VOLUME - 9, ISSUE - 8, August - 2020 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper

Anatomy

PRENATAL MORPHOMETRIC STUDY OF HUMAN FETAL TESTIS

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ABSTRACT Testis are the endocrine organs in males with the reproductive function. The prenatal morphometry and position of the testis with its descend are important as during the adult life the maldevelopment can lead to infertility, malignancy torsion etc. The gross development of testis has been a subject of interest for many embryologists. These measurement also gives indication of gestational age, and development at different stages of gestation.

The present study has been undertaken with the aim of setting morphometric parameters on testes in North West Indian fetuses of different gestational age. Morphometric parameters taken were: length, breadth, thickness, weight and volume of right and left testis. All the parameters of the testis were calculated and correlated with the increasing fetal gestational age. The present study established a significant and positive correlation between the length, breadth, thickness, weight and volume of testes. All the growth parameters showed strong and positive correlation with each other. The difference between right and left testes dimensions were also noted. The increase in the length, breadth as well as thickness of the testis was almost constant in all the age groups.

KEYWORDS : Prenatal, morphometry, fetal testis.

INTRODUCTION

Testes are reproductive and endocrine organs in male, suspended in scrotum by scrotal tissue, dartos muscle and spermatic cords. Testes are invested by three coats from outside inwards, the visceral layer of tunica vaginalis, tunica albuginea and tunica vasculosa. Each testis is separated from each other by fibrous median raphe, which is deficient superiorly[1].

The testis lies obliquely within the scrotum; its upper pole tilted anterolaterally and lower pole posteromedially. Anterior, medial and lateral surfaces and both poles are convex, smooth and covered by the visceral layer of tunica vaginalis. The posterior surface is nearly straight and only partly covered by tunica serosa, with the spermatic cord attached to it. The epididymis adjoins the lateral part of the testis[1]. In adult, average testis measures 50mm vertically, 25mm transversely and 30mm in antero-posterior dimension. Weight of the testis varies from 10.5-14gms. The left testis usually lies lower than the right[2].

In the last 20 years, there has been an increased awareness assessing aborted embryos and fetuses for evidence of developmental abnormalities. The knowledge of developing testis is important in cryptorchidism, ectopic testis, hypospadias and inguinal hernias. At birth, approximately 4.5% of new born have cryptorchidism. The cause can be testicular dysgenesis and maldevelopment, which could be associated with infertility, malignancy, atrophy, torsion etc[3].

Few authors[4,5,6] have observed morphometry of growing testis. According to them fetal testis gradually increased in weight and size. In 70% cases, right testis was heavier than the left. At term, the fetal testis had not attained the cytoarchitecture of the adult testis suggesting that the maturation of testis continues postnatally.

The Development & internal structure of testis has been topic of interest and research for various authors for a long time. A lot of work on the descent of fetal testes and histology of testes was carried out, whereas very few studies are available on direct measurements of fetal testis.

Study[5] conducted on 48 human fetal testes, aged 14-40weeks showed a positive correlation between gestational age and length, breadth, thickness, weight of the testis but there was no significant difference in testicular size between right and left testes.

Another study[6] conducted on 90 testes of 45 fetuses, between 12-40weeks observed that tubule, stromal volume and weight of the testis increased mostly between the second and third trimester but no change in the testis density ($P>0.05$).

Mittwoch[7] reported that in the human fetuses (CRL between 140-212mm) the weight of right testes were heavier than the left testes and right gonads developed more rapidly than the left gonads.

Some authors[8,9] suggested that there was no difference in the volume and weight of the right and left testes in fetuses aged 12-40weeks. This study reported that in adults the weight, size, volume of right testis were greater than the left testis.

Wikramanayake[9] suggested that the correlation between the weight and size of the testes during the fetal period was more significant than those of the adults (in fetal period $P<0.001$; in adults $P<0.05$)

Mbaeri et al[10] conducted a comparative study to determine the accuracy of various ultrasound formulas for measuring the testicular volume with the actual testicular volume measured by water displacement. A strong correlation was found between the actual testicular volume and volume calculated by ultrasound formulas.

MATERIAL AND METHODS

The present study was carried out in the Department of

Anatomy, Government Medical College and Hospital, Chandigarh over the period of two years from November 2013 to August 2015. The material for the study consisted of 55 aborted human fetal specimens from 12th to 28th weeks of gestational ages. The specimens were provided by the Department of Obstetrics and Gynaecology for routine fetal autopsy. Consent was taken from the parents to perform autopsy and to carry out additional studies. Fetus with gross anatomical abnormality, Macerated fetus as a result of IUD or spontaneous abortion and fetuses with maternal history of infections such as rubella, hepatitis, CMV, HIV etc were excluded from the study.

After routine autopsy, testes were dissected out in 55 male aborted fetuses of different gestational age ranging from 12 to 28 weeks. The right and left testis were measured in 55 aborted fetuses i.e. total 110 testes was morphometrically evaluated.

