

Original Research Article

FORENSIC APPLICATION OF TODD'S TEN PHASE METHOD FOR AGE ESTIMATION FROM PUBIC SYMPHYSIS

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ABSTRACT

Background: Identification data obtained with age estimation are primary characteristics of identification, as they are unaltered even after death. Age estimation from pubic symphysis cannot be estimated accurately with the methods of roentgenology. Even though the method remains gold standard for recent advances in skeletal age estimation, hence the age estimation from pubic symphysis is an established method in forensic anthropology.

Materials and Methods: This study was carried out to determine age at death of individuals of Indus population of Gujarat with Todd's ten phase analysis on 63 samples of unknown age that was obtained from Department of Anatomy, Zydus Medical College, and Hospital, Dahod, Gujarat.

Results: The results showed an uneven age distribution. No cases were observed in Phase I, and only one in Phase II (20–21 years). Most cases fell into middle-age categories, with Phase VI (30–35 years) being the most frequent (25.4%), followed by Phase V (27–30 years) (19.0%). Older phases, such as Phase VIII (40–44 years) (15.9%) and Phase IX (44–50 years) (14.3%), were also well represented. This distribution suggests a predominance of middle-aged to older adults, with younger individuals markedly underrepresented.

Conclusion: The study confirms the utility of Todd's Ten-Phase Method for estimating age in this population. However, the lack of younger samples and potential sex-related variation highlight the need for larger, region-specific reference datasets to improve accuracy and applicability.

Keywords: Forensic anthropology, Age estimation, Pubic symphysis, Todd's Ten-Phase, Method, Morphological analysis.

INTRODUCTION

Age estimation is a fundamental component of forensic anthropology, providing critical information for the identification of unknown remains, particularly in cases where the deceased cannot be identified by visual or genetic means. Accurate age determination is essential for narrowing down the potential identity of an individual and can significantly aid in the resolution of forensic investigations. Among the various skeletal markers used for age estimation, the pubic symphysis is considered one of the most reliable structures due to its predictable and well-documented age-related

morphological changes. These changes occur over a lifetime and are primarily influenced by factors such as growth, degeneration, and wear, making the pubic symphysis a robust marker for forensic applications.^[1,2]

The pubic symphysis, a fibrocartilaginous joint between the pubic bones of the pelvis, undergoes significant morphological changes from adolescence through adulthood. These changes are widely studied and used as a tool for age estimation. The pubic symphysis is particularly valuable because of its relatively early appearance in human development, with detectable changes occurring by late adolescence. As individuals age, the pubic symphysis

exhibits a series of identifiable phases, ranging from the smooth and youthful appearance in younger individuals to the rough and degenerated surface in older adults. These phases correlate with specific age ranges, allowing for age estimation within a reasonable degree of accuracy.^[3,4]

Among the many methods developed for age estimation based on pubic symphysis morphology, Todd's Ten-Phase Analysis remains one of the most widely used and reliable systems. Todd's method, introduced by anthropologist J.H. Todd in the early 20th century, involves a ten-phase classification system that categorizes the morphological characteristics of the pubic symphysis. Todd's analysis is grounded in the observation that the changes in the symphysis are not only age-dependent but also occur in a consistent and predictable pattern. The ten phases range from Phase I (characterized by a smooth and unmodified pubic symphysis) to Phase X (characterized by extensive erosion, porosity, and a highly degenerated surface).^[5,6]

Despite its long-standing use, Todd's Ten-Phase Analysis is not without its limitations. For example, the method has been criticized for its reliance on a specific demographic, predominantly based on North American populations, which may affect its accuracy when applied to different ethnic groups or populations with diverse environmental factors.^[2,6] Although the method provides a general age estimate, it does not offer the precision necessary for more specific age categorization, particularly in middle-aged and older individuals.

Todd's method remains a cornerstone in forensic anthropology, primarily because of its detailed, systematic approach that allows for the application of empirical observation to estimate age. Several studies have reaffirmed its relevance and usefulness in forensic contexts, particularly when more advanced methods, such as DNA analysis or radiographic techniques, are unavailable or impractical.^[1,4,7]

This study seeks to evaluate the applicability of Todd's Ten-Phase Analysis in estimating age from pubic symphysis morphology, focusing on the relationship between specific phases and known age data. By exploring the accuracy and limitations of Todd's method, this research aims to contribute to the body of knowledge on age estimation techniques and their utility in forensic practice.

