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Original Research Article

Morphological Study of Chordae Tendinae of Human Atrioventricular Valves

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Abstract

Background: Chordae tendinae (CT) are strong cord-like fibro-collagenous structures between valve leaflets and papillary muscles (PM). They are critical in conveying the systolic contraction of the PM to the valve and therefore prevent the collapse and regurgitation. Disintegration of CT can affect the valve competence.

Aims and Objective: To study the number, length, types and branching pattern of chordae tendinae.

Material and Method: The study was carried out on 100 formalin fixed hearts regardless of sex. Dissection was performed according to standard techniques. CT were observed on the basis of number, length, types and branching pattern.

Observations and Results: The mean number of CT attached to anterior cusp were found to be 12.24 in LAVV and 14.81 in RAVV, in posterior cusp 12.39 in LAVV and 12.62 in RAVV, in accessory cusp 12.75 in LAVV and 9.17 in RAVV. In case of RAVV, the mean number of CT found in septal cusp were 10.96.

For RAVV, length of the largest and the shortest CT of tricuspid heart valves were significantly higher than those of LAVV. For posterior heart valves,length of the largest CT was significantly higher in LAVV as compared to RAVV. 4 types of CT were found i.e., muscular, tendinous and membranous. The branching pattern observed were straight, branched, spiral and web forming.

Conclusions: This knowledge would help cardiac surgeon during procedures like chordal cutting and chordal dislocation for correction of valve dysfunctions.

Keywords: Fibro-collagenous, Computer Tomography (CT), Branching Pattern.

Introduction

Chordatendinae (CT) are strong cord-like fibro-collagenous structures between valve leaflets and papillary muscles. These columnar structures are connected to the mitral and tricuspid valves and modulate the transmission of strain to the valve leaflets [1].

They arise from the tips of the papillary muscles on the inside of the wall of the ventricle and extend into the hollow lumen. Most of the chorda tendinae separate into two or more branches, but some resemble simple unbranched strings. In the right ventricle, the chordae tendinae connect to the 3 cusps while in the left ventricle they connect to the 2 cusps. The atrioventricular (AV) heart valves are responsible for directing unidirectional blood flow in the heart by properly opening and closing the valve leaflets, which are supported in their functions by the chordae tendineae. They are critical for distributing forces during systolic closure from the leaflets to the papillary muscles, preventing leaflet prolapse and consequent regurgitation.

Therefore it is important to have a brief knowledge about morphology and morphometry of CT. The target of this study is to attain maximum information about the anatomical morphology and

morphometry in both right and left atrioventricular valve.

Material and Methods

The present observational study was conducted on 100 formalin fixed human hearts in the Department of Anatomy, King George's Medical University, Lucknow, UP.

Exclusion Criteria: Specimens of hearts with disrupted valves and with any pathology like valve prolapse, dilatation were not included for the study.

Inclusion Criteria: Specimen of human cadaveric hearts with normal anatomy of either sex were included for this study.

In order to visualize the chordae tendinae of right atrioventricular valve (RAVV), the 1st incision was started from the level of entry of the superior vena cava(SVC) into the right atrium till the level of entry of inferior vena cava(IVC) into right atrium.

