

Estimation of Age from Symphyseal Surface of Cadaveric Pubic Bones of Northwest Indian Male Adults

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ABSTRACT

Introduction: Age estimation of dead persons of unknown age and identity from skeletal remains has an important role in legal and forensic investigations. Due to their relatively better ability to withstand the impact of physical forces and agents, the skeletal remains of human mortals provide us with wealth of information in the form of preserved morphological patterns or markings on bones. Out of all bones, morphological features on pubic bones are by far the best indicators. A large-scale study on pubic bones was conducted by a famous anatomist, Todd, in 1920, and since then his method is being followed for the assessment of age.

Materials and methods: Cadaveric pubic bones of 204 Northwest Indian adult males aged 18 to 61 years were taken for the study from the archive collection in museum of anatomy. Sixteen morphological features on the symphyseal surface of pubic bones were noted and arranged in 10 phases according to Todd's (1920) method. Frequency of these features present in each phase was calculated. Linear regression analysis was applied to obtain an equation for estimation of age from a pubic bone of an unknown deceased individual.

Results: It was seen that frequency of most morphological features of the pubic bones in the present study age groups (phases) was 100%, i.e., similar to those in Todd's study. There was a significant correlation ($r=0.9$, $p<0.001$) between the actual age of the pubic bone and age estimated by linear regression equation.

Conclusion: Despite numerous improved methods, Todd's method remains the most useful method for determination of age. Appearance of morphological features on the symphyseal surface of pubic bones in the present study were similar to most phases of Todd's study. Thus, Todd's method can be successfully applied for the estimation of age in Northwest Indian adult male population.

Keywords: Age estimation, Morphological features, Northwest Indians, Pubic bones, Pubic symphysis.

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INTRODUCTION

Estimation of age of an individual is essential in cases of impersonation, murder, and mass disasters, when body is grossly mutilated or in advance stage of decomposition. Even when the body is completely destroyed the skeletal bones prove to be a rich source of medicolegal evidence. In such cases, age estimations are often based on age-related morphological markings on the bones. Various established methods of age determination from bones exist in research studies but every procedure has its limits. Common methods used are: Microscopic methods¹ – auricular surface of ilium,² bone growth and development,³ dental attrition,⁴ epiphyseal fusion,⁵ ectocranial suture closure,⁶ etc. Among macroscopic methods,¹ pubic bones are alleged to be the best indicators.⁷ Pubic bone and its articular surfaces are well preserved by virtue of their anatomical position being a deeply embedded structure, thus less prone to environmental influences even when the entire skeleton is destroyed. Child bearing may cause certain symphyseal changes, so assessment of age in females by pubic symphysis cannot be as accurate as in males, hence female bones were not considered. Studies on these bones are conducted in various ways: Observing the morphological features by X-rays,⁸ casts,⁹ and computed tomography (CT) scans.¹⁰

Since 1858¹¹ it was known that morphologic changes on pubic symphyseal surface occur throughout life. Later these age changes were documented by an anatomist between 1912 and 1920¹² on 306 male innominate of known age at death, in which a 10-stage method for assessing the symphyseal surface of pubic bones was outlined. These changes over time proceeded in a predictable pattern from highly contoured face to one determined by a rim in mid-30s to a surface marked by increasing porosity after 40 years. The first degenerative change usually took place around the dorsal margin. Phylogenetically, this is the oldest portion of symphyseal face.

Todd's method has been approved and followed by various Indian and Western authors.^{7,11,13-15} However, many authors used different methods of age estimation from pubic symphysis.^{13,16-20} Some authors also wanted

to improve Todd's method and tested it on a sample of Native Americans²⁰ as they found that it consistently overestimated age. Minor modifications in the age range were assigned to each phase, but the authors then accepted Todd's archetypal system. Studies^{21,22} have shown Todd's method to be the most accurate of the pubic symphyseal methods. Similar Indian studies have also been conducted on pubic bones.^{14,15,23}

Observations made in Western countries are not applicable to Indian populations due to racial differences. Also bony changes depend on climate, nutrition, geographical region, races, etc., so no universal standard can be devised for estimation of age. Hence, region-wise standards are required. The present study was thus conducted to estimate age from morphological features on symphyseal surface of pubic bones for Northwest Indian male population.

