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Original Article

Morphometric analysis of the clavicle in human foetuses

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ABSTRACT

Introduction: A lot of work has been done till date to assess the age of the foetuses (in utero), by means of clinical examination, radiographically, ultrasonographically. But not much effort has been made to assess the age of a dead foetus or of foetal remains for forensic study or for medicolegal purposes. Morphometric studies have been done earlier on long bones of foetuses but it lacked information about human foetal clavicle. Manual measurements will give the most precise data than by radiography or by sonography. Recently the various invasive and non-invasive approaches aimed at correction of different foetal defects has lead to the emergence of a highly promising super speciality of foetal therapy which has now further enhanced the scope of study on foetal anatomy.

Materials and methods: 30 human foetuses (14 weeks to 33 weeks) without congenital craniovertebral anomalies were divided into five groups on the basis of gestational age. Clavicles were dissected out in all the foetuses. Various parameters were considered which include weight, length, circumference, diameters at different levels. Student's 't' test was used to analyse the results.

Results and discussion: The human foetal clavicle was found to grow steadily in all its parameters. Weight and the interclavicular distance, also showed steady increase throughout intra-uterine growth.

Conclusion: All the parameters, therefore, can be used to determine the age of live or dead foetuses which is of medicolegal importance.

1. Introduction

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

Multiple parameters have been used for ultrasound evaluation of gestation. These include crown-rump length (CRL), biparietal diameter, head circumference, abdominal

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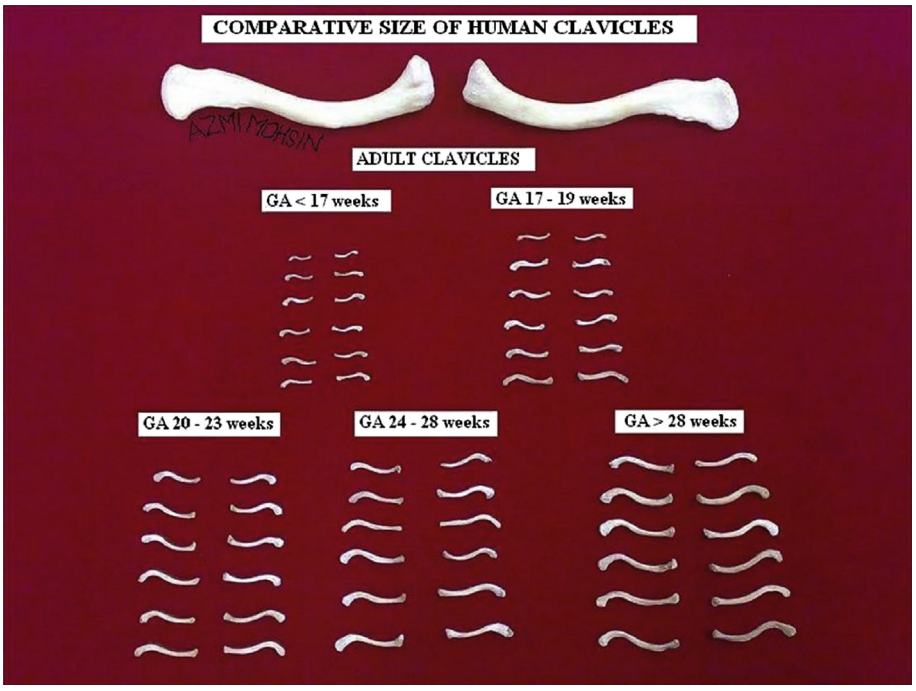

Fig. 1 – Human foetal clavicles divided into five groups on the basis of gestational age, compared with the size of adult human clavicle.

circumference and femoral length.[1] Radiological measurements *e.g.* length of foetal long bones, have also been earlier considered to determine gestational age.[2,3] The use of these methods makes it difficult to compare results. This particularly applies when in some cases the measurements are related to CRL, while in others, they are related to foetal age. The radiological assessment of maturity has been partly successful because of limitations imposed by technical problems as well as variations in foetal growth.[4,5]

A lot of work has been done till date to assess the age of the foetuses (in utero), by means of clinical examination, radiographically, ultrasonographically. Sex-specific antenatal reference growth charts for uncomplicated singleton pregnancies at 15–40 weeks of gestation[6] are available. Ultrasound fetometry in estimating gestational age in the second trimester[7] has also been prepared. But not much effort has been made to assess the age of a dead foetus or of foetal remains for forensic study or for medicolegal importance.