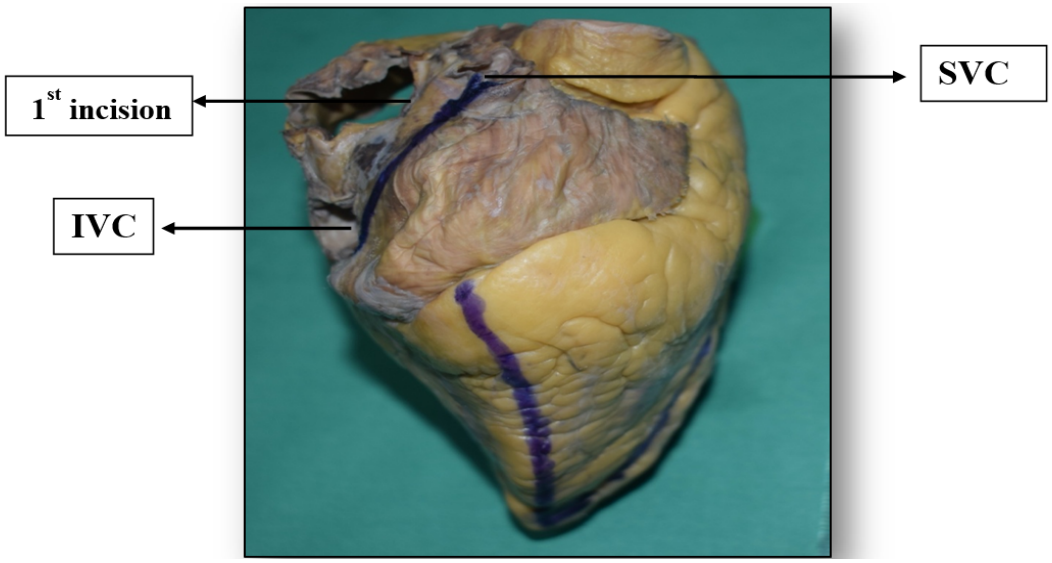

Figure 1: showing first line of incision to visualize RAVV

- Along the inferior border of the heart, the 2nd incision was given till anterior inter-ventricular groove.
- Right to the anterior inter-ventricular groove, the 3rd incision was made.
- Wall was retracted and the interior was washed under tap water thoroughly to remove the clots and to visualise the chordae tendinae[2].

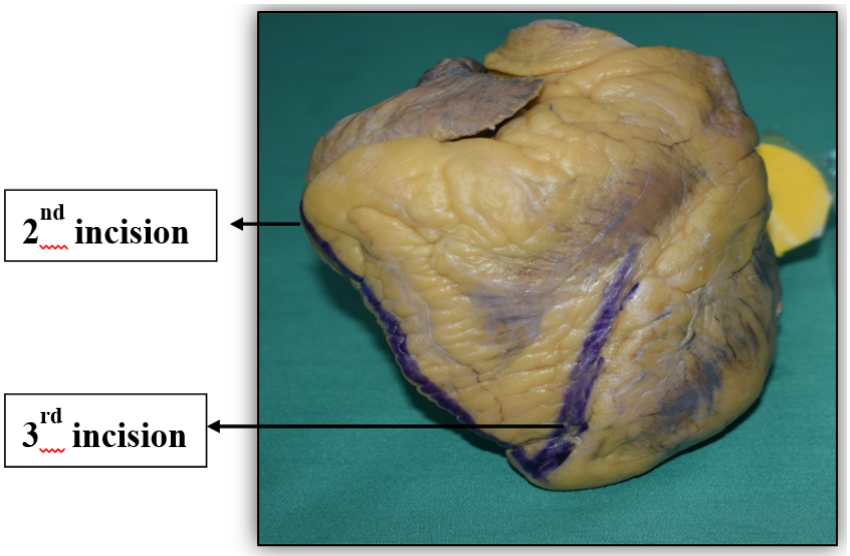

Figure 2:

For left atrioventricular valve(LAVV) apparatus, another incision was made on the left margin of the heart which was extended till the apex of the heart to open the left ventricle. After that the LAVV was retracted and observed[3].

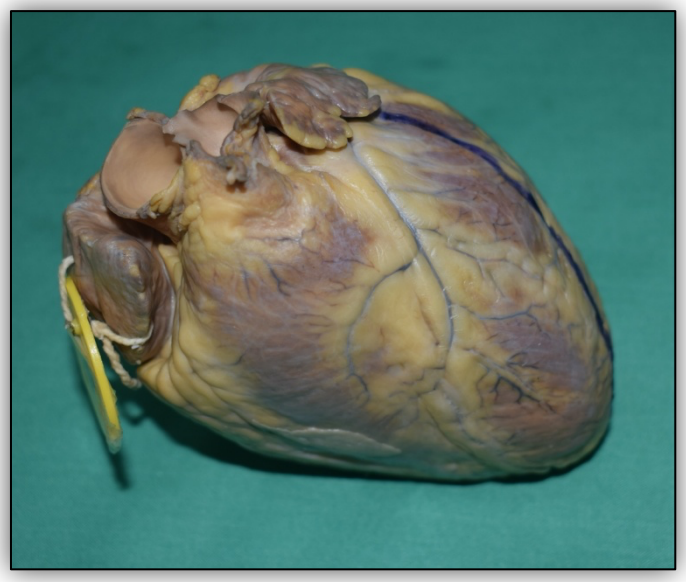

Figure3: showing line of incision to visualize LAVV

The following observations were made regarding chordae tendinae:

Length of chordae tendinae: It was measured from the tip of the papillary muscles to the edges of the cusp with the help of Vernier caliper.

Figure 4: showing method of measuring length of CT with the help of Vernier Caliper.

Types of chordae tendinae:

- **Muscular**- thick spongy and round chordae tendinae were classified as muscular chordae.
- **Tendinous**- thin and thread-like chordae tendinae were classified as tendinous chordae.
- **Membranous**- flattened chordae were classified as membranous chordae tendinae.

