AGE ESTIMATION FROM PUBIC SYMPHYSIS CHANGES IN HUMANS BETWEEN 18 TO 49 YEARS (PHASE ANALYSIS) - STUDY IN BODIES DURING AUTOPSY TO PROVE /DISPROVE AGE CHANGES USED IN ROUTINE PRACTICE.

Dissertation submitted for partial fulfilment of the requirements for the degree of M. D. (FORENSIC MEDICINE) BRANCH – XIV

DEPARTMENT OF FORENSIC MEDICINE

TIRUNELVELI MEDICAL COLLEGE

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THE TAMIL NADU

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BONAFIDE CERTIFICATE

This is to certify that the work in this dissertation entitled “Age estimation from pubic symphysis changes in humans between 18 to 49 years (phase analysis) – A study in bodies during autopsy to prove / disprove age changes used in routine practice” has been carried out by Dr.M.R.Gokula Pandia Sankar M.B.B.S., a Post Graduate student under my supervision and guidance for his study leading to Branch XIV M.D. Degree in Forensic Medicine during the period of August 2013 to August 2016.

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age estimation from pubic symphysis changes

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PROTOCOL TITLE: Age estimation from PUBIC SYMPHYSIS changes in humans between 18 to 49 years (Phase analysis) – A study in bodies during autopsy – to prove / disprove age changes used in routine practice

NAME OF PRINCIPAL INVESTIGATOR: Dr. M.R.Gokula Pandia Sankar
DESIGNATION OF PRINCIPAL INVESTIGATOR: Resident in Forensic Medicine
DEPARTMENT & INSTITUTION: Department of Forensic Medicine, Tirunelveli Medical College

Dear Dr. M.R.Gokula Pandia Sankar, *The Tirunelveli Medical College Institutional Ethics Committee (TIREC) reviewed and discussed your application during the IEC meeting held on 28.12.13.*

THE FOLLOWING DOCUMENTS WERE REVIEWED AND APPROVED

1.	TIREC Application Form	☑
2.	Study Protocol	☑
3.	Department Research Committee Approval	☑
4.	Patient Information Document and Consent Form in English and Vernacular Language	☑
5.	Investigator's Brochure	☐
6.	Proposed Methods for Patient Accrual Proposed	☑
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12.	Clinical Trial Agreement (CTA)	☐
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14.	Clinical Trials Registry-India (CTRI) Registration	☐

THE PROTOCOL IS APPROVED IN ITS PRESENTED FORM ON THE FOLLOWING CONDITIONS

1. The approval is valid for a period of 2 year/s or duration of project whichever is later
2. The date of commencement of study should be informed
3. A written request should be submitted 3weeks before for renewal / extension of the validity
4. An annual status report should be submitted.
5. The TIREC will monitor the study
6. At the time of PI's retirement/leaving the institute, the study responsibility should be transferred to a person cleared by HOD
7. The PI should report to TIREC within 7 days of the occurrence of the SAE. If the SAE is Death, the Bioethics Cell should receive the SAE reporting form within 24 hours of the occurrence.
8. In the events of any protocol amendments, TIREC must be informed and the amendments should be highlighted in clear terms as follows:
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   b. The PI must comment how proposed amendment will affect the ongoing trial. Alteration in the budgetary status, staff requirement should be clearly indicated and the revised budget form should be submitted.
   c. If the amendments require a change in the consent form, the copy of revised Consent Form should be submitted to Ethics Committee for approval. If the amendment demands a re-look at the toxicity or side effects to patients, the same should be documented.
   d. If there are any amendments in the trial design, these must be incorporated in the protocol, and other study documents. These revised documents should be submitted for approval of the IEC, only then can they be implemented.
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   f. The amendment is unlikely to be approved by the IEC unless all the above information is provided.
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Registrar, TIREC
Tirunelveli Medical College, Tirunelveli – 627011

TIRUNELVELI MEDICAL COLLEGE TAMILNADU

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Member Secretary, TIREC
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DECLARATION

I, Dr. M.R.Gokula Pandia Sankar, M.B.B.S., solemnly declare that this dissertation titled “Age estimation from pubic symphysis changes in humans between 18 to 49 years (phase analysis) – A study in bodies during autopsy to prove / disprove age changes used in routine practice” is a bonafide work done by me, under the expert guidance and supervision of Dr. A.Selvamurugan., MD., DNB., MNAMS., Associate Professor &Head of the Department of forensic Medicine, Tirunelveli Medical College, Tirunelveli. This dissertation is submitted to The Tamil Nadu Dr.M.G.R. Medical University towards partial fulfilment of requirement for the award of M.D. Degree (Branch XIV) in Forensic Medicine.

Place :

Date : Dr. M.R.Gokula Pandia Sankar,

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I take this chance to thank from my heart, a person of high caliber Dr.A.Selvamurugan., MD., D.N.B., MNAMS, Associate Professor and Head of Department of Forensic Medicine, Tirunelveli Medical College, Tirunelveli who took the burden of guiding me into the realms of Forensic Medicine and have been the centre of significance since the inception of this dissertation till its completion.

I thank all other Medical Officers, colleagues and staffs of the Department of Forensic Medicine, Tirunelveli Medical College, Tirunelveli.

I am extremely thankful to the past & present Deans of Tirunelveli Medical College, Tirunelveli, for their grateful permission on this study.

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I – TURNITIN SIMILARITY,

II – PROFORMA,

III – PHOTOPLATES,

IV – MASTER CHART.

ABBREVATIONS

&	-	And
<	-	Lesser than
>	-	Greater than
%	-	Percentage
C/o	-	Care of
D/o	-	Daughter of
F/o	-	Father of
H/o	-	Husband of
M/o	-	Mother of
W/o	-	Wife of
S/o	-	Son of
Ed.	-	Edition
R	-	Right
L	-	Left
M	-	Male
F	-	Female

i.e.	-	That is
Sl. No	-	Serial number
PM.no	-	Post mortem no
P.S.	-	Police Station
SS	-	Symphyseal surface
OS	-	Ossific nodule
DM	-	Dorsal margin
VM	-	Ventral margin
EXT	-	Extremity
VB	-	Ventral border
DB	-	Dorsal border
UEX	-	Upper extremity
LEX	-	Lower extremity
Yrs	-	Years

AGE ESTIMATION FROM PUBIC SYMPHYSIS CHANGES IN HUMANS BETWEEN 18 TO 49 YEARS (PHASE ANALYSIS) - STUDY IN BODIES DURING AUTOPSY TO PROVE /DISPROVE AGE CHANGES USED IN ROUTINE PRACTICE.

ABSTRACT:

The need of identity of an individual is of prime importance from WOMB to TOMB. Identification is the determination of individuality of a person. Though it may be a matter of everyday occurrence in every part of the world, a mistaken identity can lead to detrimental outcome and pose many problems to individual, relatives, society and in cases of administering justice when it matters the most.

Role of pubic symphyseal changes in assessing age is established by various studies but the effectiveness of the outcome proposed by Todd's phase analysis is taken as criterion and applied in local population and 100 samples of pubic bones were studied which revealed that the Todd's phase analysis was very useful and an effective tool in age estimation of an individual for both sexes.

KEY WORDS: pubic symphysis, phase analysis, age estimation.

INTRODUCTION

The need of identity of individual is of prime importance from WOMB to TOMB. Identification is the determination of individuality of a person. Though it may be a matter of everyday occurrence in every part of the world, a mistaken identity can lead to detrimental outcome and pose many problems to individuals, relatives, society and in cases of administering justice when it matters the most.

Identification may be of two types: (a) complete and (b) incomplete or partial. Complete identification means fixation of personality of the individual from absolute view point, by noting the place exactly occupied by him in the community such as his name, sex, age, fathers name, address, religion etc. All these points are established beyond any reasonable doubts in complete identification. Incomplete identification means when certain facts as to identify an individual have been determined while others required for complete identification have been left out unexplored or unknown.

Identification has primary and secondary characteristics. Primary characteristics are age, sex, stature and race. Secondary characteristics are hair, scars, tattoos, external peculiarities including deformities whether natural or due to disease, occupational stigma, religion and nationality. There are various comparative data or techniques for identification such as dental pattern, finger – foot print or hand prints, super imposition technique, neutron activation analysis trace evidence comparisons and DNA typing. More often the comparative techniques aim at finding the secondary characteristics of identification.

Identification of an individual either living or dead in a medico- legal case can be of great help. Cases demanding identification of living person include rape, sexual

assaults other than rape, for fixing age of criminal responsibility, criminal abortion, disputed sex, murder, dacoits, rioting, abduction, in interchange of new born babies and children getting lost. Also in securing unlawful possession of property or money, claim, lapsed pension or gratuity, Insurance benefits, voting rights in election, admission in schools or appearing for examinations, attainment of majority, marriage, divorce and nullity of marriage.

Role of identification in dead person arises in cases of unnatural deaths from fire, explosions, accidents from railway, ship, aeroplane, mines, foul - play in murder, manslaughter and suicide. In cases of postmortem decomposition, various changes and alteration of body features occur that make even relatives may not be able to identify or recognize the body. In few circumstances, even animal origins are produced to support false charges of murder against the enemy to settle scores of vengeance.

The problem of identifying a recently dead person whose features, clothes and figures are intact is totally different from identifying the same person dying in the same fashion but naked and discarded in a field in the peak summer or rainy season. The longer the interval between death and examination of the body or its remains, the greater need for one or more methods to establish identification.

Of the primary characteristics of identification age, sex, stature and race more variation is met with age at death. Age can be physical age, dental / skeletal age and psychological age. Of these, Dental age and Skeletal age are least affected by individual variations.

Dentition helps to estimate age of an individual from its eruption pattern (deciduous and permanent teeth) from 6 months of post natal life till 17 to 25 years. After 17 to 25 years when eruption of teeth is complete, age determination can be done mainly based on secondary changes occurring on it. Gustafson's method (Degree of attrition, periodontosis, secondary dentine formation, cementum apposition, root resorption and root transparency or translucency) is followed in finding age from secondary changes of teeth in dead person.

