DOI: 10.7860/IJARS/2022/52827.2754

Original Article

Anatomy Section

Morphometry of Mitral Valve Leaflet for Reconstructive Surgery in Human Cadaveric Hearts of South Indian Population

GEETHANJALI SAVALGI[1], V JAYANTHI[2], JP SHRUTHI[3], H MOHAN KUMAR[4]

ABSTRACT

Introduction: The pumping capacity of heart is affected by disorders involving the valves of the heart. The mitral valve in human cadaveric heart comprises of annulus, leaflets, chordae tendinae and papillary muscle.

Aim: To find morphometric analysis of normal mitral valve leaflets in the cadaveric hearts for the conservative surgical techniques.

Materials and Methods: The morphometric observational analysis was done on 50 heart of embalmed adult human cadaver of both sexes (28 males, 22 females) age between 20-60 years which were taken from the Department of Anatomy during 2016-2018 in Vydehi Institute of Medical Science and Research Centre, Bangalore, Karnataka, India. Parameters measured were length and breadth of anterior and posterior leaflet, length of anterior and posterior commissure, and length of free edge of both leaflets of mitral valve. Descriptive statistical analysis was done and Mean±SD (Standard Deviation) (Min-Max) and percentage of parameters was calculated by using statistical software Statistical Package for the Social Sciences (SPSS) version 15.0.

Results: The mean length of anterior and posterior mitral valve leaflets was 1.99±0.35 cm and 1.25±0.22 cm, respectively, breadth of anterior and posterior mitral valve leaflets was 2.84±0.47 cm and 4.00±0.53 cm. The length of anterior leaflet was more than posterior leaflet. Breadth of posterior leaflet was more than anterior leaflets. Length of anterior commissure (0.65±0.11 cm) was more than posterior commissure (0.64±0.08 cm) in males.

Conclusion: On the basis of the findings of the present study, the morphometric parameters of mitral valve leaflet was important for cardiac Surgeons during operation to assess the exact mechanical reason for valve insufficiency and in manufacture of prosthesis for mitral valve replacement.

Keywords: Clefts, Chordae tendinae, Commissures, Scallops, Valve replacement

INTRODUCTION

The mitral orifice is a well defined transitional zone between the atrial wall and the bases of the cusps. It lies posterior, inferior and slightly to the left of aortic valve. The orifice has two cusps and resembles to bishop's mitre, hence the name is given as bicuspid valve or mitral valve. Mitral annulus is an area where anterior and posterior leaflets were attached to junction of atrial and ventricular chamber. The anterior leaflet occupy one third of annulus whereas posterior occupy two third of annulus [1].

The junction of anterior and posterior leaflets has indentations known as anterior and posterior commissures. The chordae tendinae arises from the papillary muscles was attached to both leaflets of the mitral valve. The two mitral valve leaflets are actually a single continuous structure that becomes confluent at the commissures. Indentations was absent in anterior leaflet when compared to posterior leaflet. The posterior leaflet has three indentations of which the middle indentation was larger and has two smaller indentations on either side of it [2]. Anterior leaflet provides smooth contoured surface for the streamlined ejection of blood flow through the left ventricle outflow tract [3]. Identification of the individual scallops of posterior leaflet was significant in cases of prolapsed posterior leaflet with mitral regurgitation [4]. The posterior commissurotomy more often was followed by a surgically produced valvular incompetence. No commissurotomy should ever reach the mitral ring, because of the importance of maintaining a cuff of valvular tissue to ensure the closure of the orifice [5].