MATERIALS AND METHODS

This study was conducted to estimate the age of individuals using the pubic symphysis, employing Todd's Ten-Phase Method of pubic symphysis analysis. The sample set for this research consisted of 63 hip bones, which were sourced from the Department of Anatomy at Zydus Medical College and Hospital, Dahod, Gujarat. These bones were from individuals of unknown sex and age, and they represent the population from the eastern region of Gujarat.

Bone Selection and Preparation: The hip bones were selected from the existing collection maintained at the Department of Anatomy. Only well-preserved specimens that showed no signs of pathological damage, fractures, or deformities were included. All bones were carefully cleaned and labeled for identification, ensuring that no sex or age information was available prior to the analysis. As the sex of the individuals was unknown, only the pubic symphysis region was analyzed, as this part of the pelvis is commonly used for age estimation in forensic anthropology.

Todd's Method of Pubic Symphysis Aging: Todd (1920) described ten sequential phases of age-related changes in the pubic symphysis, beginning in late adolescence and extending into advanced age.

In the first phase (18–19 years), the symphyseal surface is coarse, marked by horizontal ridges separated by deep grooves. Ossific nodules are absent, and the margins or extremities show no clear definition.

During the second phase (20–21 years), the surface retains its rugged character, though the grooves begin to fill with finely textured bone, particularly near the dorsal limit. This process partially obscures the posterior ends of the ridges. Small ossific nodules may appear and fuse with the superior aspect of the symphysis. A dorsal margin begins to develop, and a ventral bevel is faintly indicated, while the extremities remain indistinct.

The third phase (22–24 years) shows progressive obliteration of the ridge-and-furrow pattern. A dorsal plateau starts to form, accompanied by the fusion of ossific nodules. The dorsal margin becomes more defined, while ventral rarefaction produces a pronounced bevel. The extremities, however, remain undefined.

By the fourth phase (25–26 years), the ventral beveled area expands, and the ridges and furrows are greatly reduced. The dorsal plateau is well developed, and the lower extremity begins to show delimitation.

In the fifth phase (27–30 years), little change is seen in the symphyseal face or dorsal plateau. Occasional attempts at forming a ventral rampart may be observed. The lower extremity becomes more clearly defined, and the upper extremity begins to appear, sometimes with the assistance of a bony nodule.

The sixth phase (30–35 years) is characterized by increasing definition of both extremities and near completion of the ventral rampart. The symphyseal face and ventral surface retain a granular texture, and there is no evidence of marginal lipping.

In the seventh phase (35–39 years), the surface changes reflect declining activity. Bony growths may appear at tendon and ligament attachment sites, notably for the gracilis tendon and sacrotuberous ligament.

By the eighth phase (39–44 years), the symphyseal face and ventral surface are largely smooth and inactive. The outline becomes oval and essentially complete, with sharply defined extremities. No distinct rim or margin lipping is present.

The ninth phase (45–50 years) shows the development of a rim around the symphyseal face. The dorsal margin becomes uniformly lipped, while the ventral margin exhibits irregular lipping.

Finally, in the tenth phase (50 years and above), the surface shows erosion with irregular ossification. The ventral border undergoes breakdown, and progressive disfigurement becomes more evident with advancing age.

Ethical approval for this study was obtained from the Institutional Review Board (IRB) of ZMCH College, Dahod. All bone samples were used in accordance with the ethical guidelines for research involving human remains.

RESULTS

The pubic symphysis phases were assessed using Todd's Ten-Phase Method across a sample of 63 hip bones. The distribution of cases in each phase is summarized as follows:

- Phase I (18-19 years): 0 cases (0%)
- Phase II (20-21 years): 1 case (1.6%)
- Phase III (22-24 years): 6 cases (9.5%)
- Phase IV (25-26 years): 5 cases (7.9%)
- Phase V (27-30 years): 12 cases (19.0%)
- Phase VI (30-35 years): 16 cases (25.4%)
- Phase VII (35-39 years): 3 cases (4.8%)
- Phase VIII (40-44 years): 10 cases (15.9%)
- Phase IX (44-50 years): 9 cases (14.3%)
- Phase X (50+ years): 1 case (1.6%)

