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# Bilateral variations in the growth and development of human foetal clavicle.

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## Abstract

**Being a long bone and having an intramembranous ossification with earliest appearance of primary ossification (two) centres and having no medullary cavity it reflects that nature too supports its importance in gaining early strength so that it can support the developing upper limbs of the foetus earliest to provide them easy movements, our study is to determine the bilateral growth variations during the intra uterine life. 60 clavicles were obtained from 30 human foetuses ranging from 14 weeks to 33 weeks of IUL from Department of Anatomy, Jawaharlal Nehru, Aligarh Muslim University, Aligarh. For the purpose of study, foetuses were divided into five groups on the basis of gestational age. Parameters selected to determine the bilateral variations were weight; length; circumference, AP and Vertical diameter at mid-shaft; AP and Vertical diameter at medial end; AP and Vertical diameter at lateral end of clavicles. All parameters were measured using vernier calliper and weight was taken by the single pan fractional weighing mechine. Students t test was used to determine the coefficient of significance, SPSS Software was used to do the calculations. Later linear graphs were prepared considering both right and left clavicles for the same parameter. It was found that bilateral variations were not significant in most of the parameters considered in our study, except thickness of its shaft at its midpoint which is more pronounced on the right side in early foetal life and on the left side in late foetal life. Thus we conclude that there is no significant bilateral variations in growth and development of clavicle during the intrauterine life. The variations that may be present in the adult clavicles are due to the factors that play their role after birth.**

**Keywords.** Morphometry, bilateral variations, clavicle, human foetus, clavicular length

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## Introduction

The developmental anatomy is gaining increasing significance, as it constitutes the basic framework of different clinical specialties possessing a foetal, neonatal or paediatric orientation. In fact the morphology of an organ often sufficiently tells the practicing physicians more than many functions. Hence, there is a continuing need for morphological data.

A lot of work has been done till date to assess the age of the foetuses (in utero), Schwarzler [1] prepared Sex-specific antenatal reference growth charts for uncomplicated singleton pregnancies at 15-40 weeks of gestation. Persson [2] assessed the reliability of ultrasound fetometry in estimating gestational age in the second trimester. Natalie [3] compared the age and sex estimation of clavicle by traditional and novel methods. Shobha [4] determined sex of adult human clavicles by morphometric parameters. However till date no study is avalable to assess the age of a dead foetus or of foetal remains which may be useful for medico legal purpose.

Many morphometric studies have been done on long bones of foetuses, Lowrance [5] and Khan and Faruqi [6] on Asian subjects; Nasrat and Bondagji [7] worked on ultrasound biometry of Arabian foetuses. Sherer [8] worked on the foetal clavicle length throughout gestation

by means of ultrasonography, Yarkoni [9] found that how the clavicular measurements can be a new biometric parameter for foetal evaluation. Diaphyseal lengths of dried material of foetal skeletons from the third to the tenth Lunar month of pregnancy have already been investigated in a forensic series by Fazekas and Kosa [10] but it lacked information about human foetal clavicle.

All these studies were based on radiographic or sonographic evaluation. Frutos [11] worked for determination of sex from clavicle and scapula in a Guatemalan contemporary rural indigenous population and by means of actual manual measurements but his work was on adult clavicles, Odgen [12] worked on 31 pairs of adult human clavicles from human cadavers (full-term stillborn to fourteen years) by means of radiology to know their post natal development. No work has been done in the field of morphometry on human foetal clavicle in actual means, because in every aspect manual measurements will give the most precise data than by radiography or by sonography so our results will be the most accurate ones in the field of morphometry of human foetal clavicle till date.

Being a long bone and having an intramembranous ossification with earliest appearance of primary ossification (two) centres and having no medullary cavity it reflects that nature too supports its importance in gaining early strength so that it can support the developing upper limbs of the foetus earliest to provide them stable movements. Moore [13]. The clavicle varies more in shape than most other long bones, it's thicker and more curved in manual workers and the sites of muscular attachments are more marked.