Linear measurements were taken with the help of digital vernier calliper and divider. Weight of testis was measured by an electronic weighing balance while volume was calculated by water displacement method.
The following morphometric measurements were taken on testis (Fig: 1&2)

1. Length (L): The length was measured along the longest axis through a vertical plane from upper pole to lower pole of testis.
2. Breadth (B): The breadth was measured as the widest point along a horizontal or oblique plane.
3. Thickness (T): The thickness was measured as the maximum distance between anterior and posterior surface.
4. Weight (W): The weight of the testis was measured by highly accurate and precise weighing balance with readability sensitivity of 0.001 g (1 mg).
5. Volume (V): The volume of testis was measured with the use of marking tube by water displacement method.

RESULTS

For this study, 110 testes(of 55 fetuses) were removed and kept in formalin. The fetuses were divided according to gestational age as follow:

Table 1: Distribution of fetuses according to gestation

Groups	Gestational age in weeks	No: of fetuses
A	12-16	13
B	16^{+} -20	18
C	20^{+}-24	13
D	24^{+} -28	11

LENGTH (L1 and L2)

Table 2: Lengths of testes (L1 & L2) (in mm)

Group	No: of cases	Right (L1)		Left (L2)	
		Range	Mean±S.D	Range	Mean±S.D
A	13	2.88-5.67	4.00±1.66	2.57-6.66	3.95±2.34
B	18	3.39-9.57	6.07±2.88	3.47-7.73	5.55±2.64
C	13	5.55-7.89	6.45±2.32	5.65-8.03	6.34±2.64
D	11	5.27-12.30	8.56±4.16	5.35-10.39	8.13±2.64

The mean length of right testes (L1) was 4.00±1.66 mm in the group A, increased to 6.07±2.88mm in group B. In group C the length was 6.45±2.32mm and in the group D the length was 8.56±4.16 mm. There was gradual increase in length (L1) of right testis as seen in different age groups. The maximum increase of 2.1mm was seen between group C & D. Minimum growth of 0.38mm was noticed between groups B & C (Fig: 3).

There was constant increase in the length of left testes (L2) from 12 to 28 weeks. However the increase was not uniform in various gestational age groups. Maximum increase of 1.79mm was observed between group C&D. Minimum growth of 0.79mm was noticed between group B &C.

The line graph plotted between the mean length of testes at all gestational age groups showed a sudden spurt of increase in length of right and left testes from group C &D.

On applying ANOVA test for length of right and left testes the F Value was equal to 20.25 & 23.074 respectively at P<.001. Therefore there is significant difference in the mean value of right and left testes between groups A to D as P<0.05. ANOVA Test suggests that there is significant difference present in groups. But to identify the significant difference between particular group pairs Bonferroni test is used.

Bonferroni test is the quantitative proof that there is significant spurt in length of testis between age groups A&B and also C&D on both sides. Between group B&C although growth occurred but it is not significant because P value is >0.05. For right length the significant difference between group pair A&B,A&C,A&D was calculated by Bonferroni test the P Value was P=.001,P<.001,P<.001 respectively since P<0.05 for all growth so Bonferroni test clarify that there is significant difference between group A&B, A&C, and A&D.

On subjecting data to Bonferroni test, P Value for group B &C was not significant (P=1.0). Therefore there was no significant difference in the mean length between group B&C.

On applying Bonferroni test for left, the significant difference between group pair A&B, A&C, A&D was calculated. The P Value was P=.006, P<.001, P<.001 respectively because P<0.05 for all group pairs. This indicates that there is significant difference between group A&B, A&C, A&D of left side.

P Value for group B&C was not significant because P=0.54. P Value for group B&D was P<.001 which indicates that there is significant difference between group B&D (Fig: 3).

BREADTH (B1 & B2)

Table 3: Breadth of Testes B1 & B2 (in mm)

Group	No: of cases	Right (B1)		Left (B2)	
		Range	Mean±S.D	Range	Mean±S.D
A	13	1.10-3.55	2.22±1.52	1.34-3.88	2.22±1.76
B	18	1.95-4.73	3.54±1.48	1.90-4.75	3.68±1.98
C	13	1.79-5.51	3.94±1.80	2.04-4.91	3.82±1.30
D	11	3.08-5.68	4.77±1.78	3.10-5.62	4.83±1.90

There was constant increase in the breadth of left and right testes. However, the increase was not uniform in all gestational age groups. Maximum increase of 1.32mm breadth of right testes was observed between group A&B. Minimum growth of 0.40mm was noticed between group B&C.

Similarly, breadth of left testes showed maximum increase of 1.46mm between groups A&B. Minimum growth of 0.14mm was noticed between group B&C (Fig: 4).

The total increase in breadth of right testes in group D(4.77mm) was 2.55 times than that observed in group A(2.22mm). The total increase in left testes in group D(4.83mm) was 2.61 times than that observed in group A(2.22mm).

There was different pattern of increase in breadth of testes on both the sides. On right side minimum growth has been observed between group B-C. On left side maximum growth has been observed between group A-B.

