallop pattern than the anterior leaflet. Two scallops were the most frequent posterior leaflet configuration (30%), followed by single (24%), three (16%), and four scallops (2%). Anterior leaflet scallops were uncommon, with single and two scallops observed in only 4% and 2% of specimens, respectively.

Conclusion: The mitral valve exhibited significant morphological and morphometric variations. The posterior leaflet was broader with greater scallop variability, while the anterior leaflet was taller. Bicuspid morphology was the predominant configuration. These findings provide useful anatomical reference data for mitral valve imaging, repair, and prosthetic valve design.

Keywords: Mitral valve, Leaflets, Scallops, Cadaveric study.

INTRODUCTION

The mitral orifice smaller than the tricuspid orifice, is a well-defined transition zone between the left atrial wall and the inserted margin of the mitral valvular leaflet basis. The mitral valvular leaflets have long been described as paired structures. The name is bicuspid valve "explicit but erroneous as a descriptor because the leafets are not cuspid or peaked in form.

A small accessory leaflets is always found between the two major leaflets (aortic and mural) and so the mitral valve is better describe as a continuous veil that is attached around the entire circumference of mitral orifice. Two indentations are sufficiently deep and regular to be defined as the ends of the solitary and oblique zone of apposition or the commissures of the valve. This inferoseptal (anteromedial) and superoposterior (posterolateral) extremities of the solitary zone of apposition may be regarded as two independent commissures.

The mural leaflet usually has two or more indentations on its free margin that forms scallops. Due to lack of definition of major intervalvular commissures has led to the possible existence to the accessory scallops.[1]

Mitral valve dysfunction is one of the most common valvular diseases affecting the left ventricle. The mitral valve plays an important role in maintaining normal forward blood flow and preserving the structural and functional integrity of the left ventricle. Structural abnormalities of any component of the valve can lead to mitral stenosis or mitral regurgitation. In severe cases, surgical repair or replacement of the damaged valve with a prosthetic valve is required. At present, valve repair and replacement are performed using biological tissues or synthetic materials. The commonly used grafts include: Homograft (allograft): transplantation of human cadaveric valves. Auto graft: transplantation of the patient's own tissue, such as fascia lata or pericardium. Heterograft (xenograft): transplantation of bovine pericardial tissue into the patient.

Mitral valve prolapses (MVP), also known as floppy mitral valve (FMV), is now widely recognized as a significant clinical condition. Patients with MVP may experience sudden cardiac death even in the absence of significant mitral regurgitation. Floppy mitral valve is considered an important underlying cause of both MVP and mitral regurgitation. Mitral valve prolapse shows variable clinical expression, ranging from mild to severe forms of valvular abnormality, and can occur across different age groups.[2]

MATERIALS AND METHODS

Study design: Cross sectional cadaveric study
Study place: Department of anatomy, GCS medical college Ahmedabad.
Sample size: 50 adult human cadaveric hearts
Collection of specimens: The current study of mitral valve measurements was done with cadaveric hearts from GCS medical college Ahmedabad. Total of 50 hearts (irrespective of age and sex) were included in study.

Inclusion criteria

Human adult cadaveric heart specimens with an intact left atrium, left ventricle, and mitral valve complex without any gross deformity.

Exclusion criteria

Hearts with evidence of congenital cardiac anomalies or decomposed and also Hearts with previous history of cardiac surgery. (coronary artery bypass surgery or valvular surgery, valve calcification or infective endocarditic changes).

Dissection of specimens: The heart was preserved by embalming. The specimen was in good condition after removal from body. After dissection the Position and orientation of the heart and its chambers were confirmed, left atrium was opened by an incision through the right and left inferior pulmonary veins and the upper part of left atrial auricle was dissected.

The heart thus opened was emptied of blood clots inside- washed thoroughly in running tap water. The mitral valve was inspected from above. Out flow tracked of the left ventricle was opened by an incision on the sternocostal surface of the heart extending from the apex, parallel and close to the inter ventricular septum up to the aortic orifice,

The following Morphological features and Morphometric parameters of mitral valve were studied namely:

1. Number of cusps. The number of cusps was considered separate only when the fissures of the cusps touched the margin of annulus.
2. Width of anterior and posterior leaflet at the base was measured by using digital Vernier calliper.
3. Height of anterior and posterior leaflet from base to apex was measured by using digital Vernier calliper.
4. A number of scallops were noted.
5. Position of scallops anterior or Posterior were observed.

All the collected data were tabulated in excel sheet and statistically analysed.

RESULTS

The morphometric analysis demonstrated differences in the dimensions of the anterior and posterior leaflets. The mean width of anterior leaflet was 19.611 ± 3.54 mm, with values ranging from 9.09 mm to 26.14 mm, While the mean width of posterior leaflet showed a slightly greater mean value of 21.146 ± 3.45 mm, ranging from 10.07 mm to 26.78 mm. The mean height of anterior leaflet was 13.887 ± 2.02 mm, with a range of 9.46 mm to 17.79 mm, whereas the mean height of posterior leaflet was comparatively lower, with value ranging between 9.274 ± 3.45 mm and of 5.32 mm to 12.84 mm. Overall, the posterior leaflet exhibited greater width, while the anterior leaflet showed comparatively higher dimensions in height.