Taking into account the aforementioned arguments, our study is to ascertain wether there are any bilateral variations found in the growth and development of clavicle during the intrauterine life.

## Materials and Method

30 (13 male and 17 female) Human Foetuses were obtained from the Museum, Department of Anatomy, Jawaharlal Nehru Medical College, A.M.U. Aligarh after being awarded Ethical Clearance Certificate from the Institutional Ethics Committee (IEC). Foetuses of all age groups without congenital craniovertebral anomalies (*e.g.* anencephaly, spina bifida, cleidocraniodysostosis) were selected for the study. The parameter used for determination of gestational age was foetal foot length. Which is already been documented by Streeter [14]. For the purpose of study, foetuses were divided into five groups on the basis of gestational age.

***Table I.*** *Division of foetuses into groups on the basis of gestational age*

| Groups | Gestational age (weeks) | No. of males | No. of females | Total |
|---|---|---|---|---|
| I | <17 | 2 | 4 | 6 |
| II | 17-19 | 2 | 4 | 6 |
| III | 20-23 | 3 | 3 | 6 |
| IV | 24-28 | 3 | 3 | 6 |
| V | >28 | 3 | 3 | 6 |

*Total no. of foetuses = 30*

Determination of sex was done taking into consideration the external genitalia.

***Measurements taken***

1. Weight (mm)
2. Length (mm)
3. Circumference at the midshaft (mm)
4. Anteroposterior diameter at the midshaft (mm)
5. Vertical diameter at the midshaft (mm)
6. Anteroposterior diameter at the medial end (mm)
7. Vertical diameter at the medial end of both left and right clavicles (mm)
8. Anteroposterior diameter at the lateral end (mm)
9. Vertical diameter at the lateral end of both left and right clavicles (mm)

All parameters were measured using vernier calliper and weight was taken by the single pan fractional weighing mechine. Student's t test was used to determine whether statistically significant differences occur between the different measurements taken from individual bones, both right and left clavicles from 30 (13 male and 17 female) human foetuses. SPSS software was used to solve the calculations.

## Results

All the parameters were measured on both the right and left clavicles in each age group and mean of the group with its standard deviation was taken into consideration, P Value and Percentage difference were calculated (Tables 2-10, (Fig. 1).

***Table 2.*** *Weight of clavicle in human foetuses - Bilateral variation*

| Groups | Side | No. of cases (n) | Mean ± SD (mg) | Per cent difference | P Value |
|---|---|---|---|---|---|
| I | Right | 6 | 12.00 ± 3.16 | R>L by 3% of its weight | <0.8 |
| | Left | 6 | 11.66 ± 3.39 | | |
| II | Right | 6 | 31.67 ± 15.25 | R>L by 1% of its weight | N.S. |
| | Left | 6 | 31.33 ± 12.56 | | |
| III | Right | 6 | 50.33 ± 13.09 | L>R by 4% of its weight | <0.8 |
| | Left | 6 | 52.50 ± 17.65 | | |
| IV | Right | 6 | 88.50 ± 19.71 | R>L by 4% of its weight | <0.8 |
| | Left | 6 | 85.00 ± 24.48 | | |
| V | Right | 6 | 159.83 ± 52.91 | L>R by 2% of its weight | <0.8 |
| | Left | 6 | 163.33 ± 54.43 | | |

*N.S.:-Not significant*
*No significant bilateral variations observed in weight of human foetal clavicle in any of the groups*

***Table 3.*** *Length of clavicle in human foetuses – Bilateral variations*

| Groups | Side | No. of cases (n) | Mean ± SD (mm) | Per cent difference | P Value |
|---|---|---|---|---|---|
| I | Right | 6 | 14.12 ± 1.46 | L>R by 2% of its length | <0.8 |
| | Left | 6 | 14.43 ± 2.04 | | |
| II | Right | 6 | 19.39 ± 2.04 | R>L by 1% of its length | <0.1 |
| | Left | 6 | 19.22 ± 2.03 | | |
| III | Right | 6 | 24.67 ± 1.40 | L>R by 1% of its length | N.S. |
| | Left | 6 | 24.71 ± 1.29 | | |
| IV | Right | 6 | 29.00 ± 2.10 | R>L by 1% of its length | <0.8 |
| | Left | 6 | 28.83 ± 1.69 | | |
| V | Right | 6 | 34.58 ± 2.21 | L>R by 0.5% of its length | N.S. |
| | Left | 6 | 34.71 ± 2.69 | | |