The mitral valve insufficiency may result from the diseases of heart which affects the valves like stenosis, regurgitation of valves or prolapse of the leaflets. The function of mitral valve depends on the anatomical and mechanical integrity of the atrioventricular ring, the valve leaflets, chordae tendinae and the papillary muscles [6]. The diseased valve of the patient is replaced by a prosthetic valve. The prosthetic valve was made of metal or tissue type. The metal type is made up of stainless steel alloys, molybdenum, pyrolytic carbon, silicon, teflon or polyster [7]. The comparative evaluation of study group of right atrioventricular valve showed similar values when evaluated by fixed, non fixed and echocardiograms [8]. This knowledge of measurement of mitral valve leaflet may be useful for cardio thoracic surgeons in mitral valve replacement [9].

Thus, the aim of the current study was to do a morphometric analysis of normal mitral valve leaflets in the cadaveric hearts for the conservative surgical techniques.

MATERIALS AND METHODS

The morphometric observational study was done on 50 hearts (28 male, 22 female) aged between 20-60 years, taken from previously embalmed adult human cadaver from the Department of Anatomy, Vydehi Institute of Medical Sciences and Research Centre, Bangalore, Karnataka, India, during the period for 36 months from January 2016 to December 2018.

Inclusion criteria: Cadaveric heart without previous history of cardiac surgery was included for the study.

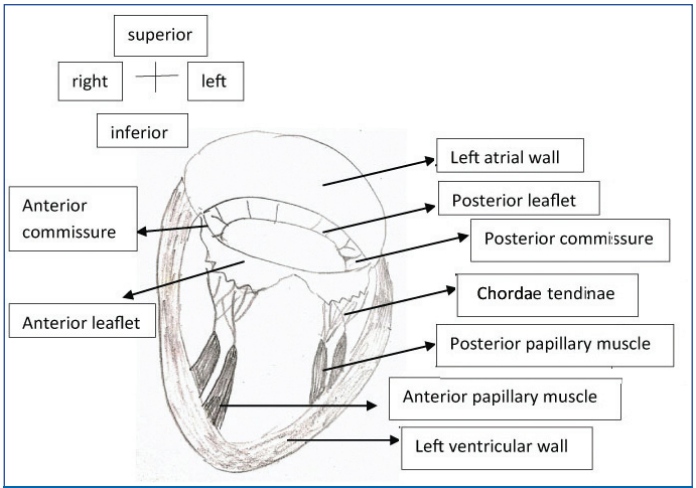
Exclusion criteria: Cadaveric heart with previous history of cardiac surgery such as coronary artery bypass surgery, valvular surgery was excluded from the study.

Dissection of Specimen

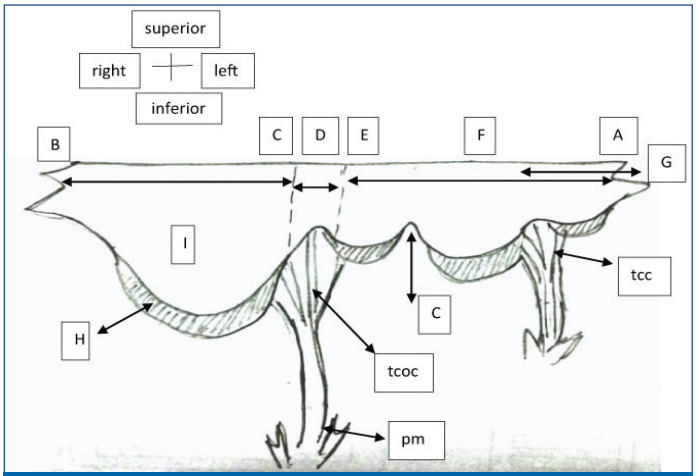
Position and orientation of each heart and its chambers was confirmed by anatomical position of heart. Left atrium was opened and the mitral valve was inspected from above. The left ventricle inflow tract was cut open along the inferolateral aspect through left atrial wall, through the anterolateral commissure of mitral valve between two papillary muscles to reach the apex [9,10].