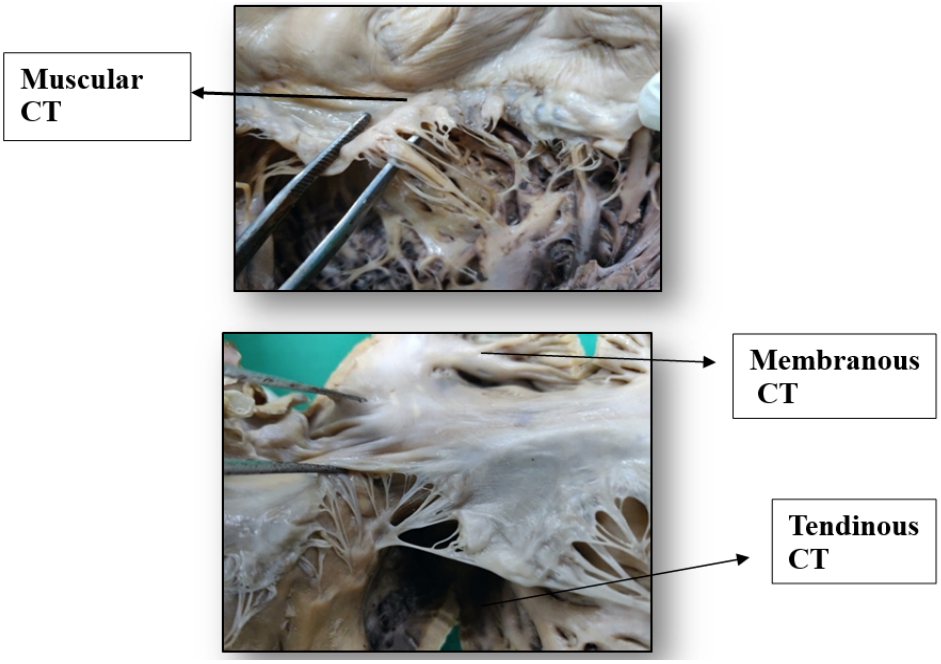

Figure 5:

Branching pattern of chordae tendinae:

- **Straight**- chordae tendinae which were unbranched were put into this category.
- **Fan shaped**- these were chordae tendinae that showed branching.
- **Dichotomous**- these are spiral chordae.
- **Irregular**- these chordae tendinae showed web-like arrangement.

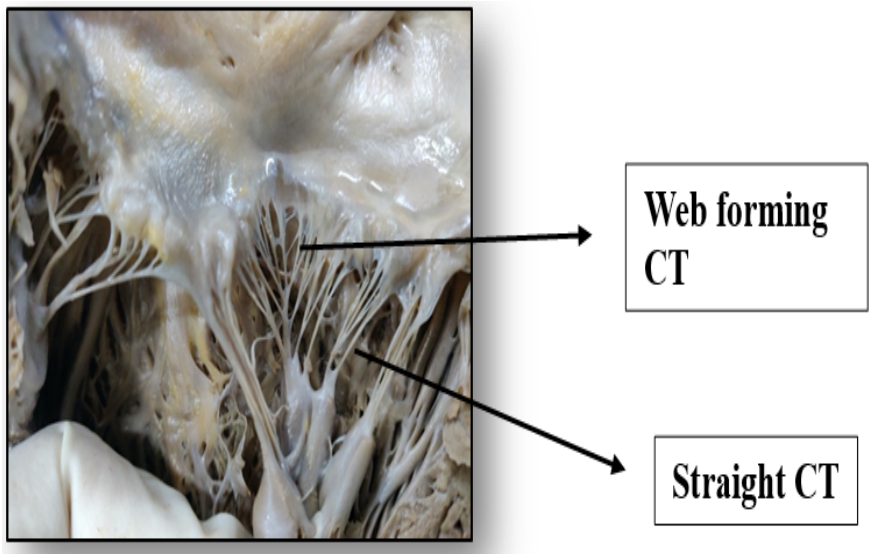

Figure 5:

Statistical tools employed: The statistical analysis was done using SPSS (Statistical Package for Social Sciences) Version 21.0 statistical Analysis Software. The values were represented in Number (%) and Mean±SD.

The following Statistical formulae were used:

1. Mean: To obtain the mean, the individual observations were first added together and then divided by the number of observations. The operation of adding together or summation is denoted by the sign Σ.