*N.S.:-Not significant*
No significant bilateral variations observed in length of human foetal clavicle in any of the groups

***Table 4.*** *Circumference at midshaft of clavicle in human foetuses – Bilateral variations*

| Groups | Side | No. of cases (n) | Mean ± SD (mm) | Per cent difference | P Value |
|---|---|---|---|---|---|
| I | Right | 6 | 4.38 ± 0.25 | L>R by 1% of its circumference | N.S. |
| | Left | 6 | 4.41 ± 0.39 | | |
| II | Right | 6 | 5.77 ± 0.77 | L>R by 1% of its circumference | <0.5 |
| | Left | 6 | 5.83 ± 0.74 | | |
| III | Right | 6 | 6.16 ± 0.19 | R>L by 0.5% of its circumference | <0.8 |
| | Left | 6 | 6.13 ± 0.26 | | |
| IV | Right | 6 | 6.82 ± 0.55 | L>R by 1% of its circumference | <0.5 |
| | Left | 6 | 6.89 ± 0.52 | | |
| V | Right | 6 | 7.63 ± 0.79 | L>R by 3% of its | <0.05 |

| | | | | |
|---|---|---|---|---|
| | Left | 6 | 7.83 ± 0.76 | circumference |

*N.S.:-Not significant*

*No significant bilateral variations observed in Circumference at midshaft of clavicle in human foetuses in any of the groups, excpet in the Group V. Where left clavicle is 3% more in circumference than the right clavicle*

***Table 5**. Anteroposterior diameter at midshaft of clavicle in human foetuses – Bilateral variations*

| Groups | Side | No. of cases (n) | Mean ± SD (mm) | Per cent difference | P Value |
|---|---|---|---|---|---|
| I | Right | 6 | 1.08 ± 0.27 | L>R by 1% of it's A.P. diameter | N.S. |
| | Left | 6 | 1.09 ± 0.22 | | |
| II | Right | 6 | 1.84 ± 0.36 | R>L by 10% of it's A.P. diameter | <0.05 |
| | Left | 6 | 1.66 ± 0.41 | | |
| III | Right | 6 | 1.88 ± 0.21 | L>R by 6% of it's A.P. diameter | <0.05 |
| | Left | 6 | 1.99 ± 0.25 | | |
| IV | Right | 6 | 2.16 ± 0.36 | R>L by 3% of it's A.P. diameter | <0.2 |
| | Left | 6 | 2.10 ± 0.37 | | |
| V | Right | 6 | 2.65 ± 0.28 | L>R by 0.5% of it's A.P. diameter | N.S. |
| | Left | 6 | 2.67 ± 0.37 | | |

*N.S.:-Not significant*

*No significant bilateral variations observed in Anteroposterior diameter at midshaft of clavicle in human foetuses in any of the groups, excpet in the Group II and III. Where in group II Right clavicle is 10% more in AP diameter than the left clavicle, while in group III Left clavicle leads by 6% in its AP diameter than the right clavicles*