ANOVA Test for breadth of right and left testes showed the F=20.45 &17.80 respectively at P<.001 which indicates significant increase in the breadth of right and left testes as gestation age progressed from group A-D.

For right breadth applying Bonferroni test proof that the P Value was <.001 between groups A&B, A&C, A&D. Therefore the Bonferroni test showed significant difference between group A&B, A&C, and A&D.

For groups B&C, C&D the p value is p=1.00& p=1.04 respectively indicate that there is no significant difference present since P Value was not less than .005.Although the line diagram showed that some growth occurred between group B&C, C&D, but applying Bonferroni the significant difference was not present.

The Bonferroni test for left side indicate that the value of P<.001 between group pair A&B, A&C, A&D. So there is significant growth present within group A&B, A&C, A&D.

For group pair B&A, B&C, B&D the P value is P<.001, P=1.00, P=0.008 respectively, suggesting the group B&C are not having significant difference. Since group B&A, B&D having P<.05 so these group having significant increase in the growth.

Fig 8 shows that there is growth spurt in the breadth of testes as the gestational age progressed from A to B and also from C to D but the spurt in breadth is relatively more in gestational age A&B. Quantitatively the testes do not show increase in the breadth between group B-C.

THICKNESS (T1 and T2)

Table 4: Thickness of Testes (T1 &T2) (in mm)

Group	No: of cases	Right (T1)		Left (T2)	
		Range	Mean±S.D	Range	Mean±S.D
A	13	0.28-2.50	1.64±1.30	0.99-2.77	1.67±1.08
B	18	1.76-3.88	2.62±0.94	1.74-3.44	2.75±1.12
C	13	1.38-3.40	2.68±1.20	1.66-3.52	2.78±1.12
D	11	1.94-4.66	3.02±1.94	2.10-4.42	3.26±1.46

There was a constant but non-uniform increase in thickness of right and left testes from 12-28 weeks. Thickness of right testes showed maximum increase of 0.98mm between group A&B. Minimum growth of 0.06mm was noticed between group B&C.

The total increase in thickness of right testes in group D(3.02mm) was 1.38 times more than that observed in group A(1.64mm)

The thickness of left testes showed maximum increase of 1.08mm between group A&B. Minimum growth of 0.03mm was noticed between group B&C (Fig: 5).

The total increase in left testes in group D(3.26mm) was 1.59mm times than that observed in group A(1.67mm). Minimum growth of thickness has been observed between group B-C on both sides.

On subjecting the ANOVA Test the F=9.85 and 15.68 respectively for right and left thickness of testes. The value of p <0.05 suggesting that there is significant difference present in between the groups.

On applying the Bonferroni test for right and left, thickness of testes indicate that there is more rapid gain in thickness between gestational age A&B. Although Fig 3 shows that there is gain in the breadth between group B&C and C&D but Bonferroni test indicates that there is not significant increase in thickness because P value is >0.05 for these groups.

WEIGHT (W1 & W2)

Table 5: Weight of Testes (W1 &W2) (in mg)

Group	No: of cases	Right (W1)		Left (W2)	
		Range	Mean±S.D	Range	Mean±S.D
A	13	0.5-5.2	1.73±2.86	0.4-5.2	1.7±2.96
B	18	0.9-9.0	4.65±4.32	0.9-9.0	5.03±5.52
C	13	1.0-8.5	6.52±3.96	1.4-9.3	6.30±4.04
D	11	3.0-20.1	10.80±10.44	3.3-18.6	10.12±9.48

The weight of right and left testes increased constantly but not uniformly in all gestational age groups. The maximum increase of 4.28mg of right testes was observed between C&D. Minimum growth of 1.87mg was noticed between group B&C.

Similarly weight of left testes showed maximum increase of 3.82mg between group C&D. Minimum growth of 1.27 mg was noticed between group B&C(Fig:6).

The total increase in weight of right testes in group D(10.80 mg) was 9 times than that observed in group A(1.73mg).

The total increase in left testes in group D(10.12mg) was 8.42 times than that observed in group A(1.7mg). Maximum growth of weight has been observed between C& D groups on both sides. Whereas minimum growth of weight has been observed between group B&C.

On subjecting the ANOVA test F Value was 20.58 &16.86 for right and left weight of testes at P<.001. There is significant difference in the mean value of right and left testes in between the group A to D as P<0.05.

The Bonferroni test is quantitative proof of increase in weight on both sides of testes because the P value is <0.05. For the right, weight of testes the P value were P=0.040, P<.001, P<.001 for group pair A&B, A&C, A&D respectively. Therefore the test suggests that significant difference exists within the group pairs.

For group pairs B&C, B&D the P value were P=0.44, P<.001 showed the group pairs B&C were not significantly different. Whereas group pairs B&D showed significant difference.