Table 1: Width and Height of mitral valve leaflets

Width				
Width	**Min**	**Max**	**Mean**	**SD**
Anterior	9.09	26.14	19.611	± 3.54
Posterior	10.07	26.78	21.146	± 3.45
Height				
Anterior	9.46	17.79	13.887	± 2.02
Posterior	5.32	12.84	9.274	± 3.45

Table 2: Mitral valve according to number of leaflets:

Classification	**No.**	**Percentage**
Bicuspid	44	88%
Tricuspid	5	10%
Tetracuspid	1	2%

The morphological classification of the 50 observed specimens revealed that the bicuspid type was the most common configuration, identified in 44 specimens (88%). The tricuspid type was observed in 5 specimens (10%), while the tetracuspid type was the least common, found in only 1 specimen (2%). These findings indicate a clear predominance of the bicuspid pattern in the present study, whereas tricuspid and tetracuspid variations were comparatively rare. The observed variations may have important anatomical and clinical significance and can provide useful baseline data for further morphological and surgical studies.

Table 3: Number of scallops present at leaflets

No. of scallops	**Total case(Posterior)**	**Total case(Anterior)**
Single	12 (24%)	2 (4%)
Two	15 (30%)	1 (2%)
Three	8 (16%)	-
Four	1 (2%)	-

The analysis of scallop patterns demonstrated variation in both the posterior and anterior leaflets. In the posterior leaflet, two scallops were the most commonly observed pattern, present in 15 cases (30%), followed by single scallops in 12 cases (24%). Three scallops were identified in 8 cases (16%), whereas four scallops were observed in only 1 case (2%), indicating that higher scallop numbers were relatively uncommon.

In the anterior leaflet, single scallops were observed in 2 cases (4%), while two scallops were noted in 1 case (2%). No cases with three or four scallops were identified in the anterior leaflet. These findings suggest that the posterior leaflet exhibited greater morphological variability in scallop number compared to the anterior leaflet.

Figure 1: Tricuspid

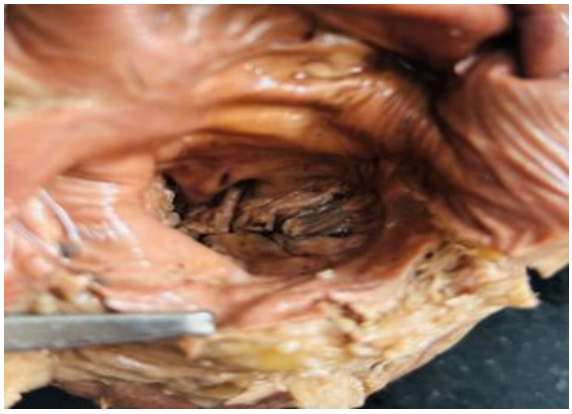

Figure 2: Tetracuspid

Figure 3: Scallops

Figure 4: Height of CUSP

Figure 5: Width of CUSP

DISCUSSION

Table 4: Comparing width and height of mitral valve leaflets

Study	Anterior leaflet		Posterior leaflet	
	Width	Height	Width	Height
Present (2026)	19.611±3.54mm	13.88±3.45mm	21.146±2.02mm	9.27±3.45mm
S.A.Gunnal et al,[12] (2012)	-	19.60±4.09mm	-	15.069±3.79mm
Agata K. et al,[9] (2017)	-	20.60±4.2mm	-	12.90±2.8mm
N.V.Ganga et al,[10] (2018)	38.43mm	18.31mm	40.875mm	16.152mm
Sriambica et al,[8] (2018)	-	23.00mm	-	10.00mm
Shruthi B.N et al,[6] (2019)	22.06±0.59mm	17.02±5.4mm	21.06±5.9mm	16.080±0.51mm
Geethanjali S. et. al,[11] (2022)	28.40±4.7mm	19.90±3.5mm	40.00±5.3mm	12.50±2.2mm
Bhagyashree et al,[2] (2023)	-	-	37.20mm	-
Khedekar DN. et al,[7] (2025)	25.50±2.10mm	19.3±1.70mm	33.70±3.20mm	13.80±1.60mm

The comparative morphometric analysis of the mitral valve leaflets demonstrated considerable variation in the dimensions of the anterior and posterior leaflets among different studies. In the present study (2026), the mean width and height of the anterior leaflet were 19.611 ± 3.54 mm and 13.88 ± 3.45 mm respectively, whereas the posterior leaflet showed a mean width of 21.146 ± 2.02 mm and height of 9.27 ± 3.45 mm. The anterior leaflet height observed in the present study was comparatively lower than that reported by S.A. Gunnal et al.[12] (2012), Agata K. et al,[9] (2017), Sriambica et al,[8] (2018), Shruthi B.N. et al,[6] (2019), Geethanjali S. et al,[11] (2022), and Khedekar D.N. et al,[7] (2025). Similarly, the posterior leaflet height in the present study was also lower than most previous studies.