The majority of the specimens were concentrated in Phase VI (30-35 years) (25.4%) and Phase V (27-30 years) (19.0%). These phases, along with Phase VIII (40-44 years) (15.9%) and Phase IX (44-50 years) (14.3%), accounted for the largest proportion of the sample. This distribution suggests that the sample predominantly represents middle-aged individuals, with fewer cases observed in the younger and older phases of life. The analysed pubic symphyses corresponding to various phases of age estimation are presented in Figures 1 based on Table 5.3, Modified from Krogman 49 [Table 3]:



Figure 1:

DISCUSSION

The results of this study provide significant insights into age estimation through Todd's Ten-Phase

Method of pubic symphysis analysis, specifically applied to the population of eastern Gujarat. The findings highlight some noteworthy patterns in the distribution of pubic symphysis phases, which are consistent with trends observed in other populations, but also exhibit certain unique features that may reflect regional and demographic influences.

One of the most striking findings is the complete absence of cases in Phase I (18-19 years) and the minimal representation in Phase II (20-21 years), which mirrors a common issue encountered in skeletal collections. Similar patterns have been documented in other forensic studies, where younger individuals are often underrepresented. Figueroa Soto (2019) notes that the preservation of skeletal remains from younger individuals is less common in forensic collections, leading to skewed distributions that emphasize older age groups.^[8] This underrepresentation is likely due to the nature of the anatomical collections at ZMCH College, Dahod, where bones from middle-aged and older individuals are more likely to be retained, while younger remains may be less frequently collected or preserved.

The middle-aged categories, particularly Phase V (27-30 years) and Phase VI (30-35 years), accounted for a substantial portion of the sample, with 44.4% of cases falling within these two phases. This concentration of cases in middle adulthood reflects a common trend observed in other studies. For example, Merritt (2018) found that pubic symphysis aging methods, including Todd's, are most reliable for individuals in these age groups. The high frequency of middle-aged individuals in our sample suggests that this demographic is well-represented in the skeletal collection, potentially due to higher survival rates among individuals in these age ranges or the biases inherent in anatomical collections.^[9]

Interestingly, our study also found a significant proportion of older individuals in the Phase IX (44-50 years) and Phase X (50+ years) categories, comprising over 30% of the total sample. This is consistent with findings from Trodi et al. (2016), who demonstrated that pubic symphysis analysis remains an effective tool for estimating age even in older adults. However, as noted by Merritt (2018), the accuracy of age estimates for older individuals can be influenced by factors such as skeletal wear and age-related changes that may complicate interpretation.^[9,10]

The impact of sex on pubic symphysis aging is another critical aspect of this study. Previous research has highlighted that there are significant sex-based differences in the aging process of the pubic symphysis, especially in the later phases. Studies by Kimmerle et al. (2008) and Lungmus (2009) have shown that males and females exhibit different patterns of pubic symphysis aging, which can lead to variations in age estimates when sex is unknown. Given that the sex of the individuals in our sample was not identified, the results should be interpreted with caution, as these sex-based differences may have contributed to some of the variability in the

aging patterns observed. This limitation is a well-known challenge in forensic anthropology, as age estimation methods often rely on sex-specific skeletal traits that can influence results, particularly in the later stages of life.^[11,12]

Furthermore, population-specific factors, such as genetics, nutrition, and environmental influences, can also affect the aging process of the pubic symphysis. Research by Kimmerle et al. (2018) and Figueroa Soto (2019) underscores the importance of adapting aging methods to account for these population-specific variations. The results from our study, based on a regional population in eastern Gujarat, suggest that local factors may play a role in shaping the pubic symphysis aging patterns, and this should be considered when applying Todd's Ten-Phase Method to different populations. Differences in skeletal maturation, dietary habits, and even climate could contribute to variations in the timing of pubic symphysis changes, which may necessitate the development of region-specific reference standards for age estimation.^[8,13]

CONCLUSION

The symphyseal surface undergoes a regular progressive change from 18 years onwards, However this study confirms that the Todd's Ten-Phase analysis method can be applied for determination of age estimation. As one of the best single criterion for estimating age at death of individuals from 3rd to 5th decade. However the applicability of Todd's phase analysis method indicates certain factors that has to be considered while interpreting the results of Younger individuals, Sex related influences, Skeletal development and Regional differences underscores and need further evaluation that includes larger and more diverse samples to validate the current method's accuracy of different populations.

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