In each heart, detailed examination of the measurements of the mitral valve, by using vernier calliper manual type, measuring scale, cotton thread, magnifying lens. In each cadaveric heart following parameters of mitral valve was noted, number of leaflets in each valve, number of clefts and scallops of posterior leaflet, variations in the cleft and indentation in each cusp of the mitral valve was observed. The length of anterior and posterior leaflet was measured from free edge to its attachment to the annulus by calliper. The breadth of anterior and posterior leaflet was measured at the line of insertion at the valve ring by calliper.

The length of free margin of both anterior and posterior leaflets was measured by cotton thread along the free edge of both the leaflets. The number and length of each commissure was measured by calliper. The basal zone was identified by attachment of chordae tendinae arising from ventricular wall to posterior leaflet. These observations were found in all 50 specimens of cadaveric hearts taken for the study is represented in [Table/Fig-1] [2]. The basal zone was identified only in posterior leaflets. The rough zone was visualised towards apex of leaflets as a crescentric area which was thicker on palpation and was attached to chordae tendinae on the ventricular surface. The clear zone was identified towards the annulus and was smooth without any chordae tendinae attached to its ventricular surface [Table/Fig-2] [2].



[Table/Fig-1]: Showing mitral valve and its component, anterior and posterior leaflet, commissure, papillary muscle, chorade tendinae of left ventricular chamber [2].



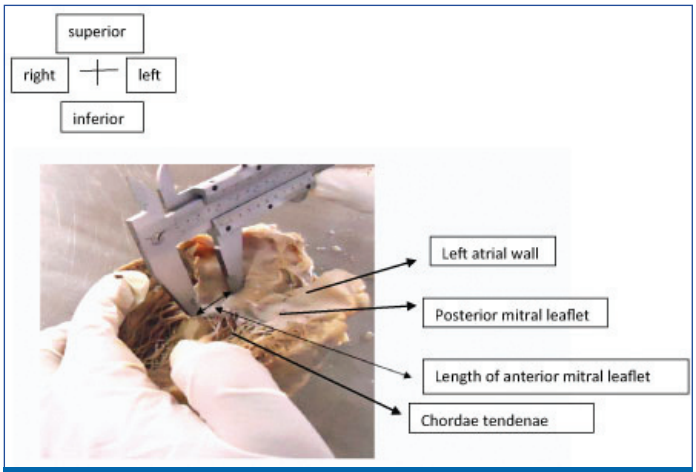
[Table/Fig-2]: Diagrammatic representation of the mitral valve with typical commissural and cleft chordae tendineae attached [2].
A-B=Mitral valve circumference; B-C=anterior leaflet; C-D=posteromedial commissure; D-A=posterior leaflet; D-E=posteromedial commissural scallop; E-F=middle scallop; F-A=anterolateral commissural scallop; c=cleft; pm=papillary muscle; tcoc=typical commissural chorda; tcc=typical cleft chorda; G=basal zone of leaflet; H=rough zone of leaflet; I=clear zone of leaflet

STATISTICAL ANALYSIS

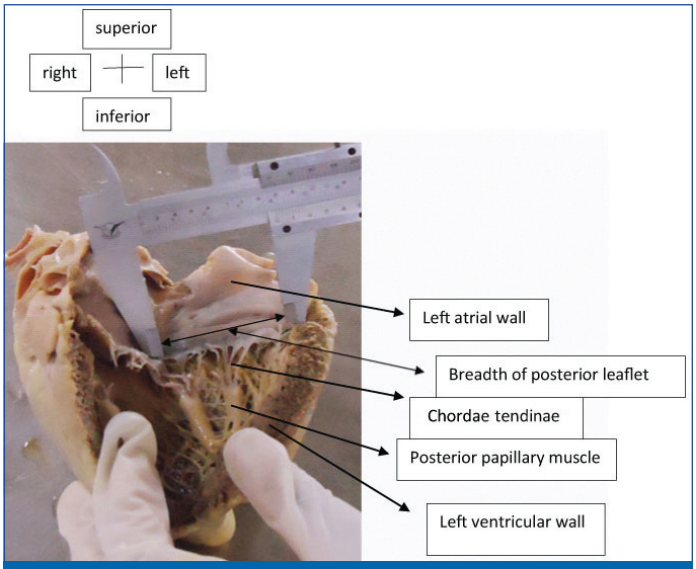
Descriptive statistical analysis was done. The result were presented as mean and Standard Deviation (SD) and percentage by using statistical software SPSS 15.0 [11].