***Table 6.** Vertical diameter at midshaft of clavicle in human foetuses – Bilateral variations*

| Groups | Side | No. of cases (n) | Mean ± SD (mm) | Per cent difference | P Value |
|---|---|---|---|---|---|
| I | Right | 6 | 1.18 ± 0.104 | R>L by 4% of its V. diameter | <0.005 |
| | Left | 6 | 1.13 ± 0.098 | | |
| II | Right | 6 | 1.39 ± 0.12 | R>L by 1% of its V. diameter | <0.8 |
| | Left | 6 | 1.38 ± 0.11 | | |
| III | Right | 6 | 1.48 ± 0.20 | L>R by 9% of its V. diameter | <0.5 |
| | Left | 6 | 1.63 ± 0.29 | | |
| IV | Right | 6 | 1.96 ± 0.186 | L>R by 5% of its V. diameter | <0.001 |
| | Left | 6 | 2.07 ± 0.189 | | |
| V | Right | 6 | 2.07 ± 0.29 | R>L by 2% of its V. diameter | <0.2 |
| | Left | 6 | 2.02 ± 0.30 | | |

*No significant bilateral variations observed in Vertical diameter at midshaft of clavicle in human foetuses in any of the groups, excpet in the Group I and IV. Where in group I Right clavicle is 4% more in Vertical diameter than the left clavicle, while in group IV Left clavicle leads by 5% in its Vertical diameter than the right clavicles*

***Table 7.** Anteroposterior diameter at medial end of clavicle in human foetuses – Bilateral variations*

| Groups | Side | No. of cases (n) | Mean ± SD (mm) | Per cent difference | P Value |
|---|---|---|---|---|---|
| I | Right | 6 | 1.43 ± 0.37 | L>R by 1% of it's A.P. diameter | N.S. |
| | Left | 6 | 1.45 ± 0.21 | | |
| II | Right | 6 | 2.22 ± 0.58 | L>R by 3% of it's A.P. diameter | <0.8 |
| | Left | 6 | 2.30 ± 0.74 | | |
| III | Right | 6 | 2.54 ± 0.50 | R>L by 10% of it's A.P. diameter | <0.1 |
| | Left | 6 | 2.28 ± 0.37 | | |
| IV | Right | 6 | 3.62 ± 0.34 | R>L by 14% of it's A.P. diameter | <0.1 |

| | | | | | |
|---|---|---|---|---|---|
| | Left | 6 | 3.12 ± 0.72 | | |
| V | Right | 6 | 3.98 ± 0.59 | R>L by 4% of it's A.P. diameter | <0.5 |
| | Left | 6 | 3.83 ± 0.72 | | |

*N.S.:-Not significant*

*No significant bilateral variations observed in Anteroposterior diameter at medial end of clavicle in human foetuses in any of the groups*

***Table 8.*** *Vertical diameter at medial end of clavicle in human foetuses – Bilateral variations*

| **Groups** | **Side** | **No. of cases** (n) | **Mean ± SD** (mm) | **Per cent difference** | **P Value** |
|---|---|---|---|---|---|
| I | Right | 6 | 1.37 ± 0.15 | L>R by 11% of its V. diameter | <0.2 |
| | Left | 6 | 1.54 ± 0.30 | | |
| II | Right | 6 | 2.15 ± 0.41 | L>R by 1% of its V. diameter | <0.8 |
| | Left | 6 | 2.18 ± 0.44 | | |
| III | Right | 6 | 2.79 ± 0.53 | R>L by 3% of its V. diameter | <0.8 |
| | Left | 6 | 2.71 ± 0.37 | | |
| IV | Right | 6 | 3.13 ± 0.13 | L>R by 5% of its V. diameter | <0.5 |
| | Left | 6 | 3.28 ± 0.36 | | |
| V | Right | 6 | 4.58 ± 1.22 | L>R by 3% of its V. diameter | <0.8 |
| | Left | 6 | 4.74 ± 1.03 | | |

*No significant bilateral variations observed in Vertical diameter at medial end of clavicle in human foetuses in any of the groups*