The individual observation is denoted by the sign X, number of observation denoted by n, and the mean by $\overline{X}$.

$$\overline{X} = \frac{\Sigma X}{\text{No. of observations (n)}}$$

2. Standard Deviation: It is denoted by the Greek letter σ. If a sample is more than 30 then.

$$\sigma = \sqrt{\frac{\Sigma(X-\overline{X})^2}{n}}$$

When sample in less than 30 then.

$$\sigma = \sqrt{\frac{\Sigma(X-\overline{X})^2}{n-1}}$$

3. **Chi square test:**

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Where O = Observed frequency

E = Expected frequency

4. **Student't' test**: To test the significance of two means the student't' test was used

$$t = \frac{\overline{X}_1 - \overline{X}_2}{S\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}$$

where $S^2 = \frac{(N_1-1)SD_1^2 + (N_2-1)SD_2^2}{N_1+N_2-2}$

where $\overline{X}_1$, $\overline{X}_2$ are means of group 1 and group 2

N_1, N_2 are number of observation group1 and group 2

SD_1, SD_2 are standard deviation in group1 and group 2

5. **Analysis of Variance: Analysis of Variance(ANOVA):**

The ANOVA test was used to compare within the group and between group variances amongst the study groups i.e. the three different sealers. Analysis of variance of these three sealers at a particular time interval revealed the differences amongst them. ANOVA provided "F" ratio, where a higher "F" value depicted a higher inter-group difference.

: $F = \frac{\text{Mean of Sum of Between Group Differences}}{\text{Mean of Sum of within Group Differences}}$

Differences	Sum of Squares	df	Mean Square	F
Between Groups	A	N_1	$X=A/N_1$	X/Y
Within Groups	B	N_2	$Y=B/N_2$	

6.Level of significance: "p" is level of significance

- p > 0.05 Not significant
- p <0.05 Significant
- p <0.01 highly significant
- p <0.001 Very highly significant

Observations and Results

Table 1(a): Morphological Characteristics of Chordae Tendinea (CT) of AV Valves Anterior cusp(AC)

SN	Characteristic	Type of valve	Mean	S.D.	Min.	Max.	Student 't' test
1-	Number of CT attached to anterior cusps	LAVV	12.24	1.58	9.00	17.00	t=8.360
		RAVV	14.81	2.64	8.00	21.00	p<0.001
2-	Length of largest CT (mm)	LAVV	14.79	1.94	11.35	20.33	t=26.250
		RAVV	23.17	2.54	17.74	28.64	p<0.001
3-	Length of shortest CT (mm)	LAVV	9.09	1.06	6.72	12.30	t=7.190
		RAVV	10.68	1.93	6.98	17.11	p<0.001
TYPE							
4-	Muscular type	LAVV	1.32	0.84	0.00	3.00	t=7.217
		RAVV	2.44	1.31	0.00	5.00	p<0.001
5-	Tendinous type	LAVV	8.03	1.77	5.00	13.00	t=2.735
		RAVV	8.77	2.04	5.00	14.00	p=0.007
6-	Membranous type	LAVV	2.89	1.36	0.00	5.00	t=3.481
		RAVV	3.60	1.52	1.00	8.00	p=0.001
BRANCHING							
7-	Straight	LAVV	1.24	1.32	0.00	6.00	t=5.844
		RAVV	2.33	1.32	0.00	6.00	p<0.001
8-	Branched	LAVV	8.10	1.59	4.00	11.00	t=1.895
		RAVV	8.60	2.11	4.00	14.00	p=0.060
9-	Spiral	LAVV	2.01	1.32	0.00	5.00	t=0.441
		RAVV	2.10	1.55	0.00	7.00	p=0.660
10-	Web forming	LAVV	0.92	1.16	0.00	6.00	t=5.322
		RAVV	1.78	1.12	0.00	4.00	p<0.001

- Statistically significant differences in characteristics of chorda tendinae of anterior cusp of LAVV and RAVV have been observed.
- RAV had significantly higher number of CT attached to anterior cusps. Length of largest and shortest CT of tricuspid heart valves were significantly higher than that of LAVV.
- Average number of Muscular, Tendinous and Membranous types of CT attached to anterior cusps of RAVV were significantly higher than that of LAVV.
- Average number of Straight, Branched, Spiral and Web forming CT attached to anterior cusps of RAVV were higher than that of LAVV but differences were found to be significant for Straight and Web forming CT.

Table 1(b): Morphological characteristics of Chordae Tendinae (CT) of AV Valves Posterior Cusp (PC)