Skeletal age estimation is made from appearance and fusion of ossification centers, pattern of closure of skull sutures (both endo cranial and ecto cranial), morphological changes in pubic symphysis and other age related non specific secondary changes (osteoarthritis, osteophytes etc.). The time of appearance of centers of ossification and the process of union of the epiphysis with the diaphysis have a sequence and time period, which is generally utilized towards age determination. This process of ossification may also be influenced by food, nutritional status and presence of some disease, physical activity and hormonal and metabolic disorders. Skeletal age from ossification pattern can be supplemented and correlated by dental age. This applies only in earlier ages of life. Beyond that age group Skull suture closure, thyroid cartilage calcification, metamorphosis of pubic symphysis is followed.

Ideally, a method for skeletal age determination must be simple, reliable and applicable to all age groups. Pubic symphysis and Cranial sutures match these criteria for being an ideal tool in age estimation. For many years, closure of the skull sutures is considered as a reliable index of age determination. But recent literature casts doubts as to its reliability in forensic work.

Even though many other ageing criteriae are available, metamorphic changes in pubic symphysis surface have been found to be one of the most reliable single skeletal event in the adult human skeleton.

Anthropologists who frequently deal with fragmentary remains use this innominate bone for assessing age, as it is most often recovered intact in the skeletal remains. In scavenging patterns, symphyseal surface of pubic bones are not damaged as it is a concealed structure. In a study conducted in 1997 on canid scavenging, the innominates were recovered in 60-70% of the cases. According to the model of scavenging patterns, the lower extremities including the innominates, are generally not removed until advanced state of decomposition. Also it seems relatively rare for scavenging animals to damage the pubic symphysis, making them suitable for age estimation.

Studies have shown age specific changes in pubic symphyseal surface between second to fifth decades of life. Meta morphosis in Greek, means (Meta – change, Morphosis – shape) shape change or bodily change into another form. Meta morphosis of pubic symphysis means the changes occurring in the pubic symphysis in a particular time (or age) of life. So pubic symphysis metamorphosis pattern can give narrow range of age, a criteria least observed in other parameters like cranial suture closure or age from ribs.

Hence pubic symphyseal surface can be used effectively in age estimation of a deceased person and in fragments of skeletal remains. Considerable studies have been done on the use of pubic symphyseal surface as a tool for age indicator

since 1920 (Todd). Most of these studies have strengthened the usefulness of pubic symphyseal surface as an age indicator.

Various studies in this regard were carried out in different parts of the world, but such study on pubis symphysis is not popular in Tamil Nadu region. Therefore, we felt the need to conduct such a study. So that, its usefulness can be availed by the medico legal community in dealing with situations demanding skeletal age estimation in fragmentary remains.

AIM OF THE STUDY:

To correlate the age from changes in pubic symphyseal surface using phase description.

OBJECTIVES OF THE STUDY:

To observe meta - morphological changes those occur in pubic symphyseal surface between 20 – 49 years of age in local population.

To correlate age of the individual with Meta – morphological changes on pubic symphysis (using Todd's phase analysis).

To compare the observations with various such studies.

To find usefulness and application of this method in age estimation in people of south India.

RISKS, (if any):

No risk of mutilation of bodies.

No risk to the examiner.

INSTITUTIONAL ETHICAL COMMITTEE CLEARANCE:

Obtained before collecting samples.

PLACE OF STUDY:

Mortuary Hall and Research lab of the Department of Forensic Medicine, Tirunelveli Medical College, Tirunelveli.

METHODOLOGY:

100 cases with known age at death, brought for medico legal autopsy at our Department are selected. Pubic part of innominate bone is cut on right and left sides. Consent is obtained from the Investigating Officer and relatives of the deceased.

Sample is obtained by the following procedure - Pubic part of the innominate are cut 3 cm away from pubic symphysis on right and left sides. Bones are then processed using Cold water Maceration technique.

OUTCOME:

May prove or disprove age estimation from phase analysis of pubis symphysis.

BENEFITS:

To carry out medico legal works with more efficacy and certainity.

NATIONAL SIGNIFICANCE:

Based on the results of many such studies on phase analysis of pubic symphysis, Indian study values can be set. This can function as an indicator of National Standard.

LITERATURE REVIEW

REVIEW OF LITERATURE:

PHYSIOLOGY OF BONE:

Bone consist mostly of an extracellular matrix composed of proteins and hydroxyapatite crystals with small amount of cells.

Cells are of three types, they are

1) Osteoblast
2) Osteoclast
3) Osteocytes

Bone formation is maintained by osteoblast. Bone resorption is maintained by osteoclast. Osteocytes come from osteoblast and encase themselves within the bone. Remodeling of bone depends upon the co-ordination between osteoblastic, osteocytic and osteoclastic activity.

Types of bone tissues are

1) Cortical (compact)
2) Trabecular (cancellous or medullary)

CORTICAL PORTION - 80% of bone mass and outer layer of bone is called cortical portion. It contains most of the bone minerals and extracellular matrix elements. Only cortical portion is interrupted by blood vessels and osteocytes. Osteocytes are interconnected with one another and osteoblast through inter – canaliculi connections. These inter - canaliculi connections transfer Ca2+ from inner to outer surface. This process is called osteocytic osteolysis.

TRABECULAR PORTION - 20% of bone mass and inner layer of bone is called trabecular part. Osteoblast synthesize osteocalcin. It is used for new bone formation. 1, 25 dihydroxy vitamin D induce the synthesis of osteocalcin. Also, osteonectin from the osteoblast is used for binding with hydroxyapatite and collagen fibers and maintain the mineralization process (1).

BLOOD SUPPLY OF THE BONE:

Bones are highly vascular through Haversion canals. These Haversian canals forms close – mesh network of blood channels. Even compact bone has 20 – 30 blood vessels per sq.mm of cross section.

The blood vessels of epiphysis and shaft are separate until the fusion. Finally long bones are permanently vascularized by complete anastomosing of metaphyseal – epiphyseal blood vessels. These nutrient arteries blood – pressure is maintained by venous drainage through the pumping action of exercising muscles (3).

NERVE SUPPLY:

Periosteum which covers the bone is sensitive. Pain appreciated by the bare nerve ending pressure through laminated Pacinian corpuscles (2).

ANATOMY:

Each hip bone / innominate bone contains 3 primary elements

1) Ilium
2) Ischium
3) Pubis

At birth, these bones are connected by cartilage in the area of acetabulum. Around 13 – 15 years of age, those components fuse together into a single bone.

PUBIS:

Topography – The pubis occupies ventral part of the hip bone and forms a median cartilaginous pubic symphysis with its fellow.

Pubis consist of

1) Body

2) Superior pubic ramus

3) Inferior pubic ramus

4) Pubic tubercle

5) Pectin pubis

Body – has 3 surfaces, Anterior surface – It is medially rough and smooth elsewhere, giving attachment to medial femoral muscles. Posterior surface - It is oblique, forms anterior wall of the lesser pelvis and is related to urinary bladder and retro pubic fat.

Symphyseal surface – It is elongated and oval, united by cartilage to its fellow at the pubic symphysis. Denuded of cartilage, it has an irregular surface of small ridges and furrows (or) nodular elevation, varying considerably with age.

Pubic crest – It is the rounded upper border of body, its lateral end is the rounded pubic tubercle. Both pubic tubercle and crest are palpable. In latter partly obscured in males by the spermatic cord that crosses above it from scrotum to the abdomen. The pubic rami diverge postero laterally from the supero lateral corner of the body.

Superior pubic ramus - Projects supero - laterally from the body and joins with the ilium and ischium at its base, which is positioned toward the acetabulum. It has marked inferior surface by the obturator groove, which forms the upper margin of the obturator canal.

Inferior pubic ramus --- Projects infero laterally from the body and joins with the ramus of the ischium.

Pubic tubercle - Provides attachment to the medial end of the inguinal ligament. It forms part of the floor of the superficial inguinal ring and is crossed by the spermatic cord.

Pectin pubis - It is sharp, superior edge of the pectineal surface. Anteriorly this line is continuous with the pubic crest. The conjoint tendon and lacunar ligament are attached at medial end and strong pectineal ligament is attached along the rest of this surface (7).

OSSIFICATION CENTRES:

1) Primary ossification centres:

There are 3 primary ossification centres, they are

1) Ilium, 2) Ischium, 3) pubis.

The iliac primary ossification centre appears about 9^{th} week of prenatal period, above the greater sciatic notch.

Ischial primary ossification centre appears in its body in 4^{th} month of prenatal period.

Pubis primary ossification centre appears in its superior ramus between the 4^{th} and 5^{th} months of prenatal period.

Gradual ossification of the three components of the acetabulum results in a tri radiate cartilaginous stem extending medially to the pelvic surface as a Y – shaped epiphyseal plate between ilium, ischium and pubis. The ossifying ischium and pubis fuse to form a continuous ischio pubic ramus around 6 year.

2) Secondary ossification centres :

There are 5secondary ossification centres. They are 2 for the iliac crest, single center for the ischial tuberosity and 2 for Y shaped cartilage of acetabulam (8).

SEX DETERMINATION

Sex determination of skeleton depends mainly on Pelvis and Skull. Reliability of sex determination by Skull - 80%, Skull and mandible - 90%, Pelvis - 98%. Pelvis, in male is higher and narrow. In female it is wider and shallow.

In 1969, Phenice noted three morphological features for female pubis.

1) Subpubic concavity
2) Ventral surface elevation
3) Sloping away of inferior pubic ramus

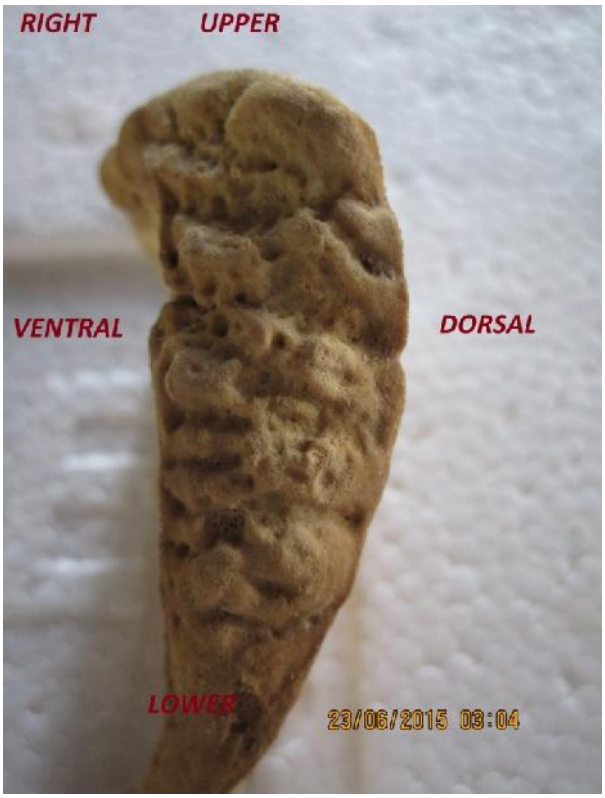
By this, pubic bone of male is triangular in shape and quadrangular in females.