MATERIALS AND METHODS

The present study was conducted on 204 pubic bones of Northwest Indian adult male cadavers aged 18 to 61 years taken from the archives cadaveric collection from the museum of Department of Anatomy, Postgraduate Institute of Medical Education and Research, Chandigarh. Age of the individual to whom the bone belonged was confirmed from documentary evidence. It is a cross-sectional study, and the exclusion criterion was suspected cases of pathology of bones, fractured and broken pubic bones, and uncertainty of the age. Since Todd found no clear difference between right and left bone, they were studied as individual bones to maintain a reasonable sample in each of the 10 phases. The dorsal and ventral sides of pubic bones were determined and morphological features were noted agewise under a magnifying glass. The number of pubic bones in each of the Todd's 10 phases (age groups 18 to >50) is noted and their frequency (%) is calculated. Sixteen morphological features were noted which are given below:

1. Ridges and furrows; 2. Superior ossific nodules; 3. Upper extremity; 4. Lower extremity; 5. Dorsal margin (rampart); 6. Ventral bevel (slope); 7. Dorsal plateau; 8. Ventral margin; 9. Symphyseal rim; 10. Lipping of dorsal margin; 11. Lipping of ventral margin; 12. Lipping of symphyseal margin; 13. Oval outline; 14. Symphyseal face; 15. Bony growths; 16. Symphyseal surface eroded.

A scatterplot between log (Todd's phase) and age in years was drawn from the data collected to show the relationship between the above two parameters. Logistic regression model development analysis was used for the estimation of age. The results of the present study were compared with those of Todd's as well as other similar Indian and Western studies.

The pubic bones were studied following Todd's (1920) method given next:

TODD'S METHOD

First Postadolescent Phase (Age 18–19 Years)

Symphyseal surface rugged, traversed by horizontal ridges separated by well-marked grooves; no ossific nodules fusing with the surfaces; no definite delimiting margin; no definition of extremities.

Second Postadolescent Phase (Age 20–21 Years)

Symphyseal surface still rugged, traversed by horizontal ridges, and the grooves between which are, however, becoming filled near the dorsal limit with a new formation of finely textured bone. This formation begins to obscure the hindered extremities of horizontal ridges. Ossific nodules fusing with upper symphyseal face may occur; dorsal limiting margin begins to develop; no delimitation of extremities; foreshadowing of ventral bevel.

Third Postadolescent Phase (Age 22–24 Years)

Symphyseal face shows progressive obliteration of ridge and furrow system; commencing formation of dorsal plateau; presence of fusing ossific nodules; dorsal margin gradually becoming more defined; beveling as a result of ventral rarefaction becoming rapidly more pronounced; no delimitation of extremities.

Fourth Phase (Age 25–26 Years)

Great increase of ventral beveled area; corresponding diminution of ridge and furrow formation; complete definition of dorsal margin through the formation of dorsal plateau; commencing delimitation of lower extremity.

Fifth Phase (Age 27–30 Years)

Little or no change in the symphyseal face and dorsal plateau except that sporadic and premature attempts at the formation of a ventral rampart occur; lower extremity like the dorsal margin is increasing in clearness of definition; commencing formation of upper extremity with or without intervention of bony nodule.

Sixth Phase (Age 30–35 Years)

Increasing definition of extremities; development and practical completion of ventral rampart; retention of granular appearance of symphyseal face and ventral aspect pubis; absence of lipping of symphyseal margin.

Seventh Phase (Age 35–39 Years)

Changes in symphyseal face and ventral aspect of pubis consequent upon diminishing activity; commencing

Table 1: Frequencies (%) of morphological features on symphyseal surface of pubic bones

Age groups	18-19	20-21	22-24	25-26	27-30	30-35	35-39	39-44	45-50	>50	Total
Phase	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	
N	14	8	10	16	20	24	6	18	56	32	204
Sl. no.											
1	14 (100)	8 (100)	10 (100)	9 (56.3)	10 (50)	-	-	-	-	-	-
2	-	7 (87.5)	10 (100)	16 (100)	-	-	-	-	-	-	-
3	-	-	-	10 (62.5)	20 (100)	24 (100)	6 (100)	18 (100)	-	-	-
4	-	-	-	10 (62.5)	20 (100)	24 (100)	6 (100)	18 (100)	-	-	-
5	-	4 (50)	9 (90)	16 (100)	20 (100)	-	-	-	-	-	-
6	-	4 (50)	9 (90)	15 (93.8)	15 (75.0)	-	-	-	-	-	-
7	-	-	5 (50)	15 (93.8)	10 (50)	24 (100)	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	2 (11.1)	56 (100)	-	-
10	-	-	-	-	-	-	-	2 (11.1)	51 (91.1)	-	-
11	-	-	-	-	-	-	-	2 (11.1)	52 (92.9)	-	-
12	-	-	-	-	-	6 (25)	2 (33.3)	17 (94.4)	-	-	-
13	-	-	-	-	-	-	6 (100)	17 (94.4)	-	-	-
14	-	-	-	-	-	12 (50)	4 (66.7)	-	-	-	-
15	-	-	-	-	-	-	4 (66.7)	-	-	-	-
16	-	-	-	-	-	-	-	-	56 (100)	32 (100)	-

bony growth into attachments of tendons and ligaments, especially of gracilis tendon and sacrotuberous ligament.