Similarly for the left side testes, on subjecting the Bonferroni test the P Value were P=.015, P=.001, P<.001 for group pairs A&B, A&C, A&D respectively since the P<0.05 so these group pair were significantly different For group pair B&C the P value was p=1.00 which was not less than 0.05 so this group was not showing significant difference.

VOLUME (V1and V2)

Table 6: Volume of Testes (V1 &V2) (in ml)

Group	No: of cases	Right (V1)		Left (V2)	
		Range	Mean±S.D	Range	Mean±S.D
A	13	0.04-0.08	0.053±0.026	0.04-0.08	0.051±0.020
B	18	0.05-0.15	0.080±0.062	0.05-0.15	0.082±0.070
C	13	0.05-0.15	0.101±0.044	0.05-0.15	0.100±0.052
D	11	0.09-0.20	0.147±0.088	0.06-0.20	0.136±0.102

The increase in volume of right and left testes was constant but not uniform Volume of right testes showed maximum increase of 0.046ml between group C&D Minimum increase of 0.021ml was noticed between group B&C.

The total increase in volume of right testis in group D(0.147ml) was 0.09 times more than that observed in group A(0.053ml).

The volume of left testis showed maximum increase of 0.036ml between group C&D. Minimum increase of 0.018ml was noticed between group B&C(Fig:7).

The total increase in left testes in group D(0.136ml) was 0.08 time more than that observed in group A(0.051ml).

On applying the ANOVA test F=20.87&12.87 for right and left testis volume respectively. The test showed that P<.001 so the significant difference was present in between groups.

To identify the significant growth within group pairs the Bonferroni test indicates that significant increase in volume present between group C&D but not in between the group pairs A&B and B&C.

On right side testis showed P value was P=.088, P=.001, P<.001 between the group pair A&B, A&C, A&D respectively. Since the P value for group A&B was not less than 0.05. So this group pair was not significant. For group pair B&D, B&C, B&D the P=.088, P=.292, P<.001.So P value indicate that group pair B&A, B&C were not showing significant difference.

Table 7: % increase in various parameters during different age groups

	A		B		C		D			
	Rt	Lt	Rt	Lt	Rt	Lt	Rt	Lt	Total Rt %	Total Lt %
Length(mm)	4.00	3.96	6.07	5.55	6.45	6.34	8.56	7.86	53.27	51.41
Breadth(mm)	2.22	2.22	3.54	3.68	3.94	3.82	4.62	4.64	53.45	54.03
Thickness(mm)	1.64	1.67	2.63	2.75	2.76	2.86	4.47	3.26	45.69	48.77
Weight(mg)	2.22	1.70	4.65	5.03	6.52	6.30	11.66	10.87	83.98	83.20
Volume(ml)	0.053	0.051	0.08	0.082	0.09	0.09	0.15	0.14	63.94	62.5

Similarly for left side volume, on applying Bonferroni test P=.088, P=.003, P<.001for group pair A&B, A&C, A&D respectively. So group pair A&B showed no significant difference.

For group pair B&C, B&D P value were P=.797, P=.001. Therefore group pairs B&C were not significant as P was not <0.05. For group pairs C&D P=.092, were not significant with each other.

TREND OF GROWTH IN VARIOUS DIMENSIONS OF RIGHT AND LEFT TESTES

From the above observations, it is obvious that growth in various dimensions of testes was seen to be proportional to gestational age. Maximum growth spurt in length, weight and volume was observed from Group C&D whereas breadth and thickness of testis, maximum growth was observed from Group A&B(Fig:8).

In 2nd trimester the total increase in length of right testis was 4.56mm and left testis was 4.18mm. The percentage increase in length of right testis from 12-28 week of gestation was 53.27% (8.56 – 4.00/8.56) and was seen to be more than length of left testis 51.41%(Table: 7).

Similarly, the total increase in the breadth of right testis was 2.55mm and left testis 2.61mm. The increase in breadth of left testis was 54.03% (4.83-2.22/4.83) and was slightly more than breadth of right testis 53.45%. The increase in thickness of right testis was 1.38mm and left testis was 1.59mm. The percentage increase in thickness of left testis was 48.77% (3.26-1.67/3.26) and was seen to be more than thickness of right testis i.e. 45.69% (3.02-1.64/3.02).

For the weight of right testis the total increase was 9.07mg and left testis was 8.42mg. The percentage increase in weight of right testis was 83.98% (10.80-1.73)/10.80) which was slightly more than the weight of left testis 83.20% (10.12-1.7/10.12).

The increase in volume right testis was 0.09ml & left testis was 0.03ml. The percentage increase in volume of right testis was 63.94% (0.147-0.053/.147) and was seen to be more than volume of left testis 62.5% (0.136-0.051/0.136).

CORRELATION BETWEEN VARIOUS PARAMETERS OF TESTIS

(a) Correlation between length, breadth and thickness.

There was almost constant increase in length and breadth of all age groups. The length of testes was roughly 1.60-1.78 times of breadth and increased gradually with increase in gestational age. The correlation between L and B was excellent(Pearson's coefficient 0.830).