SN	Characteristic	Type of valve	Mean	S.D.	Min.	Max.	Student 't' test
1-	Number of CT attached to posterior cusp	LAVV	12.39	2.38	8.00	17.00	t=0.725
		RAVV	12.62	2.09	9.00	18.00	p=0.469
2-	Length of largest CT (mm)	LAVV	17.94	2.65	10.42	28.38	t=1.141
		RAVV	18.39	2.87	12.29	28.37	p=0.255
3-	Length of shortest CT (mm)	LAVV	10.18	1.62	6.93	13.62	t=0.600
		RAVV	10.06	1.29	7.07	13.84	p=0.549
TYPE							
4-	Muscular type	LAVV	2.02	1.34	0.00	5.00	t=2.377
		RAVV	2.47	1.34	0.00	6.00	p=0.018
5-	Tendinous type	LAVV	6.55	1.98	3.00	12.00	t=6.252
		RAVV	8.30	1.98	5.00	13.00	p<0.001
6-	Membranous type	LAVV	3.80	1.44	1.00	8.00	t=9.917
		RAVV	1.85	1.34	0.00	5.00	p<0.001
BRANCHING							
7-	Straight	LAVV	1.87	1.11	0.00	5.00	t=0.866
		RAVV	2.00	1.02	0.00	4.00	p=0.388
8-	Branched	LAVV	6.02	1.80	3.00	12.00	t=5.600
		RAVV	7.37	1.61	4.00	11.00	p<0.001
9-	Spiral	LAVV	3.48	1.30	0.00	6.00	t=15.508
		RAVV	1.09	0.83	0.00	3.00	p<0.001
10-	Web forming	LAVV	1.01	0.86	0.00	3.00	t=7.707
		RAVV	2.16	1.22	0.00	5.00	p<0.001

- Number of CT attached to cusp, and length of largest and shortest CT of LAV and RAV posterior heart valves were comparable. Tendinous type of CT were significantly higher in RAVV as compared to LAVV while Membranous type of CT were significantly higher in LAVV as compared to RAVV.
- BranchedandWebformingCTweresignificantlyhigherinRAVVascomparedtoLAVVwhileSpiralbranchedCT weresignificantlyhigherinLAVVascomparedtoRAVV

Table 1(c): Morphological Characteristics of Chordae Tendinae (CT) of Accessory Cusps (ACC) of LAVV (n=4) and RAVV (n=6)

SN	Characteristic	Type of valve	Mean	S.D.	Min.	Max.	Student 't' test
1-	Number of CT attached to accessory cusps	LAVV	12.75	0.96	12.00	14.00	t=3.380
		RAVV	9.17	1.94	6.00	11.00	p=0.010
2-	Length of largest CT (mm)	LAVV	19.09	1.16	17.64	20.32	t=4.247
		RAVV	16.25	0.95	15.35	17.87	p=0.003
3-	Length of shortest CT (mm)	LAVV	7.92	0.56	7.11	8.35	t=3.162
		RAVV	9.26	0.71	8.23	10.41	p=0.013
TYPE							
4-	Muscular type	LAVV	3.25	0.96	2.00	4.00	t=1.036
		RAVV	2.67	0.82	2.00	4.00	p=0.330
5-	Tendinous type	LAVV	7.25	1.89	6.00	10.00	t=5.990
		RAVV	2.00	0.89	1.00	3.00	p<0.001
6-	Membranous type	LAVV	2.25	0.50	2.00	3.00	t=3.944
		RAVV	4.50	1.05	3.00	6.00	p=0.004

BRANCHING							
7-	Straight	LAVV	2.25	0.50	2.00	3.00	t=0.503
		RAVV	2.00	0.89	1.00	3.00	p=0.629
8-	Branched	LAVV	7.25	0.96	6.00	8.00	t=4.353
		RAVV	3.50	1.52	2.00	6.00	p=0.002
9-	Spiral	LAVV	1.00	0.00	1.00	1.00	t=0.000
		RAVV	1.00	0.89	0.00	2.00	p=1.000
10-	Web forming	LAVV	2.25	0.96	1.00	3.00	t=0.487
		RAVV	2.67	1.51	1.00	4.00	p=0.640

- Number of CT attached to accessory and length of largest CT were significantly higher in LAVV as compared to RAVV. On the contrary length of shortest CT attached to accessory cusp was significantly higher in RAVV as compared to LAVV.
- Number of Muscular and Tendinous type of CT were higher in LAVV as compared to RAVV, though difference was significant only for tendinous type of CT. Number of Membranous type CT were significantly higher in RAVV.
- Number of Straight, Spiral and Web forming CT were comparable in LAVV and RAVV. Branched CT were significantly higher in LAVV accessory cusp.