***Table 9.*** *Anteroposterior diameter at lateral end of clavicle in human foetuses – Bilateral variations*

| **Groups** | **Side** | **No. of cases** (n) | **Mean ± SD** (mm) | **Per cent difference** | **P Value** |
|---|---|---|---|---|---|
| I | Right | 6 | 1.92 ± 0.34 | L>R by 4% of it's A.P. diameter | <0.5 |
| | Left | 6 | 2.00 ± 0.38 | | |
| II | Right | 6 | 2.54 ± 0.68 | R>L by 4% of it's A.P. diameter | <0.8 |
| | Left | 6 | 2.43 ± 0.45 | | |
| III | Right | 6 | 3.31 ± 0.24 | R>L by 1% of it's A.P. diameter | <0.8 |
| | Left | 6 | 3.29 ± 0.19 | | |
| IV | Right | 6 | 3.86 ± 0.71 | R>L by 3% of it's A.P. diameter | <0.5 |
| | Left | 6 | 3.73 ± 0.58 | | |
| V | Right | 6 | 4.47 ± 0.53 | L>R by 2% of it's A.P. diameter | <0.8 |
| | Left | 6 | 4.55 ± 0.64 | | |

*No significant bilateral variations observed in Anteroposterior diameter at lateral end of clavicle in human foetuses in any of the groups*

***Table 10.*** *Vertical diameter at lateral end of clavicle in human foetuses – Bilateral variations*

| **Groups** | **Side** | **No. of cases (n)** | **Mean ± SD (mm)** | **Per cent difference** | **P Value** |
|---|---|---|---|---|---|
| I | Right | 6 | 0.97 ± 0.23 | L>R by 6% of its V. diameter | <0.5 |
| | Left | 6 | 1.03 ± 0.30 | | |
| II | Right | 6 | 1.18 ± 0.18 | L>R by 5% of its V. diameter | <0.2 |
| | Left | 6 | 1.24 ± 0.19 | | |
| III | Right | 6 | 1.59 ± 0.16 | R>L by 3% of its V. diameter | <0.5 |
| | Left | 6 | 1.55 ± 0.11 | | |

| | | | | | |
|---|---|---|---|---|---|
| IV | Right | 6 | 1.66 ± 0.328 | L>R by 1% of its V. diameter | <0.8 |
| | Left | 6 | 1.68 ± 0.333 | | |
| V | Right | 6 | 2.08 ± 0.416 | R>L by 1% of its V. diameter | <0.5 |
| | Left | 6 | 2.06 ± 0.419 | | |

*No significant bilateral variations observed in Vertical diameter at lateral end of clavicle in human foetuses in any of the groups*