The width of both anterior and posterior leaflets in the present study was smaller compared to studies by N.V. Ganga et al.[10] (2018), Geethanjali S. et al,[11] (2022), and Khedekar D.N. et al,[7] (2025), which reported relatively larger leaflet dimensions. However, the posterior leaflet width in the present study was comparable to that reported by Shruthi B.N. et al,[6] (2019). These differences in morphometric measurements may be attributed to variations in sample size, demographic characteristics, racial differences, cadaveric preservation methods, and measurement techniques used in different studies.

Table 5: Comparison of number of mitral valve leaflets:

Study	Sample size	Bicuspid	Tricuspid	Tetracuspid	Pentacuspid	Hexacuspid
Present(2026)	50	44	5	1		
Gunal S.A. et al.[12](2012)	116	65	21	18	4	2
Sri ambica K. et al.[8](2018)	50	48	2	-	-	-
Shruthi B.N.et al.[6](2019)	60	48	11	1	-	-

The comparative analysis of cusp morphology of the mitral valve revealed that the bicuspid pattern was the most common configuration in all studies. In the present study (2026), out of 50 specimens examined, 44 cases showed bicuspid morphology, 5 cases showed tricuspid morphology, and 1 case demonstrated tetracuspid morphology. No pentacuspid or hexacuspid valves were observed in the present study.

Gunal S.A. et al,[12] (2012), in a larger sample size of 116 specimens, also reported bicuspid morphology as the predominant type with 65 cases, followed by tricuspid (21 cases), tetracuspid (18 cases), pentacuspid (4 cases), and hexacuspid (2 cases). Sri Ambica K. et al,[8] (2018) observed bicuspid morphology in 48 out of 50 cases and tricuspid morphology in only 2 cases, without any higher cusp variations. Similarly, Shruthi B.N. et al,[6] (2019) reported bicuspid morphology in 48 cases, tricuspid in 11 cases, and tetracuspid morphology in 1 case among 60 specimens studied.

Overall, bicuspid morphology was consistently the predominant pattern across all studies, whereas tricuspid and tetracuspid variations were comparatively less common. Higher cusp variations such as pentacuspid and hexacuspid morphology were rare and were reported only by Gunal S.A. et al (2012).[12]

Table 6: Comparison of scallop's number

Number	Single	Two	Three	Four	Five	Six
Present study(2026)	12	15	8	1	-	-
Bhagya shree et. al.[2](2023)	8	10	28	3	-	1
Kumar BS et. al.[3](2013)	18	9	6	12	15	-
Udhay et. al.[4](2014)	31	40	210	31	8	-
Bezzare et al.[5](1994)	1	7	91	1	-	-

The present study demonstrated considerable variation in the number of scallops observed. Two scallops were the most common finding, observed in 15 cases, followed by single scallops in 12 cases and three scallops in 8 cases. Four scallops were noted only in 1 case, while no cases with five or six scallops were observed. In comparison, Bhagya Shree et al,[2] (2023) reported a predominance of three scallops (28 cases), with fewer cases showing single, two, four, and six scallops. Similarly, Kumar BS et al,[3] (2013) observed wide variation, including cases with up to five scallops, whereas Udhay et al,[4] (2014) also found three scallops to be the most frequent pattern, followed by two and single scallops. Furthermore, Bezzare et al,[5] (1994) predominantly reported three scallops in their study. The differences among these studies may be attributed to variations in sample size, demographic factors, and methodological approaches.

The present morphometric and morphological study of the mitral valve demonstrated considerable variation in leaflet dimensions, leaflet configuration, and scallop patterns. The posterior leaflet exhibited a greater mean width than the anterior leaflet, whereas the anterior leaflet showed a greater mean height, reflecting the normal structural asymmetry of the mitral valve. Morphological assessment revealed that the bicuspid configuration was the predominant pattern, while tricuspid and tetracuspid variants were infrequent anatomical variations. Furthermore, the posterior leaflet displayed significantly greater variability in scallop number compared with the anterior leaflet, with two scallops representing the most common pattern.

CONCLUSION

These findings provide important baseline anatomical data on the morphometry and morphology of the mitral valve, which may be valuable for cardiac surgeons, echo-cardiographers, and interventional cardiologists during mitral valve repair and replacement procedures. Recognition of these normal anatomical variations may improve surgical planning, facilitate accurate interpretation of imaging studies, and contribute to the development of prosthetic valve designs. Further studies involving larger sample sizes and different populations are recommended to validate these observations and establish population-specific anatomical reference values.

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