Table 2: Distribution of Chordae Tendinae (CT) of Septal Cusp(SC) of RAVV (n=90)

SN	Characteristic	Mean	S.D.	Min.	Max.
1-	Number of CT attached to septal cusps	10.96	1.47	8.00	15.00
2-	Length of largest CT (mm)	17.78	1.83	12.40	21.00
3-	Length of shortest CT (mm)	9.71	0.94	7.39	12.98
TYPE					
4-	Muscular type	2.27	0.98	0.00	4.00
5-	Tendinous type	6.03	1.11	4.00	9.00
6-	Membranous type	2.66	1.08	1.00	5.00
BRANCHING					
7-	Straight	1.70	0.95	0.00	4.00
8-	Branched	5.97	1.20	4.00	10.00
9-	Spiral	1.34	0.82	0.00	4.00
10-	Web forming	1.94	1.10	0.00	5.00

Table 3: Distribution of Characteristics of CT in LAVV

SN	Characteristic	Type of valve	Mean	S.D.	Min.	Max.	ANOVA
1-	Number of CT attached to cusps	Ant.(n=100)	12.24	1.58	9.00	17.00	F=0.231
		Pos.(n=100)	12.39	2.38	8.00	17.00	p=0.794
		Acc.(n=4)	12.75	0.96	12.00	14.00	
2-	Length of largest CT (mm)	Ant.(n=100)	14.79	1.94	11.35	20.33	F=49.226
		Pos.(n=100)	17.94	2.65	10.42	28.38	p<0.001
		Acc.(n=4)	19.09	1.16	17.64	20.32	
3-	Length of shortest CT(mm)	Ant.(n=100)	9.09	1.06	6.72	12.30	F=19.217
		Pos.(n=100)	10.18	1.62	6.93	13.62	p<0.001
		Acc.(n=4)	7.92	0.56	7.11	8.35	
TYPE							
4-	Muscular type	Ant.(n=100)	1.32	0.84	0.00	3.00	F=13.759
		Pos.(n=100)	2.02	1.34	0.00	5.00	p<0.001
		Acc.(n=4)	3.25	0.96	2.00	4.00	
5-	Tendinous type	Ant.(n=100)	8.03	1.77	5.00	13.00	F=15.538
		Pos.(n=100)	6.55	1.98	3.00	12.00	p<0.001
		Acc.(n=4)	7.25	1.89	6.00	10.00	
6-	Membranous type	Ant.(n=100)	2.89	1.36	0.00	5.00	F=11.926
		Pos.(n=100)	3.80	1.44	1.00	8.00	p<0.001
		Acc.(n=4)	2.25	0.50	2.00	3.00	
BRANCHING							
7-	Straight	Ant.(n=100)	1.24	1.32	0.00	6.00	F=7.424
		Pos.(n=100)	1.87	1.11	0.00	5.00	p=0.001

		Acc.(n=4)	2.25	0.50	2.00	3.00	
8-	Branched	Ant.(n=100)	8.10	1.59	4.00	11.00	F=38.051
		Pos.(n=100)	6.02	1.80	3.00	12.00	p<0.001
		Acc.(n=4)	7.25	0.96	6.00	8.00	
9-	Spiral	Ant.(n=100)	2.01	1.32	0.00	5.00	F=35.472
		Pos.(n=100)	3.48	1.30	0.00	6.00	p<0.001
		Acc.(n=4)	1.00	0.00	1.00	1.00	
10-	Web forming	Ant.(n=100)	0.92	1.16	0.00	6.00	F=3.307
		Pos.(n=100)	1.01	0.86	0.00	3.00	p=0.039
		Acc.(n=4)	2.25	0.96	1.00	3.00	