Many morphometric studies have been done on the long bones of Asian[8,9] and Arabian foetuses.[10] Foetal clavicular length throughout gestation has been studied by means of ultrasonography.[11] Clavicular measurements can be a new biometric parameter for foetal evaluation.[12] 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[13] but it lacked information about human foetal clavicle. All these studies were based on radiographic or sonographic evaluation. Determination of sex from clavicle and scapula in a Guatemalan contemporary rural indigenous population and by means of actual manual measurements was done on adult clavicles.[14] Work has been done on adult human clavicles from human cadavers (full-term stillborn to fourteen years) by means of radiology to know their post natal development.[15] Clavicles from 60 white and 180 black South African skeletons.[16] Paired clavicles and scapulae obtained from 102 adult Korean cadavers[17] and 1020 dry clavicles from cadavers of Italian origin,[18] to determine the prevalence of coracoclavicular joint in their samples.

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.[19] Being a long bone and having an intramembranous ossification with earliest appearance of primary ossification (two) centres and having no medullary cavity, reflects that nature too supports its importance in gaining early strength.

Recently the various invasive and non-invasive approaches aimed at correction of different foetal defects has lead to the emergency of a highly promising super speciality of foetal therapy which has further enhanced the scope of study on foetal anatomy.

2. Materials and method

30 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 (Fig. 2). The parameter used for determination of gestational age was foetal foot length. Correlation between foot length and gestational age is documented (Streeter, 1920).[1] For the purpose of study, foetuses were divided into five groups on the basis of gestational age (Table 1, Fig. 1).

Fig. 2 – Human foetal clavicles (GA = 14 weeks) been dissected out, size compared with the size of finger breadth.

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

2.1. *Measurements prior to dissection*

Although age determination was done using foot length, but various other parameters were taken into consideration.

1. Head circumference (in cm)
2. Foot length (in mm)
3. Crown-rump length (CRL) (in cm)
4. Weight of foetus (in gm)

2.2. *Measurement during dissection*

1. The Interclavicular distance (in mm) (Fig. 3)

2.3. *Measurements after dissection*

1. Weight of both left and right clavicles (in mg)
2. Length of both left and right clavicles (in mm) (Fig. 4)
3. Circumference at the midshaft of both left and right clavicles (in mm) (Fig. 5)
4. Anteroposterior diameter at the midshaft of both left and right clavicles (in mm) (Fig. 6)
5. Vertical diameter at the midshaft of both left and right clavicles (in mm)
6. Anteroposterior diameter at the medial end of both left and right clavicles (in mm)

Table 1 – 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; Total no. of clavicles = 60 (Fig. 1)				

Fig. 3 – Measuring the interclavicular distance with the help of vernier calliper.

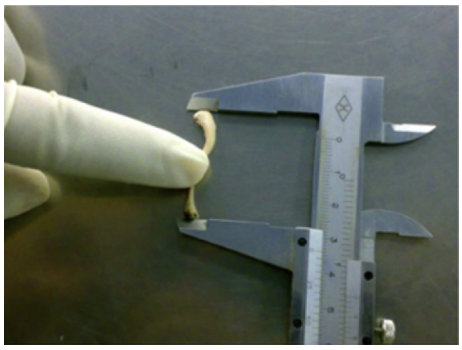

Fig. 4 – Measuring the length of human foetal clavicle with the help of vernier calliper.

7. Vertical diameter at the medial end of both left and right clavicles (in mm)
8. Anteroposterior diameter at the lateral end of both left and right clavicles (in mm)
9. Vertical diameter at the lateral end of both left and right clavicles (in mm)

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 & 17 female) human foetuses. SPSS software was used to solve the calculations.

Fig. 5 – Measuring the mid shaft circumference of human foetal clavicle with the help of thread wind around its mid shaft.

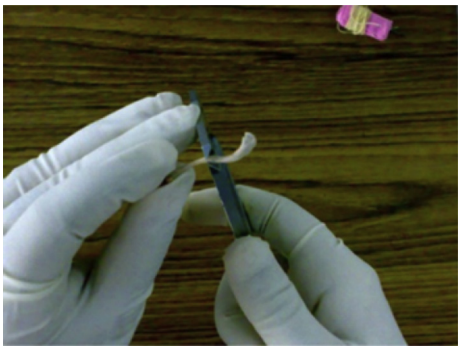

Fig. 6 – Measuring the mid shaft antero-posterior diameter with the help of vernier calliper.

3. Results

Table 2 – Interclavicular distance in human foetuses.

Groups	No. of cases (*n*)	Mean ± SD (mm)	Per cent change	*P* value
I	6	4.38 ± 0.66	–	–
II	6	6.13 ± 0.70	+40%	<0.001
III	6	6.88 ± 0.78	+12%	<0.001
IV	6	8.62 ± 0.34	+25%	<0.001
V	6	11.61 ± 1.32	+35%	<0.001

Table 3 – Weight of clavicle in human foetuses.