RESULTS

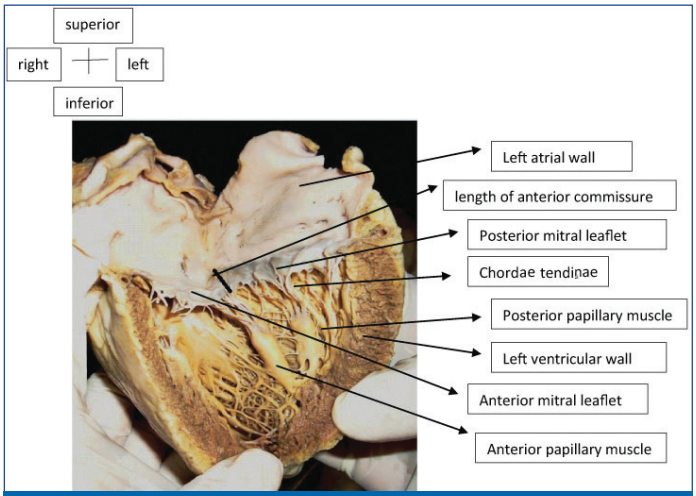
In each heart, a detailed examination of mitral valve was done and different parameters were measured [Table/Fig-3-6] and results are tabulated in [Table/Fig-7].



[Table/Fig-3]: Showing measurement of the length of anterior mitral valve leaflet from annulus to free edge of mitral valve by using vernier calliper measured in cm.

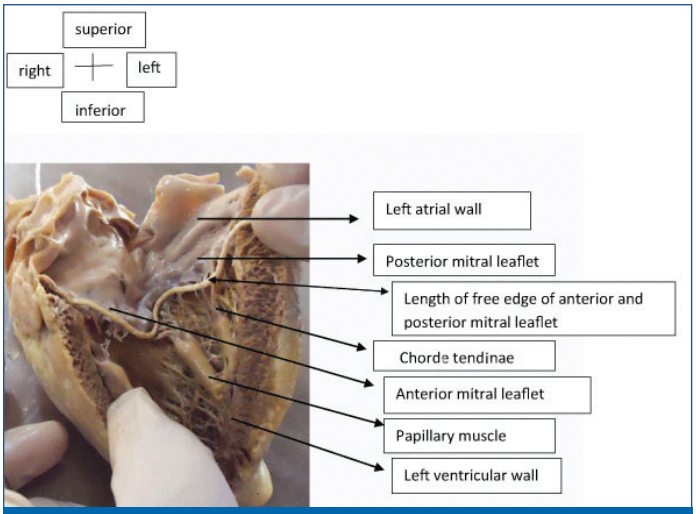


[Table/Fig-4]: Showing measurement of the breadth of posterior leaflet of mitral valve between the anterolateral and posteromedial commissures using vernier calliper measured in cm.



[Table/Fig-5]: Showing measurement of the length of anterior commissure from annulus to free edge of mitral valve between anterior and posterior mitral leaflet by using vernier calliper measured in cm.

In the present study, the mean length of anterior leaflet was 2±0.36 cm in males and 1.98±0.29 cm in females. The length of posterior leaflet was 1.29±0.24 cm in males and 1.20±0.18 cm in



[Table/Fig-6]: Showing the measurement of the length of free edge of both leaflets of mitral valve measured with help of cotton thread and same was measured in measuring scale in cm.