Table 4: Distribution of Characteristics of CT in RAVV

SN	Characteristic	Type of valve	Mean	S.D.	Min.	Max.	ANOVA
1-	Number of CT attached to cusps	Ant.(n=100)	14.81	2.64	8.00	21.00	F=57.932
		Pos.(n=100)	12.62	2.09	9.00	18.00	p<0.001
		Sep.(n=90)	10.96	1.47	8.00	15.00	
		Acc.(n=6)	9.17	1.94	6.00	11.00	
2-	Length of largest CT (mm)	Ant.(n=100)	23.17	2.54	17.74	28.64	F=98.619
		Pos.(n=100)	18.39	2.87	12.29	28.37	p<0.001
		Sep.(n=90)	17.78	1.83	12.36	20.97	
		Acc.(n=6)	16.25	0.95	15.35	17.87	
3-	Length of shortest CT(mm)	Ant.(n=100)	10.68	1.93	6.98	17.11	F=8.017
		Pos.(n=100)	10.06	1.29	7.07	13.84	p<0.001
		Sep.(n=90)	9.71	0.94	7.39	12.98	
		Acc.(n=6)	9.26	0.71	8.23	10.41	
TYPE							
4-	Muscular type	Ant.(n=100)	2.44	1.31	0.00	5.00	F=0.599
		Pos.(n=100)	2.47	1.34	0.00	6.00	p=0.616
		Sep.(n=90)	2.27	0.98	0.00	4.00	
		Acc.(n=6)	2.67	0.82	2.00	4.00	
5-	Tendinous type	Ant.(n=100)	8.77	2.04	5.00	14.00	F=63.191
		Pos.(n=100)	8.30	1.98	5.00	13.00	p<0.001
		Sep.(n=90)	6.03	1.11	4.00	9.00	
		Acc.(n=6)	2.00	0.89	1.00	3.00	
6-	Membranous type	Ant.(n=100)	3.60	1.52	1.00	8.00	F=32.483
		Pos.(n=100)	1.85	1.34	0.00	5.00	p<0.001
		Sep.(n=90)	2.66	1.08	1.00	5.00	
		Acc.(n=6)	4.50	1.05	3.00	6.00	
BRANCHING							
7-	Straight	Ant.(n=100)	2.33	1.32	0.00	6.00	F=5.116
		Pos.(n=100)	2.00	1.02	0.00	4.00	p=0.002
		Sep.(n=90)	1.70	0.95	0.00	4.00	
		Acc.(n=6)	2.00	0.89	1.00	3.00	
8-	Branched	Ant.(n=100)	8.60	2.11	4.00	14.00	F=48.453
		Pos.(n=100)	7.37	1.61	4.00	11.00	p<0.001
		Sep.(n=90)	5.97	1.20	4.00	10.00	
		Acc.(n=6)	3.50	1.52	2.00	6.00	
9-	Spiral	Ant.(n=100)	2.10	1.55	0.00	7.00	F=14.796
		Pos.(n=100)	1.09	0.83	0.00	3.00	p<0.001
		Sep.(n=90)	1.34	0.82	0.00	4.00	
		Acc.(n=6)	1.00	0.89	0.00	2.00	
10-	Web forming	Ant.(n=100)	1.78	1.12	0.00	4.00	F=2.536
		Pos.(n=100)	2.16	1.22	0.00	5.00	p=0.057
		Sep.(n=90)	1.94	1.10	0.00	5.00	
		Acc.(n=6)	2.67	1.51	1.00	4.00	

Discussion

This present study was conducted on 100 formalin fixed human cadaveric hearts to analyse their morphology of chordae tendinae of human atrioventricular valves.

The atrioventricular heart valvesare responsible for directing unidirectional blood flow in the heart by properly opening and closing the valve leaflets, which are supported in their functions by the chordae tendineae (CT). They are critical for distributing forces during systolic closure from the leaflets to the papillary muscles, preventing leaflet prolapse and consequent regurgitation [4].

Therefore it is important to have a brief knowledge about morphology and morphometry of CT. The target of this study is to attain maximum information about anatomical morphology and morphometry in both right and left atrioventricular valve.

Chordae Tendinae in RAVV:

In the present study, the number of CT were counted individually in each cusp including commissural area and we observed highest mean number of CT in AC (14.81+/-2.64) [Table 6 a)] followed by PC (12.62+/-2.09) [Table 1(b)] in case of RAVV. The least number of CT were associated with SC i.e 10.96+/-1.47 [Table 2]. In those cases where ACC was present, still lower number (9.17+/-1.94)[Table 6 c)] of CT were observed. [Table 1(a), Table 1(b), Table 1(c), Table 2, Table 4]

In the present study, the branching pattern and type (muscular, tendinous, and membranous) of CT was also observed. Branched variety of CT was observed to be commonest and it was present in the highest number in AC (8.60+/-2.11) followed by PC (7.37+/-1.61), SC (5.9+/-1.20). In case of ACC, the mean number was 3.50+/-1.52. Mean number of straight CT was 2.33 in AC, 2+1.02 in PC and 1.70+/-0.95 in SC. In case of ACC, it was 2+/-0.89. Spiral variety of CT was also found to be higher in AC i.e., 2.10+/-1.55 followed by SC (1.34+/-0.82) and PC (1.09+/-0.83). Mean number of CT in acc. Cups was 1+/-8.89.

The highest mean number of web-forming CT were counted in PC i.e., 2.16+/-1.22. in SC it was 1.94+/-1.10 and 1.78+/-1.12 in ACC was found to have 2.67+/-1.51 CT. [Table 6(a), Table 6(b), Table 6(c), Table 2, Table 4]

If we talk about the findings of type of CT in the present study, tendinous type was the commonest. The mean number of tendinous CT was found in AC, PC and SC was 8.77+/-2.04, 8.30+/-1.98 and 6.03+/-1.11 respectively. In ACC it was 2+/-0.89. Mean number of membranous type of CT found in AC was 3.60+/-1.52 and in septal cusp it was 2.66+/-1.08. It was lesser in PC (91.85+/-1.34) as compared to AC and SC. The mean number was 4.500+/-1.05 in ACC. Muscular variety of CT were also found frequently and the mean number in PC was 2.47+/-1.34 that is slightly higher than in AC (2.44+/-1.31). In septal cusp it was 2.27+/-0.98 which is lesser in number as compared to AC and PC. 2.67+/-0.82 was the mean number of muscular CT found in ACC [Table 1(a), Table 1(b), Table 1(c), Table 2, Table 4].