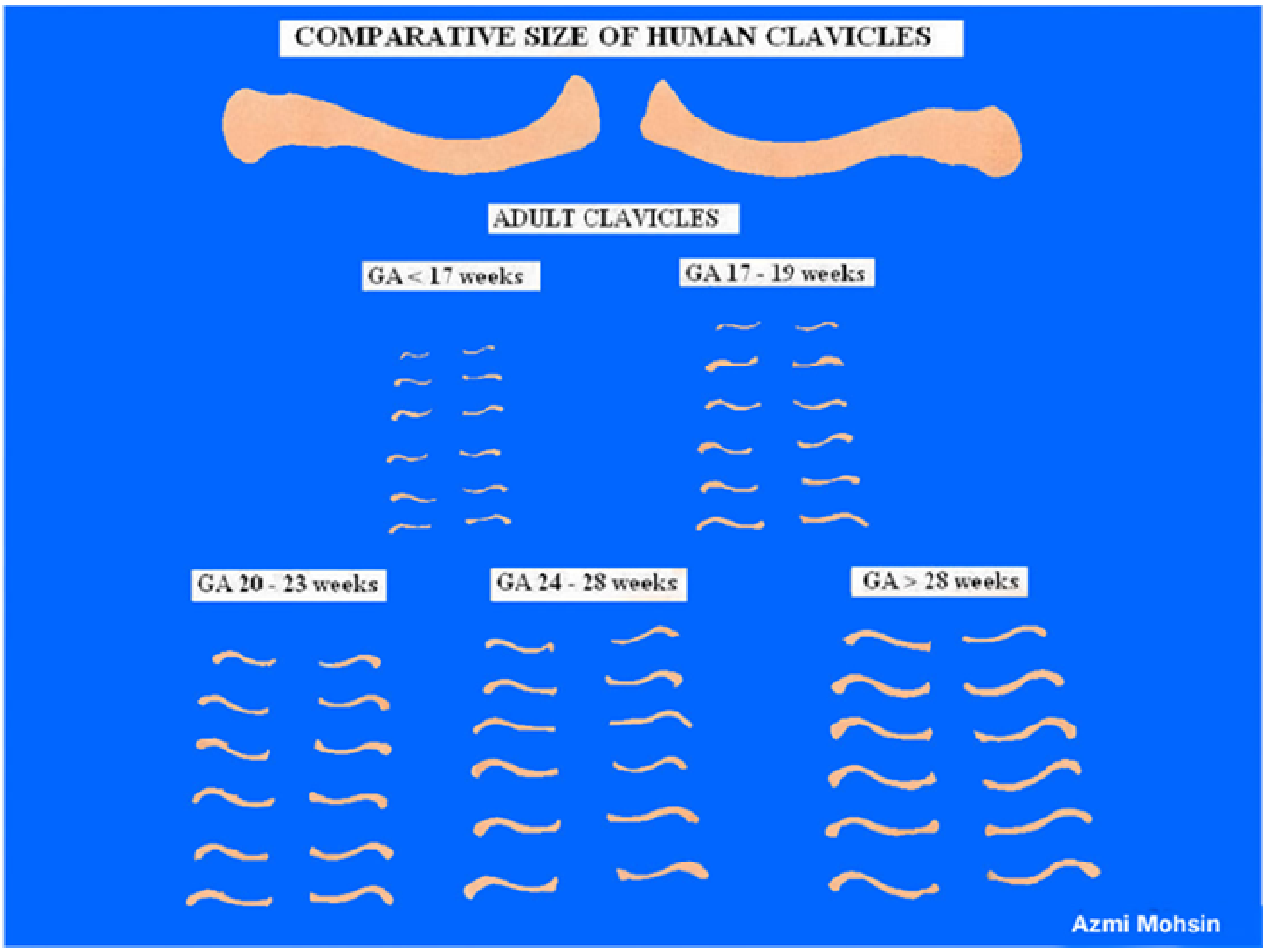


***Figure 1.*** *Comaparision of size of human foatal clavicles (all age groups) to adult clavicles*

## Discussion

Regarding Bilateral variations, Bagnall [15], presented a complicated picture of growth of the two sides of the foetal body, from his study he could not conclude any inference regarding right or left dominance of skeletal growth during foetal life. Similarly in our study bilateral variations are not noticed in most of the parameters considered in our study. Midshaft readings including diameters and circumference are the only parameters which show some significant variations but in few groups of foetuses only. The anteroposterior diameter at the midshaft of clavicle shows significant bilateral variation ($p$ <0.05) in group II & III only (Table. V). in the former the value in right clavicle is more while in latter the reading in the left clavicle is greater. Vertical diameter at midshaft of clavicle shows significant variation in group I ($p$ <0.005) and group IV ($p$ <0.001) (Table. VI), here also we find that smaller clavicle shows right dominance while the larger clavicle shows left dominance. As far as circumference at midshaft is concerned there is significant bilateral variation only in group V specimens ($p$ <0.05) (Table. IV). interestingly here also the value was more in the left clavicle. So we conclude that parameters of the midshaft of clavicle show right dominance in early foetal life and left dominance in late foetal life, which is of no significance as it is noticed only around the mid shaft

while all other parameters show no significant bilateral variations. However in adulthood the right clavicle is usually stronger and shorter than the left clavicle. Moore [13]. We further conclude that, right dominance in the growth and development of clavicle in most of the right handed population seem to be an acquired phenomenon. Benjamin and Michelle [16].

## Conclusion

Growth and development of clavicle during intra uterine life is nearly a symmetrical phenomenon, Whatever Bilateral variations observed in adult clavicle are due to factors which play their role after birth.

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