Eighth Phase (Age 39-44 Years)

Symphyseal face is generally smooth and inactive; ventral surface of the pubis also inactive; oval outline complete or approximately complete; extremities clearly defined; no distinct rim to symphyseal face; no marked lipping of either dorsal or ventral margin.

Ninth Phase (Age 45-50 Years)

Symphyseal face presents a more or less marked rim; dorsal margin uniformly lipped; ventral margin irregularly lipped.

Tenth Phase (Age 50 Years and Upward)

Symphyseal face eroded and showing erratic ossification; ventral border more or less broken down; disfigurement increases with age.

RESULTS

The frequencies (%) of presence of each morphological feature according to age groups (phases) are given in Table 1. In the age group 18 and 19 years, rugged symphyseal surface was seen due to ridges and furrows formation in all 14 (100%) bones. These continually obliterated till 27 to 30 years. In the age group 20 and 21 years, superior ossific nodules were seen fusing with upper symphyseal face 7 (87.5%), dorsal rampart commenced in 4 (50%), and foreshadowing of ventral bevel also began in 4 (50%) bones. In the age group 22 to 24 years, ridges and furrows and superior ossific nodules were also seen in 100% bones, more defined dorsal rampart and increase in ventral beveled area in 9 (90%) bones and dorsal plateau just commenced in 5 (50%) pubic bones. In the age group 25 and 26 years, ridges and furrows started to diminish in 9 (56.3%) out of 16 bones. Superior ossific nodules and complete dorsal rampart was seen in 16 (100%) bones. Both upper and lower extremities started forming boundaries in 10 (62.5%), ventral beveled area increased further in 15 (93.8%), and complete dorsal plateau was seen in 15 (93.8%) bones.

In the age group 27 to 30 years, ridges and furrows were still obliterating in 10 (50%). Dorsal plateau was still seen in 15 (75%). Upper and lower extremities were getting defined further in all 20 (100%) bones. Ventral margin showed premature formation in 10 (50%) bones and dorsal margin could be seen with clarity in 20 (100%) bones. In the age group 30 to 35 years, both upper and lower extremities were well defined and ventral margin was complete in all 24 (100%) bones. Ventral aspect and symphyseal face of pubic bone showed granular appearance



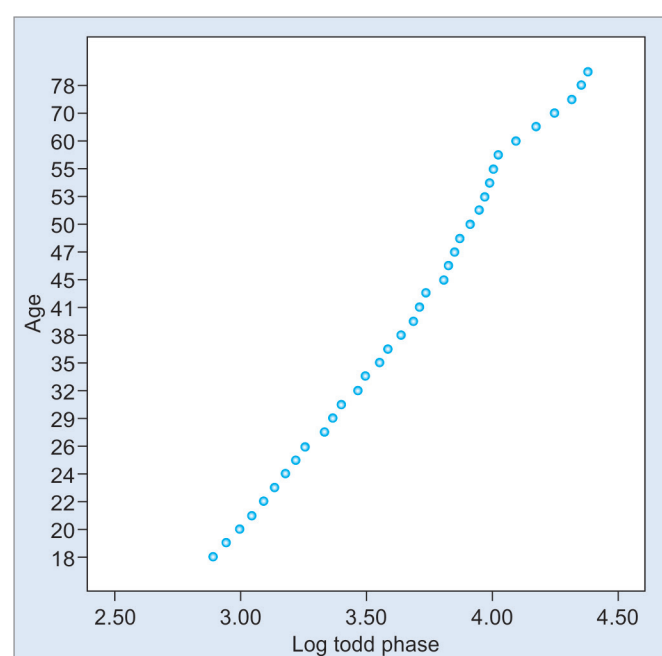
in 6 (25%) and 12 (50%) bones respectively. In the age group 35 to 39 years, well-defined upper and lower extremities and complete outline was formed in 100% bones (n=6). Ventral aspect changed to less granular in 2 (33.3%) and symphyseal face became smoother in 4 (66.7%) bones. In the age group 39 to 44 years, both upper and lower extremities were clearly defined in all 18 (100%), symphyseal rim began to form in 2 (11.1%), while lipping of dorsal and ventral margin was present in only 2 (11.1%) bones, ventral aspect became smooth and oval outline now completed in 17 (94.4%) bones. In the age group 45 to 50 years, symphyseal rim was now marked in all 56 (100%) bones, dorsal margin became uniformly lipped in 51 (91.1%), ventral margin was irregularly lipped in 52 (92.9%), and an eroded symphyseal face was present in all bones. In the last age group >50 years, all 32 (100%) bones were completely disfigured and eroded.