Pubic pits --- it is also very useful in identification of age at death and sex. Pubic pits is ligament attachment site of pubic bone. It is more obvious in females due to remodeling. But it is very much useful in assessing age at death than in obstetric practice (11, 12, 13).

MORPHOLOGY OF PUBIC SYMPHYSIS:

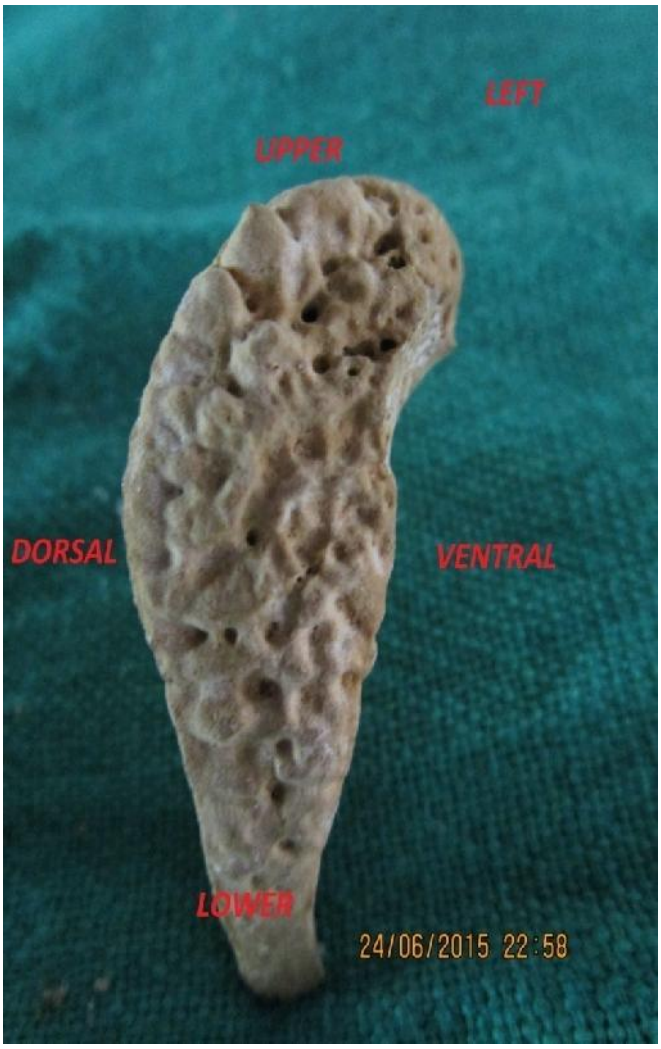
The oval symphysis has five features –

1) Surface
2) Ventral(outer) border or rampart
3) Dorsal(inner) border or plateau
4) Superior extremity and
5) Inferior extremity



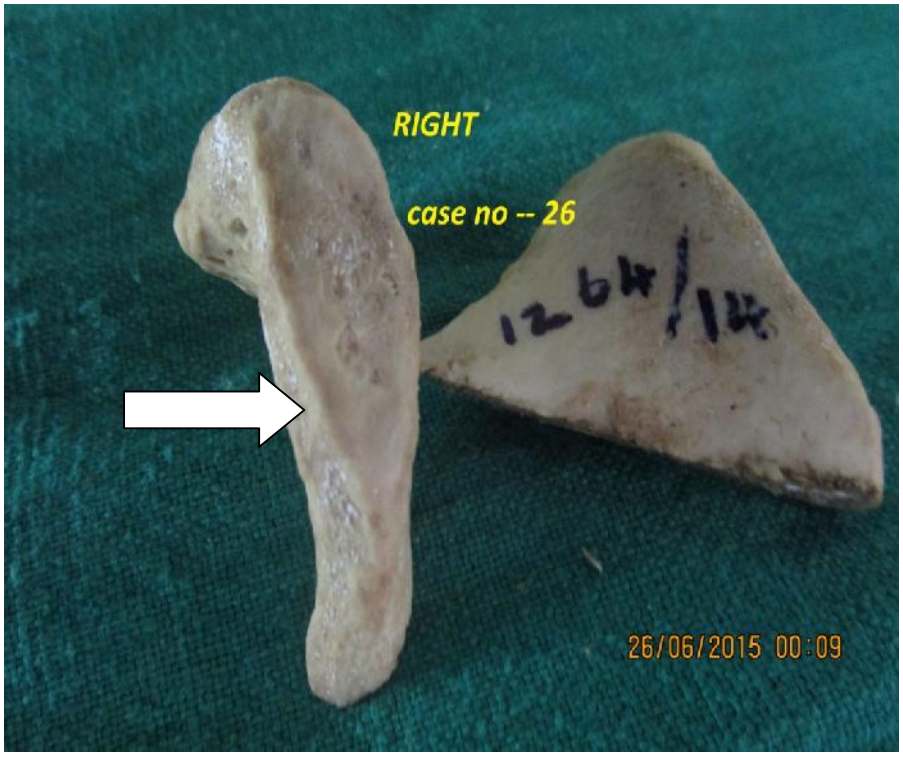
Picture: 1 Right side pubic symphysis

In pubic symphysis bone outer anterior border is called ventral border (margin), inner posterior border is called dorsal border (margin), superior border is called upper extremity and inferior border is called lower extremity. Identification of right side of the bone can be done using the upper part of the ventral border -- having slight concavity with upper lip like projection. If concavity and lip like projection present in the viewer's left side then it is the right side pubic bone. Above picture is right side pubic bone.



Picture: 2 Left side pubic symphysis

Identification of left side of the bone can be done using the upper part of the ventral border -- slight concavity with lip like projection. This concavity and lip like projection when present in the viewer's right side then it is said to be the left side pubic bone.



Picture: 3 Ventral rampart

Ventral rampart -- In early ages, pubic bone shows rugged appearance with horizontal grooves and on progressive developmental growth, this horizontal groove get progressively obliterated through sporadic and premature attempts at the ventral border and complete the entire formation of ventral margin.

Picture: 4 Dorsal plateau

Dorsal plateau – In early ages, pubic bone shows rugged appearance with horizontal grooves and on further developmental stages this horizontal grooves are progressively filled and dorsal plateau gets completed and ends with the formation of dorsal margin.

In1743, Hunter. W. described lipping of the symphyseal dorsal margin and ventral beveling during 3rd decade (9).

In1858, Aeby described the symphyseal face as a more or less irregular convex surface rounded by an oval outline. He observed that marked changes have undergone in symphyseal surface with age. He stated that passing of childhood, the variety of irregularity occur in the symphyseal surface, but later in life it becomes a single smooth surface (10).

Cleland (1884) noted the curved line appearance which forms the lateral border of the ventral rampart. Also, he used it as age criterion in the 4th decade (11).

Martin.R. (1914) measuring the height of the bony symphysis without any indication, he noted that after 35 years there is no increase in height of the bony symphysis (14).

Todd (1920) – he was responsible for the early fundamental and significant contribution on the pubic symphysis as suitable for age determination. Originaly Todd's collection named as Western Reserve University collection, but now it is named a Hamman – Todd collection. Now these 3422 bone collections are present in Department of Anthrophology, Cleveland museum of Natural History, Clevland University. Out of them 3175 specimens were reviewed to obtain test samples (15).

In principle Todd considered this oval surface has nine morphological features namely

1. Ridges and furrows
2. Dorsal margin
3. Ventral beveling
4. Lower extremity
5. Ossific nodule
6. Upper extremity
7. Ventral rampant
8. Dorsal plateau
9. Symphyseal rim

Todd (1921) suggested 10 phases in pubic symphysis metamorphosis---

1) Age 18 – 19 ---- surface has rugged and transverse, horizontal ridges. This makes grooves visible very well. No ossific nodules, no definite margin, no definite extremities.
2) Age 20 -21 ---- Rugged surface with dorsal end filled by newly formed bone texture. Dorsal margin begins to appear. Ossific nodules may appear. No extremities.

3) Age 22 – 24 --- Increased obliteration of ridges in dorsal region produce the dorsal plateau. Dorsal margin gradually gets more defined. Beveling due to ventral rarefaction more pronounced.

4) Age 25 – 26 --- Ridges get diminished in the ventral end, this produce ventral beveling, delimination of lower extremity, complete definition of dorsal margin by dorsal plateau formation.

5) Age 27 – 30 --- Sporadic and premature attempts in forming ventral rampart and commencement of upper extremity, clear formation of lower extremity.

6) Age 30 – 35--- Granular surface with well-defined extremities. Ventral rampart completes. Defined dorsal margin.

7) Age 35 – 39 --- Diminishing activity in surface and ventral region, beginning of bony outgrowth into tendon and ligament attachments.

8) Age 39 – 44 --- Smooth and oval surface, no lipping of margins. No rim to symphyseal surface.

9) Age 45 – 50 --- Symphyseal rim occur and lipping of margins occur. (Dorsal – uniformed; ventral – irregular).

10) Age > 50 --- Erosion of surface and erratic ossification. Disfigurement increases with age.

Based on various studies made by Todd, he concluded that “The symphyseal face undergoes a distinct metamorphosis after puberty, comprised of remodelling rather than the new bone deposition and pubic symphysis is a more reliable age indicator from 20years to 40 years than at later ages.” Later he went on to suggest that the phases might be grouped within three periods which are as follows:

PHASES PERIODS

I - III -----> Post- adolescent stages

IV - VI -----> Various processes by which the symphyseal outline is build up

VII - X ------> Period of gradual quiescence and secondary changes

Boland (1933) conducted a study about changes in the pubic symphysis during pregnancy and after delivery. In his study, he described the symphysis pubis separation and this can involve hemorrhage, laceration and infection of the ligaments during pregnancy, delivery period and after (20).

Abramson D (1934) explained pubic joints getting relaxation during pregnancy and delivery. This explained the role of sex in pubic symphysis phase analysis (21).