Groups	No. of cases (*n*)	Mean ± SD (mg)	Per cent change	*P* value
I	12	11.83 ± 3.13	–	–
II	12	31.50 ± 13.32	+166%	<0.001
III	12	51.42 ± 14.86	+63%	<0.001
IV	12	86.75 ± 21.27	+69%	<0.001
V	12	161.58 ± 51.21	+86%	<0.001

Table 4 – Length of clavicle in human foetuses.

Groups	No. of cases (*n*)	Mean ± SD (mm)	Per cent change	*P* value
I	12	14.27 ± 1.70	–	–
II	12	19.30 ± 1.94	+35%	<0.001
III	12	24.69 ± 1.28	+28%	<0.001
IV	12	28.93 ± 1.82	+17%	<0.001
V	12	34.64 ± 2.34	+20%	<0.001

Table 5 – Circumference at midshaft of clavicle in human foetuses.

Groups	No. of cases (*n*)	Mean ± SD (mm)	Per cent change	*P* value
I	12	4.40 ± 0.31	–	–
II	12	5.80 ± 0.72	+32%	<0.001
III	12	6.15 ± 0.22	+6%	<0.1
IV	12	6.85 ± 0.51	+11%	<0.001
V	12	7.73 ± 0.75	+13%	<0.001

Table 6 – Anteroposterior diameter at midshaft of clavicle in human foetuses.

Groups	No. of cases (*n*)	Mean ± SD (mm)	Per cent change	*P* value
I	12	1.09 ± 0.23	–	–
II	12	1.75 ± 0.38	+61%	<0.001
III	12	1.93 ± 0.23	+10%	<0.05
IV	12	2.13 ± 0.35	+10%	<0.02
V	12	2.66 ± 0.32	+25%	<0.001

Table 7 – Vertical diameter at midshaft of clavicle in human foetuses.

Groups	No. of cases (*n*)	Mean ± SD (mm)	Per cent change	*P* value
I	12	1.15 ± 0.10	–	–
II	12	1.39 ± 0.11	+21%	<0.001
III	12	1.56 ± 0.25	+12%	<0.02
IV	12	2.01 ± 0.19	+29%	<0.001
V	12	2.04 ± 0.28	+1%	<0.8

Table 8 – Anteroposterior diameter at medial end of clavicle in human foetuses.

Groups	No. of cases (*n*)	Mean ± SD (mm)	Per cent change	*P* value
I	12	1.44 ± 0.29	–	–
II	12	2.26 ± 0.63	+57%	<0.001
III	12	2.41 ± 0.44	+7%	<0.5
IV	12	3.37 ± 0.60	+40%	<0.001
V	12	3.90 ± 0.64	+16%	<0.001

Table 9 – Vertical diameter at medial end of clavicle in human foetuses.

Groups	No. of cases (*n*)	Mean ± SD (mm)	Per cent change	*P* value
I	12	1.45 ± 0.25	–	–
II	12	2.17 ± 0.40	+50%	<0.001
III	12	2.75 ± 0.44	+27%	<0.001
IV	12	3.20 ± 0.27	+16%	<0.001
V	12	4.66 ± 1.08	+46%	<0.001

Table 10 – Anteroposterior diameter at lateral end of clavicle in human foetuses.

Groups	No. of cases (*n*)	Mean ± SD (mm)	Per cent change	*P* value
I	12	1.96 ± 0.35	–	–
II	12	2.48 ± 0.56	+27%	<0.001
III	12	3.30 ± 0.21	+33%	<0.001
IV	12	3.80 ± 0.62	+15%	<0.01
V	12	4.51 ± 0.56	+19%	<0.001

Table 11 – Vertical diameter at lateral end of clavicle in human foetuses.

Groups	No. of cases (*n*)	Mean ± SD (mm)	Per cent change	*P* value
I	12	1.00 ± 0.26	–	–
II	12	1.21 ± 0.18	+21%	<0.005
III	12	1.57 ± 0.13	+30%	<0.001
IV	12	1.67 ± 0.32	+6%	<0.5
V	12	2.07 ± 0.40	+24%	<0.001

4. Discussion

The interclavicular distance (ICD) in human foetuses, ranged from 4.38 mm in group I (<17 weeks of IUL) to maximum 11.61 mm in group V (>28 weeks of IUL). There is consistent increase in the interclavicular distance throughout the intra-uterine life (IUL), as the *p* value being <0.001 in all the adjacent groups. Two groups *i.e.* group II and group V showed maximal increase, the percentage changes being +40% and +35% respectively (Table 2). The aforementioned consistent increase in the ICD has been additionally shown in line chart.