Both the length and thickness of testis increased with increase in gestational age. While both the dimensions showed minimum growth from Group B-C, maximum growth was seen from A-B. The correlation between L & T was seen to be strong and significant (Pearson's coefficient 0.814). There is a strong positive correlation between breadth and thickness with Pearson's coefficient 0.811. As gestational age increased, both breadth and thickness also increased. The maximum growth was seen from Group A-B(Fig:9).

(b) Correlation between weight and volume of testis.

The weight and volume of testis increased with increase in gestational age. The maximum growth was seen from group C-D in both the dimensions, while minimum growth showed from group B-C (Fig:10). The correlation between weight and volume of testis was seen to be strong and significant (Pearson's coefficient 0.887).

(c) Correlation between all five growth parameters of testis.

All the growth parameters showed strong and positive correlation with each other. As the gestational age increased, all growth parameters also increased. The length of testis was 1.60-1.78 times breadth and 2.16-2.65 times the thickness. The breadth of testis was roughly 1.34-1.52 times the thickness(Fig:11). The Pearson' coefficient between length and weight was 0.906 and between length and volume was 0.831. The correlation between breadth & weight and breadth & volume was 0.840 and 0.756 Pearson's coefficient respectively. The thickness showed positive correlation with weight and volume with Pearson's coefficient of 0.836 and 0.670 respectively.

(d) Correlation between CRL and all five growth parameters of testis.

As the total length of fetus increased, there was proportional increase in the values of length, breadth, thickness, weight and volume of testis. The increase in all the growth parameters of testis were not seen to be uniform. The maximum increase of CRL with breadth and thickness was seen between group A-B, whereas length of testis showed maximum increase between group C-D (Fig: 12). The Pearson's coefficient between CRL & length, CRL & breadth, CRL & thickness were 0.764, 0.797, 0.741 respectively showed a significant correlation.

The weight and volume increased, as the CRL of fetus increased with gestational age (Fig:13). The CRL showed significant correlation between weight and volume of testis with Pearson's coefficient of 0.698 and 0.617 respectively.

(e) Correlation between abdominal circumference and all five growth parameters of testis.

The abdominal circumference of fetus and all growth parameters of testis increased constantly with increasing gestational age. The abdominal circumference was roughly 2.11-2.27 times of length, 3.52-3.77 times of breadth and 4.75-5.73 times of thickness (Fig:14).

The abdominal circumference showed strong and significant correlation between length, breadth and thickness with Pearson's coefficient of 0.819, 0.827, 0.761 respectively.

DISCUSSION

Over the past year, the evaluation of fetal morphometrical growth parameters has been a subject of awareness for assessing fetal growth and development. Some important parameters were used as standards like crown- rump length, biparietal diameters, head, chest and abdominal circumference. In some studies fetal organs were also measured to see their gross development at various gestational ages. The gross development of testis has been a subject of interest for many embryologists. These measurement gives indication of gestational age, descent of testis and development at different stages of gestation.

Few studies[5,6,11,12] correlated measurement of fetal testes with gestational age. The present study was conducted on 55 fetal specimens to measure the various parameters of the right and left testis with increasing gestational age. The measurement included length, breadth, thickness, weight and volume as well as position of testes on both sides.

Malas et al[6] observed that the height, width, thickness and weight of fetal testes divided the fetuses into three groups i.e. group 1(14-25weeks), group 2(26-37weeks) and group 3(38-40weeks). The study showed that there was no significant difference between the dimensions of the right and left testis within any group, but there was a significant difference in the dimensions of the testes between group 2 and 3. There was positive correlation between gestational age and all the dimensions and among testicular parameters of the same group.

Whereas in the present study, it was noticed that all the growth parameters showed strong and positive correlation with each other. The difference between right and left testes dimensions were also noted. A significant difference exists within the group pairs except between groups B and C. It was found that although growth occurred in between group B and C but growth was so minimal that this group was not showing any statistical difference.

Lemeh[12] found that length and average diameter of fetal testes increased with the increasing CRL of testis. Between 75-100mm CRL(12-16weeks) average length of both the testis was 3.85mm, from 120-155mm CRL(16-20weeks) average length was 5.42mm and in between 185-225mm CRL(21-25weeks) the testes length was 7.6mm. The average testicular diameter was 1.94mm, 2.47mm and 4.8mm with the respective age groups.

In the present study, the length of testis was almost similar with 3.97mm in 12-16weeks, 5.81mm in 16-20weeks, 6.39mm in 20-24weeks and 8.34mm in 24-28weeks of gestation. Also the breadth and thickness of the testes was comparable to study done by Lemeh et al[12].

In the present study, the length, weight and volume showed maximum increase in growth from group C to D whereas the maximum increase in breadth and thickness was observed from group A to B. The minimum increase in all the growth parameters was seen between the group B and C.