Brooks (1955) published a critical examination of Todd's method based on demographic problems. Todd's ten phases were consolidated into six - phase system based on the problems and data reported. This method was applied in a Californian archaeological sample.

Hanihara (1952), Krogman (1962), Meindl et al (1983) and Katz and Suchey (1986) all suggested similar findings.

Mckern and Stewart (1957) observed some anatomical changes in the surface of female pubic symphysis due to pregnancy. In response to both improved age estimation method and Brooks critique, he developed a three component system intended to improve Todd's system . The study is based on a sample of 450 skeletonized and identified U. S. war dead that were being reported from North - Korea in 1954 . Their documentation was more than Todd's, and included age,

state (or) territory of origin race and ethnic background, all verified by military records. In subsequent tests, the McKern – Stewart method did not prove useful for traditional, non – military samples because its upper bound is very low (36 years) and the original database is heavily concentrated on very young (22).

COMPONENT ANALYSIS

Mckern and Stewart made another analysis method from Todd's 9 morphological changes that is called component method. It was noted that feature 1, (Ridges and furrows) was divided by longitudinal ridge or groove into dorsal and ventral halves, termed dorsal demi-face and ventral demi- face respectively. Obliteration of ridges and grooves was not considered a separate feature.

It was noted that

Lower extremity (4) and Dorsal margin (2)

Upper extremity (6) and Ventral beveling (3)

Ossific nodule (5) and Ventral rampant (7)

were inter-related and these features are included for the complete description of two demi- faces. Hence 9 features of Todd were reduced to3 components with 5 developmental stages.

A preliminary stage of "0" denotes absence of features in each set of stages.

The three stages of component analysis are summarized below:

COMPONENT --- 1 – DORSAL PLATEAU

0 --- Absence of dorsal margin.

1 --- Slight margin present in middle third of dorsal region.

2 --- Margin extents up to full dorsal region.

3 --- Plateau formation in middle 3rd of dorsal demi face.

4 --- Plateau formation extends up to full of dorsal demi face with vestiges of billowing.

5 --- Disappearance of billowing and flat granulated dorsal surface.

COMPONENT –2 --- VENTRAL RAMPART

0 --- Absence of ventral beveling.

1 --- Only superior extremity has ventral beveling.

2 --- Bevel extends inferiorly along ventral border.

3 --- Bony extension from either or both extremities (Ventral rampart).

4 --- Extensive rampart with gaps present mostly in upper two 3rd.

5 --- Rampart complete.

COMPONENT –3 --- SYMPHYSEAL RIM

0	---	Symphyseal rim absent.
1	---	Round and smooth partial dorsal rim elevated above the symphyseal surface.
2	---	Dorsal rim complete; ventral rim beginning to form.
3	---	Completion of symphyseal rim with finely grained, irregular or undulating surface.
4	---	Rim breakdown with lipping of ventral edge.
5	---	Further breakdown of rim and rarefaction of symphyseal face; erratic ossification along ventral rim (23).

Stewart (1957) found that Todd's method is less reliable for females than males. He stated that all methods at those time were based on male samples. However Stewart brought into focus that certain changes in symphysis like pitting and deformation of the dorsal border shall arise as a consequence of trauma during child bearing and delivery. So age assessment in females can be wrongly interpreted and he emphasized to be vigilant in using male pubic standards for female assessment of age (24).

Mckern – Gilbert (1973) carried out a research on 103 American females with known age and obstetric history. He concluded that there is a very significant variation in the symphyseal rim in females when compared with other studies on male pubic standards. Further he inferred that "symphyseal rim in males encloses ventral and dorsal demi-faces in females it separates the two".

In Osmania Medical College, Hyderabad (1975) a study was conducted from 126 pubic bones by using Mckern and Stewart method. This study indicate the accurate age estimation is in higher age group than younger (16 -32yrs) (25).

In Kerala (1981) a study was conducted from forty six female and hundred and four male pubic bones between 14 - 80years. A statistical table was made showing mean age and standard deviation for the total score separately for both sexes. It was concluded that age reliability from pubic symphysis is more reliable in males than in females (26).

Meindl et al (1985) observed that sex and age distribution, the accuracy was generally better in phase analysis system than that of component system in 20 - 40 years age range (27).

In 1985, another research was done in Osmania Medical College (Hyderabad) from 16 to 70 years pubic bones of both sex by using Mckern and Stewart method. By this study age estimation was accurate in 17 to 35 years and not accurate in females (28).

Suchey – Brooks ---- 6 Phases (1990):

1) Billowing surface with well-marked ridges (horizontal), ventral beveling may or may not present.

2) Ridges may or may not present, ventral rampart may or may not begin on either extremities.

3) Lower extremity present well, dorsal plateau well developed.

4) Complete oval out line present, ventral margin shows bony out growth. Lipping may appear in dorsal portion.

5) Completely rimmed face with depression, lipping of dorsal portion is more than 4^{th} phase.

6) Irregular shape due to erosion (29).

Kowalk et al, (1996) studied progesterone and relaxin influence in the bones.

After delivery, changes occurs in bone mineralization due to lactation. Oral contraception are hormonal based, so usage of oral contraception has an important role in mineralization of bone. This affects the density of bone and so pregnancy and lactation affects mineralization of bones (30).

Berg (2008) further revised the Todd's method by adding a seventh phase to the Suchey -- Brooks modification for females only. He reported that this inclusion resulted in values consistently better than those reported for Suchey – brooks method, even though the sample included not only young individuals, but also large quantities of older females. So Breg add female – specific seventh – phase addition to Suchey – Brooks method (31).

BREG's 7 phases;

(1), (2), (3), (4) are same as in Suchey – Brooks.

5) Surface shows minimal depression due to starting of erosion. Porosity is < 15%.

6) Rim erosion of ventral margin with breaking quality. Porosity is < 50%. Lipping (mild to moderate)

7) Extreme erosion with porosity is > 50%. Lipping (moderate or severe).

Gautam Biswas writes:

2nd decade	---	Transverse ridges across the surface of pubic symphysis.
2nd and 3rd decade	---	Gradual disappearance of ridges of pubic symphysis surface.
4th decade	---	Granular symphyseal surface with well-defined ventral and dorsal margin.
5th decade	---	Beaded rim along the symphyseal margin.
6th decade	---	Erosion of symphyseal surface and break down of ventral margin.
7th decade	---	Irregular erosion of symphyseal surface.

In young there is an undulating symphyseal surface, this symphyseal surface undergoes a regular progressive changes from age 18 yrs onwards (32).

KSN Reddy writes:

Before 20 yrs	---	has layer of compact bone near its surface.
Around 20 yrs	---	there is uneven ridges run transversely across the articular surface.
Between 25 – 35 yrs	---	ridges gradually disappear and ventral and dorsal beveling present.
Early 5th decade	---	smooth symphyseal surface. Erosion of surface and breaking of ventral and dorsal margin (33).

Karmakar writes:

Upto 20 yrs --- the symphyseal surface is smooth and compact.

Between 20 – 25yrs --- The articular surface becomes ridged and billowed (irregular). Radiologically they present as undulating lines.

Between 25—30yrs --- The billowing start disappearing and the articular surface becomes granular with prominent anterior and posterior margins.

Between 35 – 40yrs --- The auricular surface becomes smooth and oval with raised upper and lower margins.

Between 45 - 50yrs --- The margins of the auricular surface is encircled by beaded rims, bony erosion start this period.

After 50yrs --- Erosion of bone well marked with breakdown of margins (34).

Biswas explained phase analysis method of pubic symphysis. He is of the opinion that phase method of symphyseal surface is the best single criterion for determining age for 3rd to 5th decade. He explained this by

1) < 20 years --- compact bone near its surface

2) about 20 years --- (a) Uneven surface

(b) Transverse ridges +

3) 25 to 40 years --- (a) Ridges gradually disappear

(b) Granular appearance of Surface

(c) Margins well defined

4)	40 +	---	Early 5th decade – oval smooth surface with raised upper and lower end Late 5th decade – margins have narrow beaded rim.
5)	50 +	---	surface erosion with ventral margin breakdown.
6)	60 +	---	Irregular surface erosion.

If this method is used for females, the age would be underestimated by 10 years (35).

PARIKH explained, the symphyseal surface undergoes a number of changes between the ages of 16 – 50 years. Before 20 years surface has compact bone layer. It has irregular, transverse ridges at about 20 years. By the age of 30, the irregularity is much less obvious. More than 50 years, the ridges disappear, being replaced by a granular and eroded appearance. Also, it is found that the age by this single event are more dependable than similar age estimation from other bones (36).

Apurba Nandy , described the changes of symphyseal surface in component method by,

1st component	---	changes occurring at the dorsal demi face – dorsal part (half) of the symphyseal surface.
2nd component	---	changes occurring at the ventral demi face – ventral half of the symphyseal surface.
3rd component	---	changes which occur in common, around the whole symphyseal surface, after the series of changes occurring

in the 1st and 2nd components are over. Determination of age from the changes at the symphyseal surface is considered more dependable than from the skull bones suture closure (37).

Umadethan writes:

After the second decade, the symphysial face exhibits morphological changes related to the advancement of age.

1) Upto age of 20 years --- the surface is covered by horizontal ridges and grooves.

2) Between 25 – 35 years --- the ridges disappear and the surface assumes a granular appearance. The ventral and dorsal margins also develop.

3) By 50th year --- the symphyseal face has oval smooth surface with lipping of the margin.

4) By 60th year --- the surface erodes and the margins breakdown.

5) By 70th year --- the surface is completely eroded (38).

P.V.Guharaj writes:

The irregular faces of symphysis pubis become granular or smooth as age advances.

1) It becomes partly granular around the 25th year and

2) Granularity becomes marked and involves the entire symphyseal face by the age of 35 years.

3) Lipping of the symphyseal face commences at about 35 years and is well marked at 45 – 50 years (39).

J.B. Mukherjee writes:

Symphysis pubis helps greatly in determination of age from second to fifth decades.

Below 20 years	---	The symphyseal surface has an even appearance with a layer of compact bone over its surface.
Between 20 to 25 years	---	The symphyseal surface looks marked ridged and irregular, the ridges or billowing run transversely and irregularly across the articular surface. In x-ray films, the billowing appears as undulating lines.
Between 25 to 35 years	---	The billowing gradually disappears and the articular surface of macerated bone presents granular appearance with its anterior and posterior margins sharply defined.
Between 35 to 45 years	---	The articular surface looks smooth and oval with raised upper and lower extremities.
Between 45 to 50 years	---	Narrow beaded rim develop in and around the margins of the articular surface, showing some erosion.
Above 50 years	---	The symphyseal surface presents varying degrees of erosion with breaking down of ventral margin. Later on, the surface becomes irregularly eroded (40).