Scatterplot between log (Todd's) phase and age in years of pubic bones (Graph 1) showed the points to lie along an imaginary line, thus graphically showing a linear relationship between the two variables and that it can be used to estimate age at death. Highly significant bivariate correlation ($r=0.9$, $p<0.001$) was found between actual age of the pubic bone and age estimated by linear regression equation.

By regression analysis, the following linear equation was obtained:

$$\text{Age (at death)} = 37.74 \log (\text{Todd's phase}) - 97.01$$

For example, if a pubic bone of unknown age is found, its morphological features will show the Todd's phase and thus the log of this phase can be put in the linear equation above and the age can be estimated.



Graph 1: Scatterplot between log (Todd's phase) and age (years)

DISCUSSION

Since the past decades, the face of pubic symphysis was frequently used as the only source of information for estimation of age of unknown individuals.⁷ Other anatomical sites have been considered to be less reliable and thus rejected by some authors.^{6,22} The appearance of a regular epiphysis-like addition of bone (ventral rampart) is certainly one of the distinctive age-related changes.⁷ Todd's method¹² was the first formal method used for age determination from pubic symphyseal surface and was followed by various authors.^{7,19} The age estimation was done either by regression method⁷ or scoring method.²² Some authors attempted to revise Todd's method stating that "if a particular pubis did not coincide with Todd's age groups then it is not possible to age it". Also that it either overestimates or underestimates the age,^{13,16-20} yet till date this method is considered and is being followed in majority of such studies.^{7,11,13-15}

The present work compares well with Todd's study¹² as the frequency of age group wise presence of most features on the symphyseal surface of pubic bones was almost 100%. Very few features either lagged behind or were ahead by a year or two, especially the specimens in fourth decade and older. According to regression equation the relationship between actual and estimated age was significant. Comparing the age progressive biological events of pubic symphyseal face, of both studies, although the morphotyping of present study did not strictly adhere to Todd's method, yet the time of commencement and completion of most features were similar (Table 2). This table also compares the present study with another Indian¹⁴ and Western study.¹³ This Indian study was also based on Todd's method. Eighty-two pairs of pubic symphysis of fresh male cadavers, from Delhi, were taken for study. It used varying combinations of morphological features, as criteria for age estimation of the subjects. According to them, pubic symphysis surface is the most reliable for estimating age between 20 and 40 years. On comparison with this study, the present study showed delay in commencement and completion age in most of the features. By comparison with Western study on 52 Japanese cadavers, the author found that Todd's descriptions can be applied but with some disagreements between Todd's whites and the Japanese.

CONCLUSION

The morphological features at symphyseal face of pubic bones in the present study are almost similar to Todd's study in most age groups (phases). Thus, this study can be used for estimating age of cadaveric pubic bones of unknown adult males from Northwest Indian region with the criteria obtained in this work.

Table 2: Comparative studies showing age (years) in relation to morphological features at symphyseal face of pubic bones

Sl. no.	Morphological feature	Present 2015	Todd (1920) ¹²	Sinha and Gupta (1995) ²²	Hanihara (1952) ¹³
1	Ridges and furrows	18–30	18–26	17–27	20–27
2	Superior ossific nodules	20–26	27–44	18–50	21–27
3	Upper extremity	25–44	25–44	22–35	
4	Lower extremity	25–44	25–44	18–30	22–30
5	Dorsal rampart (margin)	20–30	20–26	12–18	19–27
6	Ventral bevel	20–26	20–26	20–35	–
7	Dorsal plateau	22–30	22–26	After 20	After 22
8	Ventral margin	27–35	27–30	18–35	–
9	Symphyseal rim	39–50	45–50	12–39	30–34
10	Lipping of dorsal margin	39–50	45–50	Above 30	–
11	Lipping to ventral margin	39–50	45–50	–	–
12	Ventral aspect granular to smooth	30–44	30–44	–	–
13	Oval outline	30–39	39–44	Starts at 12 years	–
14	Symphyseal face granular to smooth	30–39	30–44	After 30–45	–
15	Bony growths	35–39	35–39	–	–
16	Symphyseal face eroded	45–50	>50	After 40	–

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