Weight of clavicle in human foetuses, showed significant growth ($p < 0.001$) in all the groups (Table 3), but the change was maximum (+166%) in group II (17–19 weeks of IUL). Weight gain takes up a rapid speed after 28 weeks.

No parallel reports exist regarding ICD and weight of clavicle during IUL in human foetuses till date.

Length of clavicle in human foetuses, is a parameter which has been studied by several workers earlier by radiographic and sonographic means, (Yarkoni S. et al, (1985)[12] and Sherer D.M. et al, (2006)).[11] In our study length of human foetal clavicle shows a steady growth from 14 weeks onwards throughout gestation in all age groups (Table 4). Although all the adjacent groups show a highly significant increase in length of clavicle ($p < 0.001$), but the percentage growth is maximum (+35%) in group II (17–19 weeks of IUL).

Circumference at the midshaft of human foetal clavicle, shows that maximal osseous tissue is laid around its shaft in the early weeks of gestational period, showing +32% increase in group II (17–19 weeks of IUL) supported by a highly significant *p* value *i.e.* <0.001 (Table 5). In group III thickening of shaft nearly stops with only +6% increment in four weeks and then again in the subsequent groups IV & V the midshaft girth takes up a gradual speed in growth showing +11% change in former and +13% change in latter, changes being highly significant in both ($p < 0.001$).

Anteroposterior diameter at the midshaft of human foetal clavicle, shows an interesting pattern of growth (Table 6). It grows rapidly in early weeks (groups I & II) with a maximal change of +61% in group II (17–19 weeks of IUL) which is highly significant statistically ($p < 0.001$). It then nearly halts in the subsequent two groups (groups III & IV) showing a plateau phase, for next 9 weeks or during 6th to 7th month, then in the later weeks of IUL (group V), the growth starts increasing with a +25% change which is highly significant ($p < 0.001$).

Vertical diameter at the midshaft of human foetal clavicle, shows nearly a sigmoid curve, with a maximal growth during 24–28 weeks *i.e.* +29% increase in group IV of our sample which is highly significant ($p < 0.001$). However the adjacent groups (group III & V) show relatively slow growth (Table 7). The start of growth in initial weeks (17–19 weeks of IUL) is also highly significant ($p < 0.001$) with a +21% increment in vertical diameter but in later part of gestational period this parameter becomes nearly static showing only +1% change in group V (>28 weeks of IUL).

Anteroposterior diameter at the medial end of clavicle in human foetuses, shows that the pattern of growth is having a sigmoid curve. There is a rapid increase (+57%) in early weeks (group II). This is a maximum change in its anteroposterior thickness supported by a highly significant *p* value *i.e.* <0.001 (Table 8). In the next group III it shows a halt with only +7% change, but then it starts increasing again from 24–28 weeks (group IV) by +40% and in later part of pregnancy (group V) by +16%. Both these changes are highly significant ($p < 0.001$).

Vertical diameter at the medial end of clavicle in human foetuses, is the only parameter among the various diameters measured along the length of clavicle showing a highly significant growth ($p < 0.001$) throughout the gestational period (Table 9). It starts with a maximal +50% change in group II. In group III & IV growth is relatively less rapid. Growth again takes up a rapid increase after 28 weeks of IUL with +46% change in group V.

Anteroposterior diameter at the lateral end of clavicle in human foetuses, shows a steady growth throughout the IUL, with a maximal increment of +33% during 20–23 weeks of IUL (group III). Growth in this parameter is also highly significant ($p < 0.001$) throughout gestation except during 24–28 weeks (group IV) where the growth dips to only +15% (Table 10) which is relatively less significant ($p < 0.01$).

Vertical diameter at the lateral end of clavicle in human foetuses, shows a steady growth with a maximal increment +30% in growth during 20–23 weeks (group III). The increase in growth is +24% after 28 weeks *i.e.* the last group V. Both the changes are highly significant ($p < 0.001$). In group IV growth is not significant ($p < 0.5$), which dips to only +6% change (Table 11).

All the above mentioned diameters and circumference measured along the length of the clavicle of human foetuses is our original study, not been documented by earlier scientists.

5. Conclusion

The human foetal clavicle grows steadily in all its parameters in all directions including its weight and the interclavicular distance. All the parameters, therefore, can be used to determine the age of foetuses or foetal remains which is of medicolegal importance. This can also prove beneficial in early assessment of foetal well being.

Conflicts of interest

All authors have none to declare.

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