In Russia, a study was conducted from 365 pelvis (170 males and 195 females). Regression equation was developed from the 5 morphological changes of pubic joint. That morphological changes are (1) joint surface (2) front border (3) rear border (4) upper end (5) lower end. From statistical analysis and regression equation it was estimated that age estimation from 15 – 90 years can be done with difference of + (or) – 7 years (41).

In Japan (1952), a study was done in 135 pubic bones by applying Todd's 10 phase method. By this study pubic bone age changes of Japanese were two to three years earlier (43).

In 1993 a study was conducted in Kerala with 54 pubic symphysis (33male & 21 female) between ages of 17 - 60 years. Both Todd's and Mckern- Stewart methods were applied. Study showed that Todd's method was simple and reasonably accurate for both sexes and no advantages were recorded with the usage of Mckern - Stewart method (44).

In Surat (2004), there was a study of comparison between the dental and pubic age estimation in dead. This study also shows the pubic results are very narrow in 3rd decade (45).

Application of Suchey - Brooks method (2005) in 3 dimensional pubic imaging gives very good age estimation result (46).

In East Delhi, a study in metamorphosis of symphysis shows morphological changes occurs late in Delhi population compared with American population by this result of +1 in first 20 to 30years, +5 in 30 to 40years, +8 in 40 to 50 years. These late changes are due to regional and life style variation of Delhi population (47).

A study about five biological (stage) classification. Todd's first 5 phases comes under pre epiphysis, 6^{th} phase comes under active epiphysis, 7^{th} phase comes under post epiphysis immediate period, 8^{th} phase comes under maturing / pre degenerative, last 9^{th} and 10^{th} phases comes under degenerative period. From this study authors says that many criteria are available, but they are all lower correlation with original age which compare to symphysis pubis (48).

Meindl et al (1985) described five biological stages. This five biological stages preserve the simplicity of Todd's ten phases appear below:

Stage 1 ---- Pre – epiphyseal (Todd's I – V)

Stage 2 --- Active epiphyseal (Todd's VI)

Stage 3 --- Immediate post – epiphyseal (Todd's VII)

Stage 4 --- Maturing ; pre --- degenerative (Todd's VIII)

Stage 5 --- Degenerative Todd's (IX – X) (50)

Ascadi and Nemeskeri (1970) evaluates the symphysis phases by radiographical method. They inferred that, radiographic method provide a greater range of age estimation than Todd, McKern and Stewart, and Gilbert and McKern method. But they accept that the radiographical method has some technical parameters and infrastructure difficulties where it cannot be applied in many places most of the time. By this radiographical method they described five phases, these phases says age is under 50 years, about 50 years and above 50 years easily, but in this method narrow age range as 18 – 19 years, 20 – 21 years, 22 – 24 years, 25 – 26 years is

difficult. This narrow age variation is very easy in metamorphological analysis method.

Phase I – The surface is convex, traversed by horizontal ridges and furrows; curved transition in the region of the rami.

Phase II – The original structure of the surface begins to disappear with ridges becoming flatter and grooves shallower. Ventral and Dorsal margin shows rim formation.

Phase III – Granular remnants only; continuous rim is forming on the ventral and dorsal margins, with well-defined upper and lower border.

Phase IV – Completely smooth face, development of sharp rim along the ventral and dorsal margins, inferior end of the face forms an acute angle.

Phase V – The completely smooth surface is partly concave, sunken inwards, porous and shriveled. Crest like ventral and dorsal rim appeared and merges with the sharp lower extremity.

Phase I and Phase II ---- Age under 50 years.

Phase III ---------- Age about 50 years.

Phase IV – V ---------- Age above 50 years (49).

MATERIALS & METHODS

MATERIALS & METHODS:

Cases are selected randomly from the bodies received for medico legal autopsies during the period of study. Study comprises of 100 cases with known age at death. Ages from 18 to 50 years of both sexes are included in the study. Subjects are grouped into 18 to 19 yrs, 20 to 21 yrs, 22 to 24 yrs, 25 to 26 yrs, 27 to 30 yrs, 30 to 35 yrs, 35 to 39 yrs, 39 to 44 yrs, and 45 to 50 yrs. Age at death is taken from the details given by the Police / Magistrate (depending upon the case), post mortem requisition, case history and Form no. 86. Preference given to the Government issued identity proofs with date of birth such as Pass port, Voter's ID , Ration card, Aadhar card, Driving license, School Transfer certificate, Mark sheet etc. Age correction that are made at a later date is also taken into account.

Study design:

Cross sectional study.

Methods:

Methodology followed in this study is broadly classified into i) dissection, ii) processing and iii) observation.

Dissection:

1) Extended I – shaped incision made from symphysis menti to 3 cm below upper border of pubic symphysis.
2) By separating the soft tissues, superior and inferior ramus of pubis were identified.
3) Superior ramus of pubis is sawed 3 cm lateral to the pubic tubercle (through obturator foramen).

4) Similarly, inferior ramus of pubis is sawed 4 cm below pubic arch.
5) Dissected Pubic part of innominate bone was taken out.

Processing:

Following methods were adopted for processing the pubic bone to find out a suitable method for sample collection.

1) Deep burial,
2) Burial in soil within a container / plastic bag,
3) Boiling in water,
4) Plain water soakage,
5) Air drying.

Deep burial: Cut portion of innominate bones are buried under the soil about 2 feet deep for 6 – 8 weeks. Bone is exhumed, washed and air dried for 2 days. Removal of remaining tissue particles is difficult and further attempt at removal may damage the bone in this type of processing.

Burial in soil within a container/ plastic bag: Bones are kept in container/ plastic bag and buried in soil for 6 – 8 weeks. Bones are washed and air dried for 2 days.

Boiling: Bones are boiled in water for 6 - 8 hours to remove the remaining soft tissues. Boiling in water is under taken in a phased manner. Each phase is for 2 hours. At the end of the phase, boiling water is completely replaced. This is to remove fat, muscle, and debris that gets accumulated in due process of boiling. Periodically the bones are checked for soft tissue status to avoid bones getting over heated and

desiccated. Bones are then set out to air dry for 2 days. This method is known as hot water maceration.

Boiling with ammonia / house hold bleach shortens the boiling time but some amount of damage occurs to the bone's architecture. As, the morphology of pubic symphysis is the main stay of this study, plain water is preferred for boiling.

Plain water soaking: Bones are kept in a jar of volume 500 cc with ¾ of the jar filled with water for 20 – 30 days. After that bones are set out to air dry for 2 days. This method is known as cold water maceration.

In deep burial method, after bone is exhumed some remaining soft tissue particles attached with the bone. Removal of these remaining tissue particles by any means damage the symphyseal surface or ventral aspect or dorsal aspect. In burial in soil within a container or plastic bag more soft tissue particles have found attached with the bone. In boiling method if over heated that may damage the bone, so periodical checkup and periodical water change is necessary.

Of these methods, cold water maceration seems to be an ideal and relatively easier method.

PLAIN TAP WATER OR COLD WATER MACERATION:

1) 500 ml capacity plastic container with ¾ of plain tap water.
2) Label with serial number, postmortem number and date of processing (started).
3) Keep the jar air tight.
4) After 30 – 40 days, bone is washed in the running tap water.
5) Air dried for 2 days.
6) Serial number written on both pubic bones.

In this plain tap water study, periodical exchange of water is not needed.

Todd's phase description method is applied for age estimation which considers developmental stages into.

(1) Age 18 – 19 years (phase I)

Symphyseal surface -- Rugged horizontal grooves, furrows and ridges

Ossific nodules -- Not developed

Dorsal margin -- Not developed

Ventral margin -- Not developed

Extremities -- Not developed

(2) Age 20 – 21 years (phase II)

Symphyseal surface -- Grooves are started filling from dorsally

Ossific nodules -- May appear on symphyseal surface

Dorsal margin -- Begins

Ventral margin -- Ventral beveling begins (foreshadowing)

Extremities -- No definition

(3) Age 22 – 24 years (phase III)

Symphyseal surface -- Progressive obliteration of ridges and furrows

Ossific nodules -- Almost present

Dorsal margin -- more definite dorsal plateau begins

Ventral margin -- Beveling more pronounced

Extremities -- no definition

(4) Age 25 – 26 years (phase IV)

Symphyseal surface -- more obliteration of ridges and furrows

Ossific nodules -- may present

Dorsal margin -- complete dorsal plateau present

Ventral margin -- Beveling greatly increased

Extremities -- started forming lower extremity

(5) Age 27 – 30 years (phase V)

Symphyseal surface -- one or few ridges

Ossific nodules -- may be present

Dorsal margin -- completely defined

Ventral margin -- Sporadic attempt at ventral rampart formation

Extremities -- lower – clear ; upper extremity forming

(6) Age 30 – 35 years (phase VI)

Symphysel surface -- granular appearance retained

Ossific nodules -- may be present

Dorsal margin -- defined

Ventral margin -- ventral rampart complete

Extremities -- increased definition of both Extremities

(7) Age 35– 39 years (phase VII)

Symphyseal surface -- texture finer; diminishing activity

Ossific nodules -- may be present

Dorsal margin -- defined

Ventral margin -- complete

Extremities -- extremities well defined

(8) Age 40 – 44 years (phase VIII)

Symphyseal surface	--	smooth and inactive; no rim
Ossific nodules	--	may be present
Dorsal margin	--	no lipping
Ventral margin	--	no lipping
Extremities	--	oval outline complete Extremities clearly outlined

(9) Age 44 – 50 years (phase IX)

Symphyseal surface	--	rim present
Ossific nodules	--	may be present
Dorsal margin	--	uniformly lipped
Ventral margin	--	irregularly lipped
Extremities	--	outline well defined

(10) Age 50+ (phase X)

Symphyseal surface	--	erosion and erratic ossification
Ossific nodules	--	broken down
Ventral margin	--	broken down
Dorsal margin	--	broken down
Extremities	--	broken down

Sample size :

100 cases with known age at death.

Sampling design :

Purposive sampling.

Inclusion criteria :

Bodies subjected to post mortem examination belongs to age group of 18 – 49 years.