Parameters measured	Male (n=28) M±SD (min-max)	Female (n=22) M±SD (min-max)	Over all mean±SD value (cm)
Length of anterior leaflet	2±0.36 (1.32-2.98)	1.98±0.29 (1.26-2.64)	1.99±0.35
Length of posterior leaflet	1.29±0.24 (0.65-1.91)	1.20±0.18 (0.92-1.72)	1.25±0.22
Breadth of anterior leaflet	2.85±0.55 (1.9-4.52)	2.83±0.32 (2.12-3.52)	2.84±0.47
Breadth of posterior leaflet	3.99±0.58 (2.86-5.62)	4.01±0.43 (3.4-4.8)	4.00±0.53
Length of anterior commissure	0.65±0.11 (0.5-0.95)	0.60±0.05 (0.51-0.71)	0.64 ±0.10
Length of posterior commissure	0.64±0.08 (0.46-0.79)	0.64±0.08 (0.48-0.76)	0.66±0.10
Free edge of both anterior and posterior leaflet	9.42±1.26 (7.5-13)	9.41±1.19 (7-12.2)	9.40±1.23

[Table/Fig-7]: Showing the length and breadth of mitral valve leaflet, commissure, free edge of leaflet in male and female.

females. The breadth of anterior leaflet was 2.85±0.55 cm in males and 2.83±0.32 cm in females. The breadth of posterior leaflet was 3.99±0.58 cm in males and 4.01±0.43 cm in females. The length of anterior commissure was 0.65±0.11 cm in males and 0.60±0.05 cm in females and length of posterior commissure was 0.64±0.08 cm in both male and female. The free edge of leaflet was 9.42±1.26 cm in males and 9.41±1.19 cm in females. All the parameters of mitral valve were greater in males except breadth of posterior leaflets which was more in females. The length of anterior commissure was more than posterior commissure in males, length of posterior commissure was equal both in males and in females. The length of anterior leaflet was more compared to posterior leaflets and breadth of posterior leaflets was more compared to anterior leaflets both in male and females. The edge of the anterior leaflet was smooth and there was no indentation. It was triangular in shape. Free edge of the posterior leaflet showed 2 clefts and 3 indentations in all 50 specimens. The middle indentation was large in all the specimens. The rough zone and clear zone was identified in both the anterior and posterior leaflets.

DISCUSSION

When compared to other studies the mean length of anterior leaflets was more compared to posterior leaflets and mean breadth of anterior leaflets was less compared to posterior leaflets in all the studies including the present study [Table/Fig-8] [4,6,9,10,12-22]. In the present study mean length of anterolateral and posterolateral commissure was less compared to other studies [Table/Fig-9] [4-6,10,16-18,20-24]. The anterior commissure length was more in males than in females in the present study and also in a few studies where relevant data for the same was provided [Table/Fig-10] [4-6,12,13,15,19,20,24].

S. No.	Authors	No. of cadaveric hearts	Publication year, place of study	ALL (in cm)	PLL (in cm)
1	Walmsley T et al., [12]	Unavailable	1929 New York	1.5-1.8	1-1.2
2	Rusted IE et al., [13]	50	1952 United States	2.2	1.25
3	Broke RC [14]	150	1952 United States	1.5-1.8	1-1.2
4	Morris EWT [15]	100	1960 London	2.7	1.3
5	Du plessis LA and Marchand P [16]	10	1964 Johannesburg	2.7	1.3
6	Silvermen ME and Hurts JW [17]	50	1968 United States	1.8-3.2	0.8-2.5
7	Ranganathan N et al., [4]	50	1970 United States	2.4 (M) 2.2 (F)	1.4 (M) 1.2 (F)
8	Patil D et al., [18]	50	2009 Surat, India	1.924	1.104
9	Gunnal SA et al., [19]	116	2012 Maharashtra, India	1.96	1.52+0.42
10	Kumar SB and Anand A [6]	45	2013 Tamil Nadu, India	1.63±0.02	0.95±0.07
11	Mishra PP et al., [20]	120	2014 Lucknow, India	2.11±0.84	1.52±0.42
12	Ilankathir S [10]	50	2015 Puduchery, India	2.42	1.28
13	Agata K et al., [21]	200	2017 Poland	2.06±0.42	1.29±0.49
14	Sriambika K et al., [9]	50	2018 Pondichery, India	1.9±0.26	1±0.16
15	Singh B et al., [22]	52	2018 Allahabad, India	2.03	1.12
16	Present study	50	2022, Bangalore, India	2±0.36 (M) 1.98±0.29 (F) 1.99±0.35 (mean value of both male and female)	1.29±0.24 (M) 1.20±0.18 (F) 1.25±0.22 (mean value of both male and female)