Study[6] done on fetuses of 12-40weeks gestation and divided them in four groups from 0-12 weeks (1st trimester), 13-25weeks (2nd trimester), 26-37 weeks (3rd trimester) and 38-40 weeks to assess the total testis volume and weight. In this experiment the first group was not statistically compared with all other groups due to limited number of cases. The 2nd, 3rd and 4th groups were compared, the difference between the parameters was significant (for weight $p<0.05$, for testis volume $p<0.01$). The testis volume and weight increased more between 2nd and 3rd trimester. The testis volume was measured using stereological method to assess the seminiferous tubule volume, stromal volume and total testis volume. The seminiferous tubules volume regarded as seminiferous tubules surface area and outside the tubules, stroma with the Leydig cells was regarded as stromal volume. They noted that tubule volume gradually increased whereas stromal volume decreased. The tubular volume was more significant than the stromal volume. The increase in the testis volume was observed to be in favour of tubule volume.

In the present study 4 groups were made: Group A (12-16 weeks), Group B (16-20 weeks), Group C (20-24 weeks) and Group D (24 -28 weeks). It was observed that correlation between weight and volume of testis was significant. The total volume of testis was measured by water displacement method, so tubular volume and stromal volume could not be compared with Malas et al[13].

Wahengbam et al[4] observed gradual increase in the weight and size of the testis with advancing gestational age. They studied the fetuses from 9-40 weeks of gestational age, but did not divide them into groups. The study suggested that in 70% of cases, right testes were heavier than the left one.

In the present study, the maximum increase in weight was observed on the right testis than the left. Also there was significant correlation between weight and volume similar to Wahengbam et al[4].

Sotos et al[11] suggested that clinically volume of testes can be observed from width of the testes and this volume closely matched to ultrasound finding. In the present study we noted that correlation between the breadth and volume was significant, thus it may be possible to determine the testicular volume with the help of breadth of testis.

The present study established a significant and positive correlation between the length, breadth, thickness, weight and volume of testes. All the parameters were correlated to one another. It was observed that there was similar increase in breadth and thickness of testis along with increase in length Maximum increase in breadth and thickness was seen from group A-B, whereas in length, weight and volume of testis the maximum increase was seen from group C-D. In all the parameters of testes the minimum growth was noticed between group B-C. It was observed that there was not much difference in growth of the right and left side of testis.

The increase in the length, breadth as well as thickness of the testis was almost constant in all the age groups. The breadth of right testes was roughly 1.35-1.57 times of the thickness and left testis 1.32-1.48 times. The ratio of right testis breadth and thickness remained roughly constant throughout the gestation with maximum ratio seen to be 1.5:1 in group D. The maximum ratio of right testes length and thickness was seen to be 2.83:1 in group D also.

No study was available to compare the present findings.

SUMMARY AND CONCLUSION

The knowledge of morphometry of the testis is important in case of undescended testis, cryptorchidism, hypospadias, ectopic testis, inguinal hernias, infertility, and testicular tumors.

The present study has been undertaken with the aim of setting morphometric parameters on testes in North West Indian fetuses of different gestational age. In the present study, following morphometric parameters were taken: length, breadth, thickness, weight and volume of right and left testis. All the parameters of the testis were calculated and correlated with the increasing fetal gestational age.

The growth in various dimensions of testis was seen to be

proportional to the gestational age group of fetus. Maximum growth spurt of testis in length, weight and volume was observed from group C (>20-24 weeks) to D (>24-28weeks) whereas in breadth and thickness, it was observed from group A (12-16 weeks) to group B (>16- 20 weeks), thereby implying that there was maximum transverse growth in initial gestational age groups (12-20 weeks) and maximum longitudinal growth occurred from groups C-D (20-28 weeks). The increase in length, weight and volume of right testis from 12-28weeks of gestation was seen to be more than the left side of testis. The increase in breadth and thickness of left side of testis was more than the right side of testis.

The present study established a significant and positive correlation between all the five growth parameters (length, breadth, thickness, weight and volume) of testes and they also positively correlated with CRL and abdominal circumference (AC). All the parameters were correlated to one another and increased with increasing gestational age. The increase in the length, breadth as well as thickness of the testis was almost constant in all age groups.