Exclusion criteria :

Deformed pelvis (Traffic / assault injuries, charred remains),

Congenital anomalies (bony defects),

Nutritional deficiency (if demonstrable during autopsy),

Fracture of pubic bone onto surface damage,

Crush injury of pubic bone involving the symphyseal surface,

Different ethnicity are excluded (migratory population),

Touristors from other states,

Touristors from other district.

Study Period :

One and half year.

Place of study :

Autopsy Hall,

Department of Forensic Medicine & Toxicology,

Tirunelveli Medical College,

Tirunelveli.

ANNEXURE – I : Proforma

Age estimation from pubic symphysis changes (phase analysis)

(Known age from 18 to 49 years at death)

Sl. no. / case no: Date:

PM No:

Police station & Crime no:

1. Name :
2. Age from :
   - Driving license :
   - Ration card :
   - Voters ID :
   - Mark sheets :
   - Pass port :
3. Sex : M / F
4. Address :
5. Occupation :
6. Married/ unmarried :
7. Physical Examination :
   - Nourisment : (poor/ moderate/ well)
   - Built : (poor/moderate/ well)

8**. Consent:**

I _____

S/o, D/o, F/o, M/o _____ pubic bone from my father/ mother/son/ daughter for using this bone's findings and photographs for study / publishing as paper / future researches.

Signature of the legal heir **Signature of the examiner**

Master Chart:

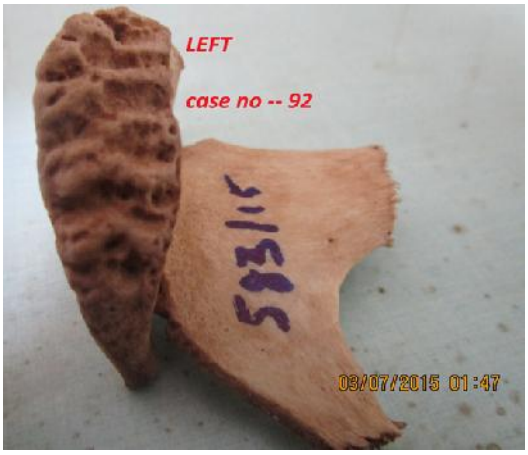
Age estimation from pubic symphysis changes (phase analysis) with known age from 18 – 49 years.

Sl.no	PM no& date of collection	Age in records	SS	ON	DM	VM	EXT	Observed age	Phase

IN PRESENT STUDY, FOLLOWING FINDINGS ARE NOTED

PHASE --- 1 (AGE 18 – 19 years)

Symphyseal surface	---	Rugged horizontal ridges separated by well marked grooves.
Ossific nodules	---	not developed
Dorsal margin	---	not developed
Ventral margin	---	not developed
Extremities	---	no definition



picture: 5 picture: 6

In my present study 8 sets of bones belongs to the age group of 18 – 19 years. All eight sets of bone are having rugged symphyseal surface with horizontal ridges separated by well marked grooves. There is no ossific nodules, no dorsal margin, no ventral margin and no definition of extremities.

PHASE ----- 2 (AGE 20- 21years)

Symphyseal surface	---	Grooves started filling from dorsally.
Ossific nodules	---	may or may not be present.
Dorsal margin	---	begins
Ventral margin	---	ventral beveling begins (foreshadowing)

Extremities --- no definition

Picture: 7 picture:8

In my present study 10 sets of bone belongs to the age group of 20 – 21 years. All ten sets of bone having dorsal filling, ossific nodules and dorsal margin beginning. In all sets of bone except sample no. 64 have foreshadowing of ventral beveling and advanced premature and sporadic attempts of formation of ventral rampart. All ten sets of bone do not have extremities.

PHASE ----- 3 (AGE 22-24 years)

Symphyseal surface --- progressive obliteration of ridges and furrows

Ossific nodules --- almost present

Dorsal margin --- more definite dorsal plateau begins

Ventral margin --- beveling more pronounced

Extremities --- no definition

Picture: 9 picture:10

In my present study eight sets of bone belongs to age group of 22 – 24 years. All eight sets of bone shows, progressive obliteration of ridges and furrows in symphyseal surface, Ossific nodules, more defined dorsal margin, beginning of dorsal plateau formation and more pronounced ventral margin beveling. Sample no.71having advanced phase changes in the form of lower extremity formation.

PHASE ------ 4 (AGE 24 – 26 years)

Symphyseal surface	---	more obliteration of ridges and furrows
Ossific nodules	---	present
Dorsal margin	---	complete dorsal plateau
Ventral margin	---	beveling greatly increased
Extremities	---	lower extremity formation started

Picture:11 picture:12

In my present study seven sets of bone belongs to age group of 24 – 26 years. All seven sets of bone are having rapid progressive obliteration of ridges and furrows, Ossific nodules, complete dorsal plateau and very well increased ventral beveling. Formation of lower extremity started in all bone sets.

PHASE --- 5 (AGE 27 – 30 years)

Symphyseal surface	---	one or few ridges
Ossific nodules	---	present
Dorsal margin	---	completely defined
ventral margin	---	premature and sporadic attempts of formation of ventral rampart
extremities	---	lower extremity – clear; upper extremity – formation started

Picture: 13 picture: 14

In present study sixteen sets of bone belongs to age group of 27 – 30 years. In all sixteen sets of bone in this phase are having few ridges with granular appearance of symphyseal surface, Ossific nodules, completely defined Dorsal margin, premature and sporadic attempts of ventral rampart formation, clear lower extremity and starting of upper extremity formation.

PHASE --- 6 AGE 30 – 35 years)

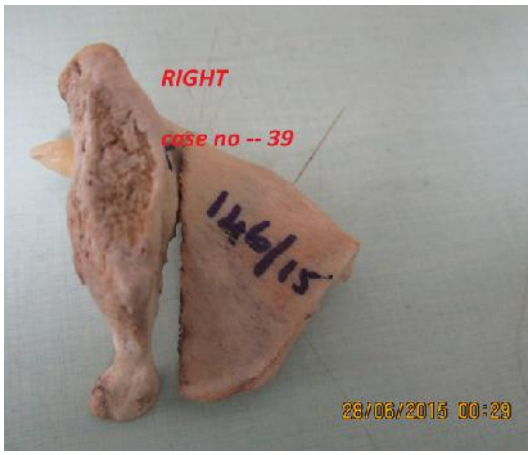
Symphyseal surface	---	granular appearance retained
Ossific nodules	---	present
Dorsal margin	---	well defined
Ventral margin	---	ventral rampart complete
Extremities	---	increasing definition of both Extremities

Picture:15 picture:16

In my present study eighteen sets of bone belongs to age group of 30 – 35 years. In all sets of bone in this phase are having granular appearance of Symphyseal surface except sample no. 8 which shows, two ridges and one furrow in the symphyseal surface, and sample no. 96 having smooth symphyseal surface. All sets of bone are having ossific nodules, well defined dorsal margin, complete ventral rampart and clear lower extremities. Dorsal aspect of upper extremity is clear, but ventral aspect of upper extremity is incomplete in sample nos. 41, 63, 65 and 70.

PHASE – 7 (35 – 39 years)

Symphyseal surface	---	fine texture with diminishing activity
Ossific nodules	---	present
Dorsal margin	---	well defined
Ventral margin	---	complete ventral rampart with tendon intervention
Extremities	---	both extremities well defined



Picture: 17 picture:18

In my present study fourteen sets of bone belongs to age group of 35 – 39 years. All sets of bone are having fine granular texture with diminishing activity except sample no. 29 and 66. These two sets of bone are having two ridges and one groove. All sets of bone are having ossific nodules, well defined dorsal margin and complete ventral rampart formation. Tendon intervention present mainly in upper part of ventral margin except in sample nos. 29, 39, and 61. All sets of sample bone are having clear upper and lower extremities.

PHASE --- 8(AGE 40 – 44 years)

Symphyseal surface	---	smooth and inactive; no rim
Ossific nodules	---	present
Dorsal margin	---	no lipping
Ventral margin	---	no lipping
Extremities	---	oval outline complete with clear Outline extremities

Picture:19 picture: 20

In my present study twelve sets of bone belongs to age group of 40 - 45 years. All sets of bone are having smooth symphyseal surface except in sample no. 82 which has rim presentation. All sets of bone are having ossific nodules. All sets of bone are having complete dorsal margin without lipping but sample no. 77 which has lipping in dorsal margin. All sets of bone are having complete ventral rampart without lipping but sample no. 77 has lipping in ventral margin. All sets of bone are having oval outline except sample no. 81which has only upper and lower extremities without oval outline.

PHASE --- 9 (AGE 44- 49 years)

Symphyseal surface	---	Rim present
Ossific nodules	---	may be present
Dorsal margin	---	uniformly lipped
Ventral margin	---	irregularly lipped
Extremities	---	oval out line well defined

Picture: 21 picture:22

In my present study seven sets of bone belongs to age group of 45 – 49 years. All sets of bone are having rim with minimal central erosion, except sample no. 53 and 73. They have smooth symphyseal surface without central erosion. All sets of bone are having uniform lipping in dorsal margin. All sets of bone are having irregular lipping in ventral margin except sample no. 43 which has smooth surface with complete ventral rampart without lipping.

PHASE – 10(AGE 50+ years)

Symphyseal surface	---	erosion and erratic ossification
Ossific nodules	---	broken down
Dorsal margin	---	broken down
Ventral margin	---	broken down
Extremities	---	broken down

DISCUSSION

My study is based on the ten phase analysis suggested by Todd. A total of 100 samples were taken from bodies subjected to autopsy in mortuary of Tirunelveli Medical College, Tirunelveli with known age available from records. Samples were taken with ages from 18- 49 years. Consent obtained from concerned persons. In total of 100 bone samples – 69 are males & 31 are females. In Todd's phase analysis, age group of 50years & above falls under phase 10. In my study phase 10 is avoided as there is no defined upper limit of age and for significance in statistical analysis.

Table 1: Sample Distribution

Number of samples taken in each phases are given in table 1.