[Table/Fig-8]: Literature review of mitral valve leaflet length ALL- anterior leaflet length, PLL- posterior leaflet length [4,6,9,10,12-22].
Values given in mean min-max or M±SD

S. No.	Authors	Cadaveric hearts	Publication year and place of study	ALB (in cm)	PLB (in cm)
1	Cheichi MA [5]	105	1956 Unavailable	3.7 (M) 3.3 (F)	3.3 (M) 3 (F)
2	Du Plussis LA and Marchand P, [16]	10	1964 Johannesburg	3.5	6.7
3	Silvermen ME and Hurts JW [17]	50	1968 United States	2.4-4.5	2.3 cm-4.1
4	Ranganathan N et al., [4]	50	1970 United States	3.6 (M) 2.9 (F)	2.3 (M) 1.8 (F)
5	Carpentier A et al., [23]	60	1976 New York	3.2±1.3	-
6	Sakai T et al., [24]	57	1999 United states	3.2±4.9	4.7±3.6
7	Patil D et al., [18]	50	2009 Surat, India	3.32	6.7-4.9

8	Kumar SB and Anand A, [6]	45	2013 Tamil Nadu, India	2.85±0.07	3.26±0.03
9	Mishra PP et al., [20]	120	2014 Lucknow, India	3.4±0.87	5.19±1.16
10	Ilankathir S [10]	50	2015 Puduchery, India	3.23	4.82
11	Agata K et al., [21]	200	2017 Poland	3.08±0.49	4.51±0.82
12	Singh B et al., [22]	52	2018 Allahabad, India	2.98	4.02
13	Present study	50	2022 Bangalore, India	2.85±0.55 (M) 2.83±0.32 (F) 2.84±0.47 (mean value of both male and female)	3.99±0.58 (M) 4.01±0.43 (F) 4.00±0.53 (mean value of both male and female)

[Table/Fig-9]: Literature review of mitral valve leaflet breadth (ALB-Anterior leaflet breadth, PLB-Posterior leaflet breadth) [4-6,10,16-18,20-24].
Values given in mean min-max or M±SD

S. No.	Authors	Cadaveric hearts	Publication year, place of study	Anterior Commissure (in cm)	Posterior Commissure (in cm)
1	Walmsley T et al., [12]	Unavailable	1929 New York	1.5-1.8	1-1.2
2	Rusted IE et al., [13]	50	1952 United States	0.8 (M) 0.7 (F)	0.8 (M) 0.7 (F)
3	Cheichi MA et al., [5]	105	1956 United States	0.8 (M) 0.7 (F)	0.7 (M) 0.65 (F)
4	Morris EWT [15]	100	1960 London	2.7	1.3
5	Ranganathan N et al., [4].	50	1970 United States	0.8 (M) 0.7 (F)	0.8 (M) 0.8 (F)
6	Sakai T et al., [24]	57	1999 United Stated	0.7±2.1	0.7±2.1
7	Gunal SA et al., [19]	116	2012 Maharastra, India	1.96±0.42	1.50±0.37
8	Kumar SB and Anand A [6]	45	2013 Tamil Nadu, India	0.73±0.09	0.65±0.07
9	Mishra PP et al., [20]	120	2014 Lucknow, India	0.77±0.1	0.77±0.1
10	Present study	50	2022 Bangalore, India	0.65±0.11 (M) 0.60±0.05 (F) 0.64±0.10 (mean value of both male and female)	0.64±0.08 (M) 0.64±0.08 (F) 0.66±0.10 (mean value of both male and female)