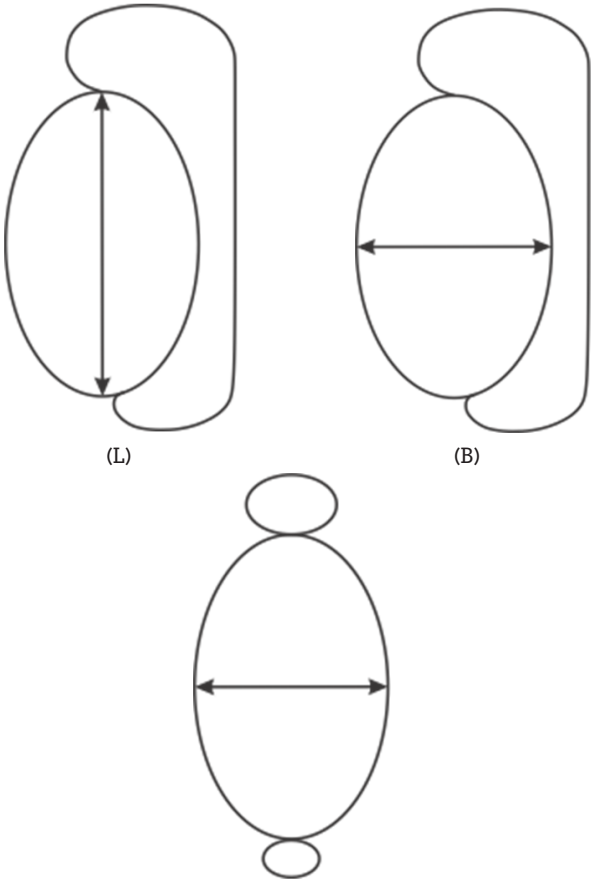


Figure 1: Anatomical parameters measured on testis on each specimens:- Length (L), Breadth (B), Thickness (T)

FIGURES

Length Breadth

Thickness

Weight Volume

Figure 2: Measurements taken on fetal testis by Vernier caliper, weighing balance and water displacement method

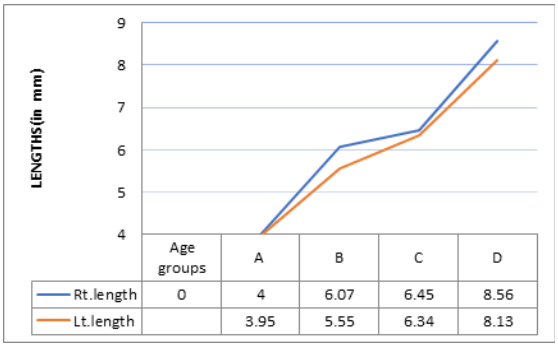


Figure 3: Increase in right and left testis length in different gestational age

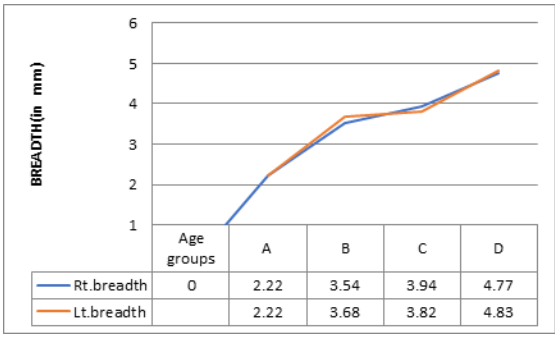


Figure 4: Increase in right and left testis breadth in different gestational age

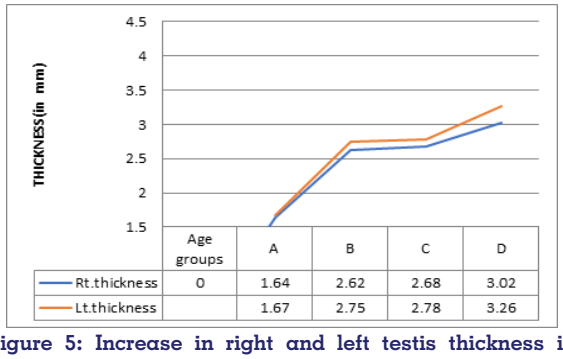
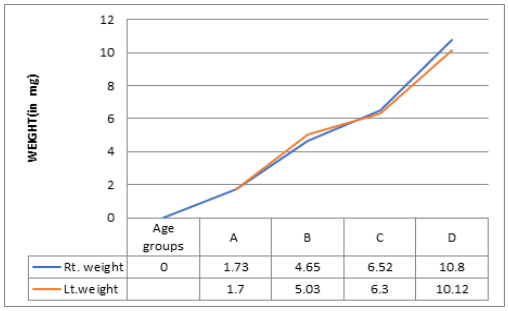
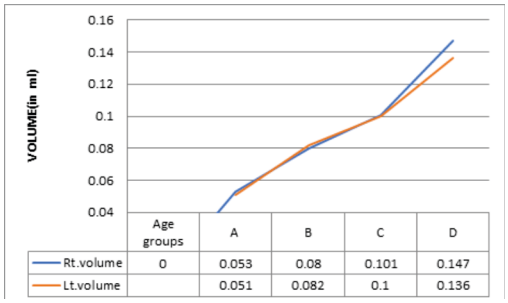


Figure 5: Increase in right and left testis thickness in different gestational age



Age groups	A	B	C	D
Rt. weight	0	1.73	4.65	6.52	10.8
Lt.weight		1.7	5.03	6.3	10.12

Figure 6: Increase in right and left testis weight in different gestational age



Age groups	A	B	C	D
Rt.volume	0	0.053	0.08	0.101	0.147
Lt.volume		0.051	0.082	0.1	0.136

Figure 7: Increase in right and left testis volume in different gestational age

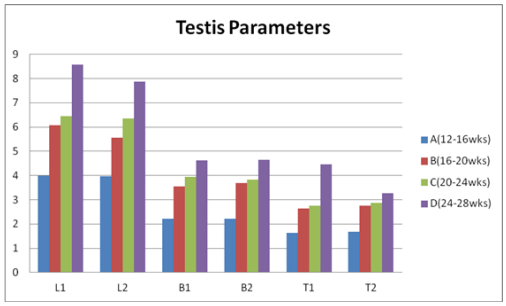


Figure 8: The trend of growth of various morphometric parameters in different gestational groups.