Phase	**Age**	**Male**	**Female**	Total
I	18 - 19	3	5	8
II	20 - 21	9	1	10
III	22 - 24	6	2	8
IV	25 - 26	5	2	7
V	27 - 30	8	8	16
VI	30 - 35	11	7	18
VII	35 - 39	12	2	14
VIII	40 - 44	9	3	12
IX	45 - 49	6	1	7

Distribution of the number of samples according to sex in each phase is depicted in the figure 1 below:

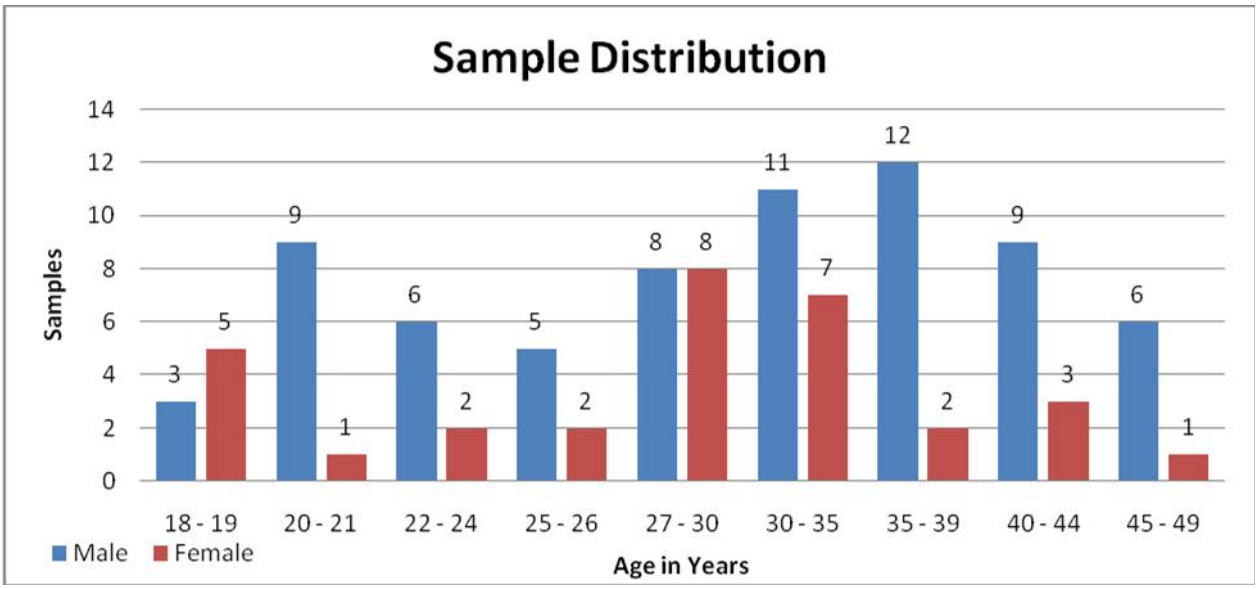


Figure 1: Sex Distribution in case sample

Statistical analysis of sample reveals, samples belonging to age group of 18 to 19 years are 8 in number out of total 100 samples, in which 3 bone samples are males constituting 38% and the remaining 5 bone samples are females constituting 62% in phase 1 as shown in the figure 2 below. Samples belonging to age group of 20 to 21 years are 10 in number out of total 100 samples, in which 9 bone samples are males constituting 90% and the remaining 1 bone sample is a female constituting 10% in phase II. Samples belonging to age group of 22 to 24 years are 8 in number out of total 100samples, in which 6 bone samples are males constituting 75% and the remaining 2 bone samples are females constituting 25% in phase III. Samples belonging to age group of 25 to 26 years are 7 in number out of total 100 samples, in which 5 bone samples are males constituting 71% and the remaining 2 bone samples are females constituting 29% in phase IV.

Samples belonging to age group of 27 to 30 years are 16 in number out of total 100 samples, in which 8 bone samples are males constituting 50% and the remaining 8 bone samples are females constituting 50% in phase V. Samples belonging to age group of 30 to 35 years are 18 in number out of total 100 samples, in which 11 bone samples are males constituting 61% and the remaining 7 bone samples are females constituting 39% in phase VI. Samples belonging to age group of 35 to 39 years are 14in number out of total 100 samples, in which 12 bone samples are males constituting 86% and the remaining 2 bone samples are females constituting 14% in phase VII. Samples belonging to age group of 40 to 44 years are 12 in number out of total 100 samples, in which 9bone samples are males constituting 75% and the remaining 3 bone samples are females constituting 25% in phase VIII. Samples belonging to age group of 45 to 49 years are 7 in number out of total 100samples, in which 6 bone samples are males constituting 86% and the remaining 1 bone sample is a female constituting 14% in phase IX.

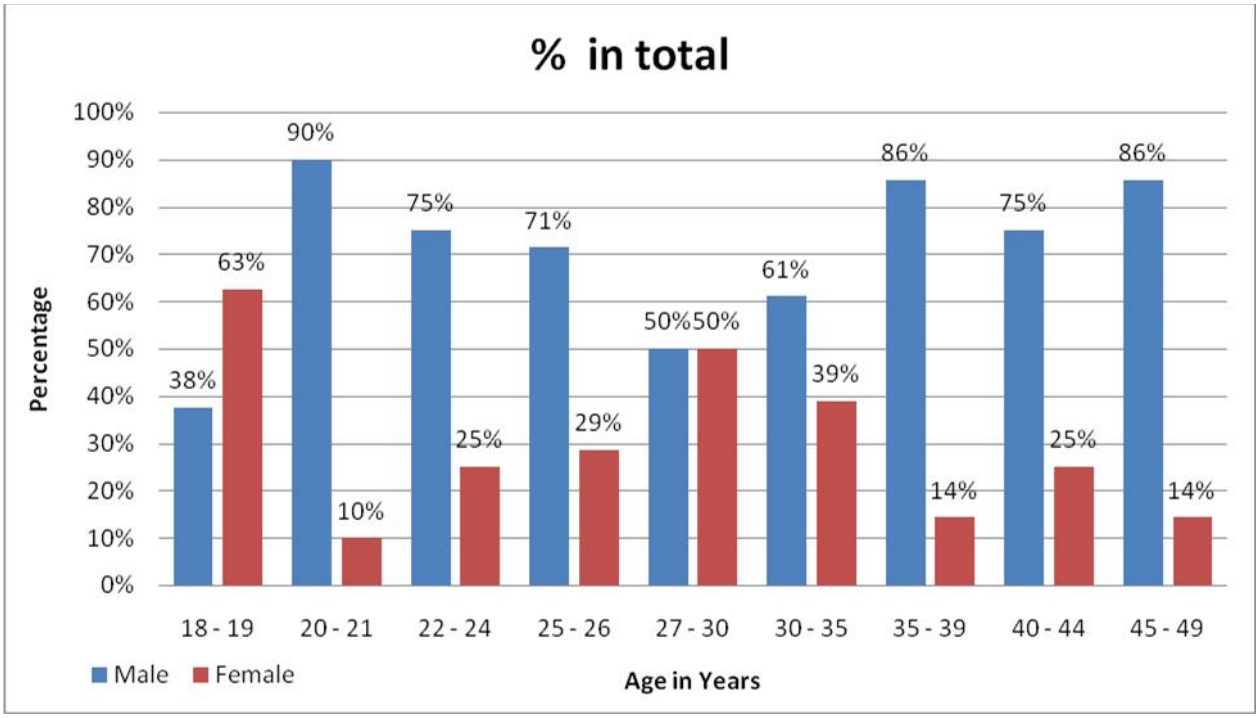


Figure 2: % distribution of samples

Observations made in my study are described below in each age group:

Age group (18-19 years)(phase 1): .

I observed that in first phase 18 – 19 years aged bones out of 8 samples (3 males /5 females) all were consistent with the Todd's phase I features as given in table 2 below:

Table 2: Phase I Analysis

	Features	Male (3)	Female (5)
Phase I	SS	3	5
	ON	3	5
	DM	3	5
	VM	3	5
	EXT	3	5

Presentation in phase I:

Symphyseal surface --- Rugged horizontal ridges & well marked grooves.

Ossific nodules --- not developed

Dorsal margin --- not developed

Ventral margin --- not developed

Extremities --- no definition

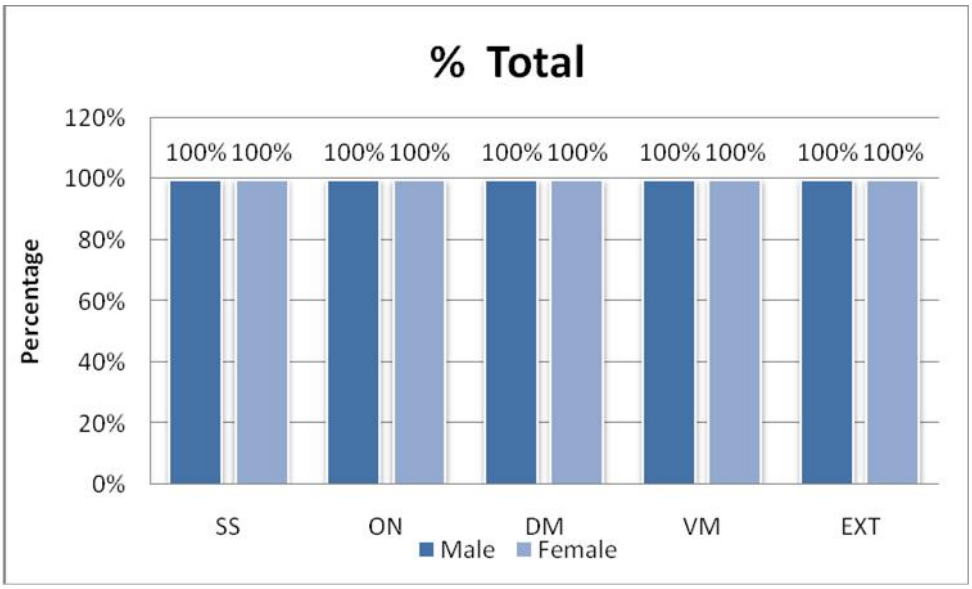


Figure 3: % distribution of samples -phase I

Both the male and female bone samples presented with all the features described in Todd's criteria of phase I and the percentage distribution of samples of both sexes presenting with the features is 100% and it is shown in figure 3.

Mean percentage of phase I is 100%.

Age group (20 – 21 years):

Presentation in phase II:

Symphyseal surface	---	Grooves started filling from dorsally.
Ossific nodules	---	may or may not be present.
Dorsal margin	---	begins
Ventral margin	---	ventral beveling begins (Foreshadowing)
Extremities	---	no definition

Samples belonging to age group of 20 to 21 years are 10 in number out of total 100 samples, in which 9 bone samples are males constituting 90% and the remaining one bone sample is a female constituting 10% in phase II(as shown in table below).