Babita K et al., (2016) characterized CT into rough zone, fan shaped, free edge, deep and basal type. The average number of chordae tendineae arising from each papillary muscle were as follows-APM-5.07, PPM- 3.04 and SPM – 2.1.The average number of chordae tendineae inserted into each cusp was as follows: anterior cusp-5.64, posterior cusp-4.07, septal cusp -8.64 and at each commissure -0.9. Thus, the average number of chordae attached to the tricuspid valve was 19.25 [5]. According to Skwarek et al., (2006), the main leaflets usually had 20.79±8.43 CT and the accessory cusps presented 8.14±4.85 CT [6].

Chordae Tendinae in LAVV:

In the present study, mean number of CT was more in PC (12.39+/-2.38) as compared to AC (12.24+/-1.58) whereas ACC was found to have mean number of CT more than AC and PC i.e., 12.75+/-0.96 [Table 1(a), Table 1(b), Table 1(c), Table 3].

In LAVV also, four types of branching pattern were observed in which branched variety of CT was noted to be maximum. It was 8.10+/-1.59 in AC and 6.02+/-1.80 in PC. Also in ACC, it was 7.25+/-0.96. Straight type of CT were more in PC (1.87+/-1.11) than in AC (1.24+/-1.32) whereas in ACC it was 2.25+/-0.50. Spiral CT was also present more in PC i.e., 3.48+/-1.30 than in AC i.e., 2.01+/-1.32. The mean number of web-forming CT was also found to be in consensus with spiral and straight CT as it was also more in PC (1.01+/-0.86) than in AC (0.92+/-1.16) [Table 1(a), Table 1(b), Table 1(c), Table 3] .

Talking about the types of CT in LAVV, tendinous CT were the commonest. Tendinous CT were more in AC (8.03+/-1.77)than in PC (6.55+/-1.98). In cases where ACC was found they had 7.25+/-1.89 as a mean number of CT. This value is more than PC but less than AC. Mean number of membranous CT were more in PC i.e., 3.80+/-1.44 than in AC (2.89+/-1.36). In ACC it was 2.25+/-0.50.Also, it was observed that the mean number of muscular CT present in AC, PC and ACC was 1.32+/-0.84, 2.02+/-1.34 and 3.25+/-0.96 respectively [Table 1(a), Table 1(b), Table 1(c), Table 3].

Skwarek et al., (2007)stated three types of connections, which represent the evolutionary line. These connections are straight connection,

membranous connection andtendinous connection. The straight type of connections was present in 30.27% and membranous connections were found in 6.54% of the group studied [6].The number of CT observed in the present study is higher than other studies as the commissural chordae are also included whereas other mentioned authors have observed CT in leaflets excluding their commissural area. Commissural CT were counted separately by them. This might explain the variability of mean number of CT in our study with the findings of others.

Limitations

This study has certain limitations. The analysis did not account for gender differences, and the age range of participants was broad, spanning 70 years (10-80 years), which may introduce bias. Furthermore, the sample size was relatively small, consisting of only 100 cases, potentially leading to broad representations. Also, the use of formalin for preserving deceased bodies might have altered the original measurements, affecting the study's outcome.

Conclusion

- RAVV had significantly higher number of CT attached to anterior cusps than LAVV.
- For RAVV, length of the largest and the shortest CT of tricuspid heart valves were significantly higher than those of LAVV.
- Average number of Muscular, Tendinous and Membranous types of CT as well average number of Straight, Branched, Spiral and Web forming CT attached to anterior cusps of RAVV were higher than that of LAVV. Differences were found to be significant for Straight and Web forming CT.
- For posterior heart valves, tendinous type of CT were significantly higher in RAVV as compared to LAVV while Membranous type of CT were significantly higher in LAVV as compared to RAVV.
- For posterior heart valves, Branched and Web forming CT were significantly higher in RAVV as compared to LAVV while Spiral branched CT were significantly higher in LAVV as compared to RAVV.
- For posterior heart valves, number of CT attached to accessory and length of largest CT were significantly higher in LAVV as compared to RAVV.
- For posterior heart valves, number of Muscular and Tendinous type of CT were higher in LAVV as compared to RAVV. This difference was significant only for tendinous type of CT.
- For posterior heart valves, Branched CT were significantly higher in LAVV accessory cusp.

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