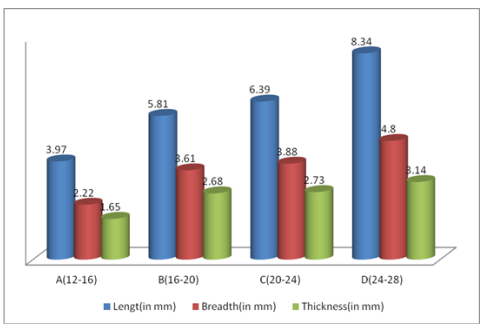


Figure 9: Correlation between length, breadth and thickness of testis in different age groups.

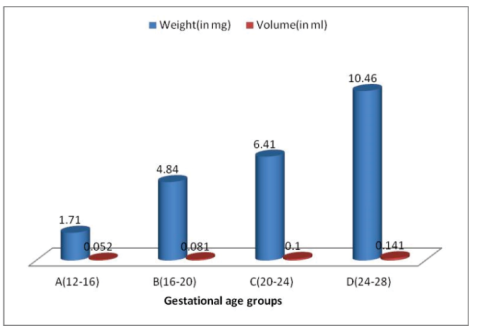


Fig 10: Correlation between weight and volume of testes in different age groups.

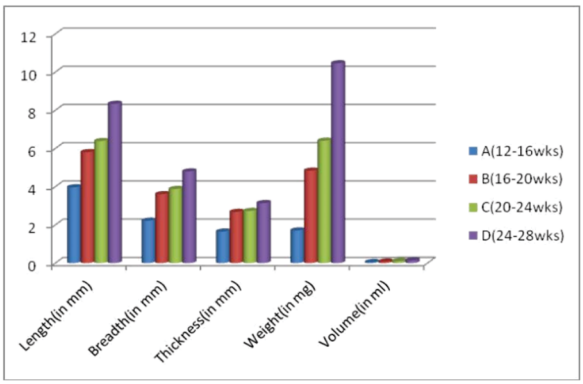


Fig 11: Correlation between various growth parameters in different age groups.

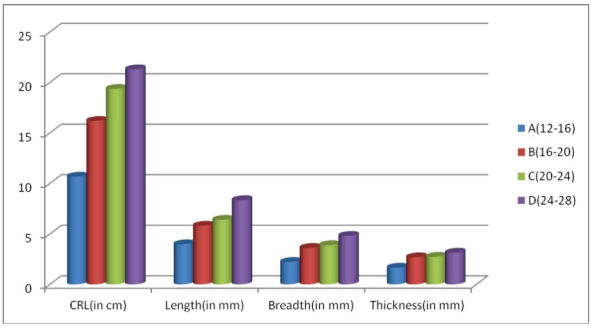


Fig 12: Correlation between CRL and various growth parameters of testes in different age groups

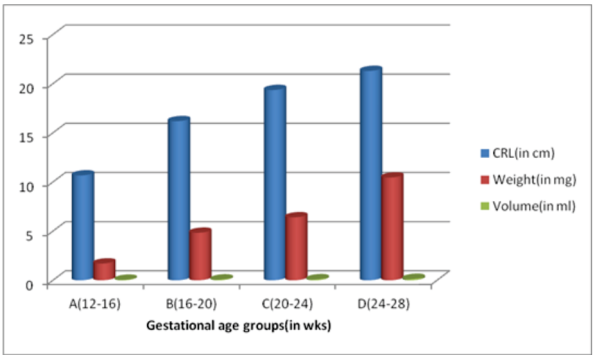


Fig 13: Correlation between CRL and weight & volume of testis in different age groups

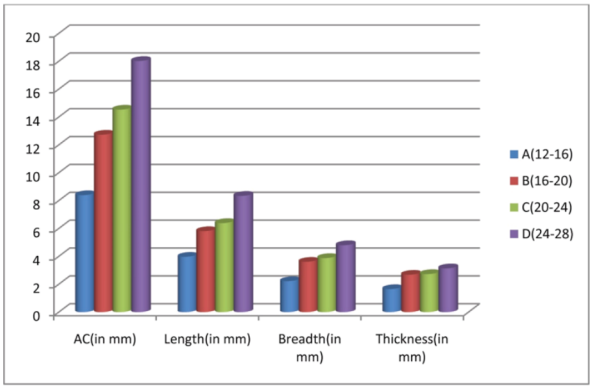


Figure 14: Correlation between abdominal circumference & and growth parameters in different age groups.

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