[Table/Fig-10]: Literature review of commissure lengths [4-6,12,13,15,19,20,24].
Values given in mean min-max or M±SD

The mean length of free edge of both leaflets was more than the studies of Du Plussis LA and Marchand P and Patil DS et al., [Table/Fig-11] [16,18].

S. No.	Authors	Cadaveric hearts	Publication year, place	Free edge of leaflets (in cm)
1	Du Plussis LA and Marchand P, [16]	10	1964 Johannesburg, South Africa	9.1
2	Patil D et al., [18]	50	2009 Salem, India	7.36
3	Present study	50	2022 Bangalore, India	9.42±1.26 (M) 9.41±1.19 (F) 9.40±1.23 (mean value of both males and females)

[Table/Fig-11]: Literature review of lengths of the free edges of both edges of both mitral leaflets [16,18].
Values given in mean or M±SD

Improper valve prosthesis replacement may worsen the cardio vascular problems thus these normal morphometric measurement of mitral valve help cardiothoracic surgeon in identifying correct size of the prosthesis for valve replacement like valvotomy, commisurotomy, valvuloplasty [9].

Limitation(s)

Agewise measurement of parameters of leaflets of mitral valve was not done for precise dimension of mitral valve leaflets for cardiothoracic surgeons during mitral valve reconstruction surgeries. The formalin fixation may alter the size of valve measurement in exact prosthesis manufacture.

CONCLUSION(S)

The present study showed mean value of length of anterior and posterior mitral valve leaflets and breadth of anterior mitral valve leaflets and length of anterior commissure was more in males compared to females except breadth of posterior leaflets was more in females and posterior commissure was equal in both male and female. Length of anterior commissure was more than posterior commissure. Accurate knowledge about the normal anatomy of the mitral valve complex is needed in assessing the valve pathology and in manufacture of prosthetic valve replacements during surgical interventions like valvotomy, Valvectomy and valvuloplasty.

REFERENCES

[1] Standring S, Borley NR, Collins P, Crossman AR, Gatzoulis MA, Healy JC, et al. Gray's Anatomy. The Anatomical Basis of Clinical Practice. 40th ed. Elseiver: Churchill Livingstone. 2008: 970-972.
[2] Dutta AK. Essentials of Human Anatomy part 1 Thorax, Abdomen and Pelvis. 4th ed. Kolkata: Current Books International; 2007:72-73.
[3] Jeffrey J, Silbiger, Raveen B. Contemporary insights into the functional anatomy of the mitral valve. American Heart Journal. 2009;158(6):887-95.
[4] Ranganathan N, Lam JHC, Wigle ED, Silver MD. Morphology of the human mitral valve II, the valve leaflets. Circulation. 1970;41:459-67.
[5] Chiechi MA, Lee WM, Thompson R. Functional anatomy of the normal mitral valve. Journal of Thoracic Surgery. 1956;32(3):378-98.
[6] Kumar SB, Anand A. Morphometric study of mitral valve in human hearts-A comparative anatomical study. Int J Pharm Bio Sci. 2013;4(4):(b)105-10.
[7] Ho SY. Anatomy of the mitral valve. Heart. 2002;88(4):05-10.
[8] Tei C, Pilgrim JP, Shah PM, Ormiston JA, Wong M. The tricuspid valve annulus: Study of size and motion in normal subjects and in patients with tricuspid regurgitation. Circulation. 1982;66:665-71.
[9] Sriambika K, Kumar VN, Bage NN. Morphological and morphometric study of mitral valve with reference to anatomical variability in south Indian subjects. Int J Anat Res. 2018;6(4.3):5994-97.
[10] Ilankathir S. A cadaveric study on adult human heart valve annular circumference and its clinical significance. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS). 2015;14(12):60-64.
[11] Rosner B. Fundamentals of Biostatistics. 5th ed. Duxbury; 2000: 80-240.
[12] Walmsley T, Sharpey-Schafer E, Symington J, Bryce TH. The heart, In Quain's Elements of Anatomy. 11th ed .Longmans: Greens & Co.1929:42.
[13] Rusted IE, Schiefley CH, Edwards JH, Studies of the mitral valve. Anatomic features of the normal mitral valve and associated structures. Circulation. 1952;6:825-31.
[14] Brock RC. The surgical and pathological anatomy of the mitral valve. Br Heart J. 1952;14:489-513.
[15] Morris EWT. Some features of the mitral valve. Thorax. 1960;15(70):22.
[16] Du plessis LA, Marchand P. The anatomy of the mitral valve and its associated structures. Thorax. 1964;19:221-27.
[17] Silvermen ME, Hurts JW. The mitral complex, interaction of anatomy, physiology, and pathology of the mitral annulus, mitral valve leaflets, chordae tendinae, and papillary muscles. American Heart Journal. 1968;76(3):399-418.
[18] Patil D, Mehta C, Prajapati P. Morphology of mitral valve in human cadavers. Internet Journal of Cardiology. 2009;7:2.
[19] Gunal SA, Farooqui MS, Wabale RN. Study of mitral valve in human cadaveric hearts. Heart Views. 2012;13(4):132-35.
[20] Mishra PP, Rao MP, Paranjape V, Kulkarni JP. Morphometry of mitral valve. Medical Journal of Dr. D.Y. Patil University. 2014;7(5):625-30.
[21] Agata K, Sorysz D, Siudak Z, Piotrowska K. Morphologic variability of the mitral valve leaflets. The Journal of Thoracic and Cardiovascular Surgery. 2017;154(6):1927-32.
[22] Singh B, Tiwari K, Singh N, Nayak A, Anand M. Morphometry of mitral valve and its variations. International Journal of Contemporary Medical Research. 2018;5(6):F1-F3.

[23] Carpentier A, Guerinon J, Deloche A, Fabiani JN, Relland J. Pathology of the mitral valve. In: Kalmanson D editors. The mitral valve. London: Edward Arnold. 1976;65-77.

[24] Sakai T, Okita Y, Ueda Y, Tahata T, Ogino H, Matsuyama K, et al. Distance between mitral anulus and papillary muscles: Anatomic study in normal human hearts. The Journal of Thoracic and Cardiovascular Surgery. 1999;118(4):636-41.

PARTICULARS OF CONTRIBUTORS:
1. Professor and Head, Department of Anatomy, Sapthagiri Institute of Medical Sciences and Research Centre, Bangalore, Karnataka, India.
2. Principal and Dean, Department of Anatomy, Sapthagiri Institute of Medical Sciences and Research Centre, Bangalore, Karnataka, India.
3. MBBS Student, Department of Anatomy, East Point Institution of Medical Sciences and Research Centre, Bangalore, Karnataka, India.
4. Professor and Head, Department of Opthalmology, Sapthagiri Institute of Medical Sciences and Research Centre, Bangalore, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Geethanjali Savalgi,
No. 45, 5th Cross, Malagal, Bangalore, Karnataka, India.
E-mail: geethamohan76@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Oct 13, 2021
- Manual Googling: Jan 10, 2022
- iThenticate Software: Jan 15, 2022 (10%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? No
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. No

Date of Submission: **Oct 12, 2021**
Date of Peer Review: **Nov 10, 2021**
Date of Acceptance: **Jan 13, 2022**
Date of Publishing: **Apr 01, 2022**