Table 3: phase II Analysis

	Features	Male (9)	Female (1)
Phase II	SS	9	1
	ON	9	1
	DM	9	1
	VM	8	1
	EXT	9	1

All samples on observation matched the criteria given by Todd's analysis in phase II except in one case in which ventral margin (sample no. 64) present with early appearance of premature and sporadic attempts of formation of ventral rampart.

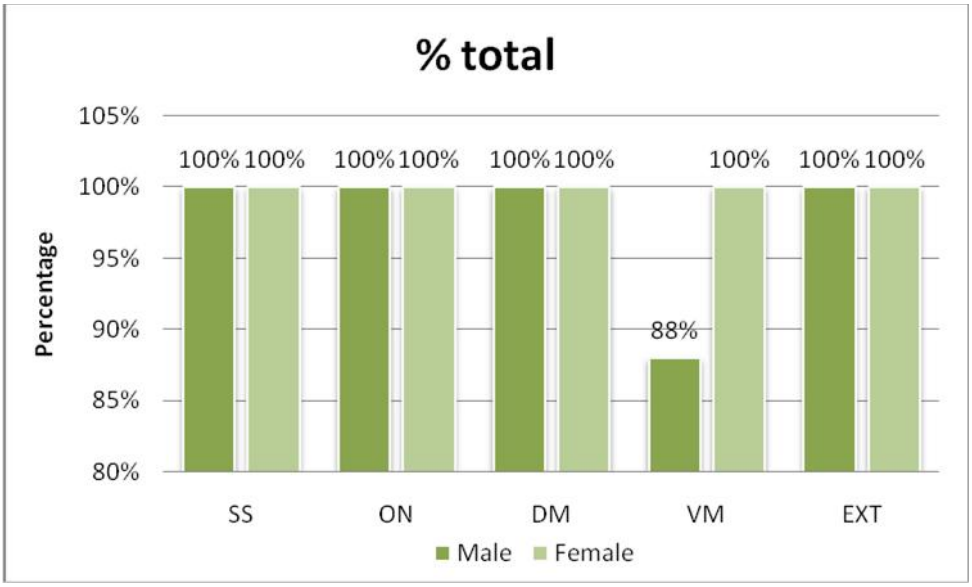


Figure 4: % distribution of phase II

The percentage distribution of samples of both sexes presenting with the features of Todd's phase II are given in figure 4.

As depicted in figure 4, female sets of bone satisfies the Todd's criteria - 100%. In male sets of bone except ventral margin other criteria satisfies 100%.

Mean percentage of phase II is 98%.

Age group (22 – 24) years:

Presentation in phase III:

Symphyseal surface --- progressive obliteration of ridges and furrows

Ossific nodules --- almost present

Dorsal margin --- more definite dorsal plateau begins

Ventral margin --- beveling more pronounced

Extremities --- no definition

Samples belonging to age group of 22 to 24 years are 8 in no. out of total 100 samples, in which 6 bone samples are males constituting 75% and the remaining 2 bone samples are females constituting 25% in phase III (as given in table below).

Table 4: phase III analysis

	Features	Male (6)	Female (2)
Phase III	SS	6	2
	ON	6	2
	DM	6	2
	VM	6	2
	EXT	5	1

In my study, all bone sets are having progressive obliteration of ridges and Furrows, Ossific nodules almost present, dorsal margin more definite, dorsal plateau begins, Ventral margin beveling more pronounced, in all the eight sets of bones except in one sample(sample no. 71), having advanced phase changes in the form of lower extremity formation.

The percentage distribution of samples of both sexes presenting with the features of Todd's phase III are given in figure 5.

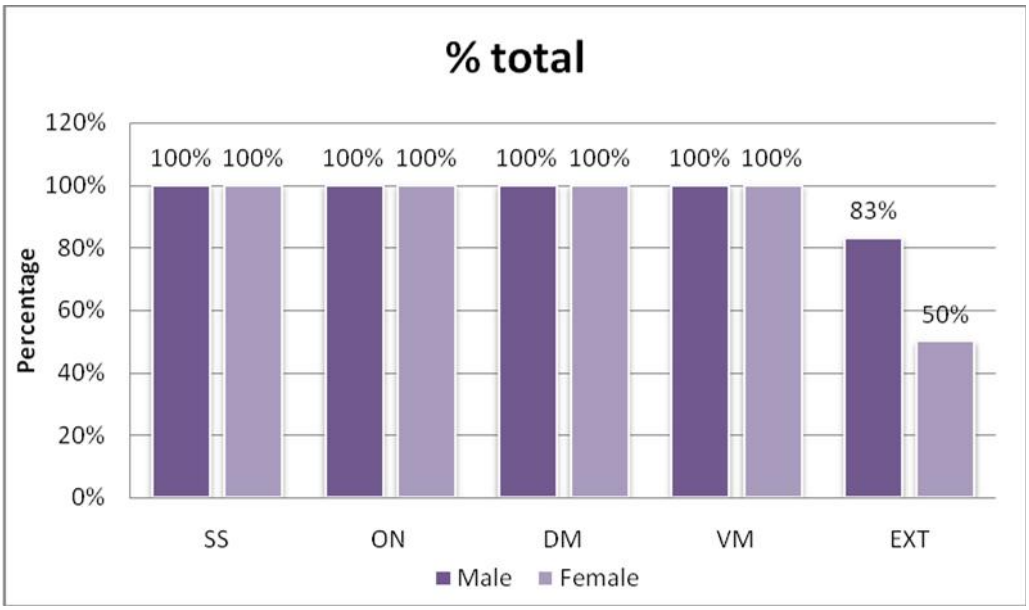


Figure 5: % distribution in phase III

As depicted in figure 5, In male sets of bone extremity shows 83% while other criteria satisfies 100%, in female sets of bone extremity shows 50% while other criteria satisfies 100%.

Mean percentage of phase III is 93%.

Age group (25 - 26 years):

Presentation in phase IV:

Symphyseal surface	---	more obliteration of ridges and furrows
Ossific nodules	---	present
Dorsal margin	---	complete dorsal plateau
Ventral margin	---	beveling greatly increased
Extremities	---	lower extremity formation started

Samples belonging to age group of 25 to 26 years are 7 in number out of total 100 samples, in which 5 bone samples are males constituting 71% and the remaining 2 bone samples are females constituting 29% in phase IV (as in table below).

Table 5: phase IV analysis

	Features	Male (5)	Female (2)
Phase IV	SS	5	2
	ON	5	2
	DM	5	2
	VM	5	2
	EXT	5	2

In my study, all eight sets of bone had rapid progressive obliteration of ridges and furrows, Ossific nodules were present in all bone sets. All bone sets had complete dorsal plateau and very well increased ventral beveling. Formation of lower extremity started in all bone sets. In short, all the bone sets were exactly in line with the Todd's phase requirements.

The percentage distribution of samples of both sexes presenting with the features of Todd's phase IV are given in figure 6.

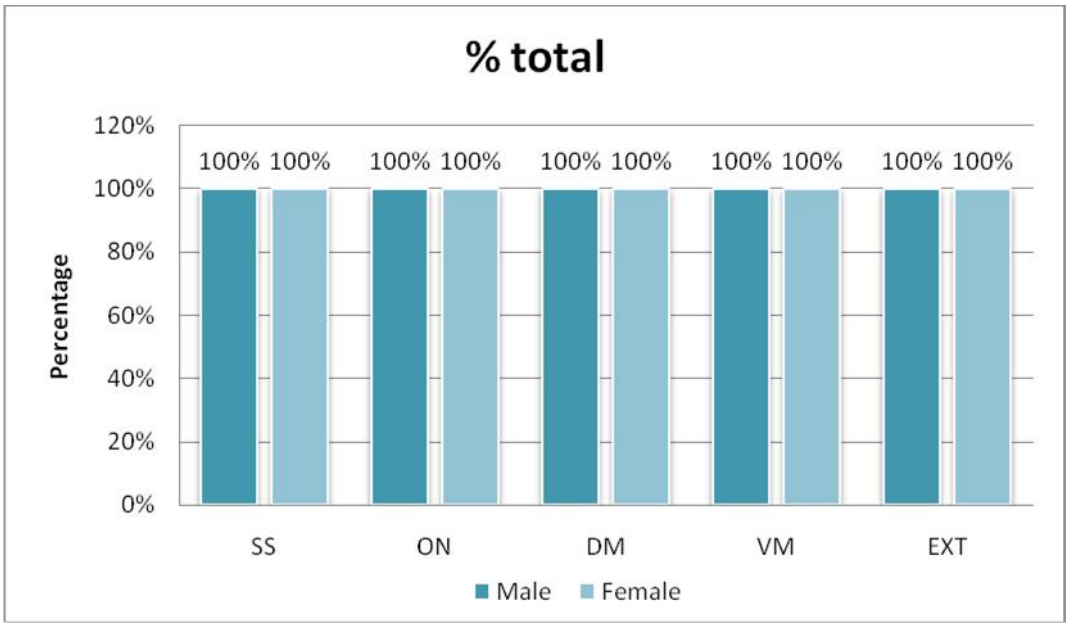


Figure 6: % distribution in phase IV

Both the male and female bone samples presented with all the features that Todd's criteria of phase IV and the percentage distribution of samples of both sexes presenting with the features is 100% and it is shown in figure 6.

Age group (27- 30 years):

Presentation in phase V:

Symphyseal surface	---	one or few ridges
Ossific nodules	---	present
Dorsal margin	---	completely defined
Ventral margin	---	premature and sporadic attempts of rampart formation of ventral
Extremities	---	lower extremity – clear; upper extremity – formation started

Samples belonging to age group of 27 to 30 years are 16 in number out of total 100 samples, in which 8 bone samples are males constituting 50% and the remaining 8 bone samples are females constituting 50% in phase 5 (as given in table below).

Table 6: phase V analysis

	Features	Male (8)	Female (8)
Phase V	SS	8	8
	ON	8	8
	DM	8	8
	VM	8	8
	EXT	8	8

In my present study, all sixteen sets of bone in this phase are having few ridges with granular appearance of symphyseal surface. Ossific nodules present in all sets of bone and are having completely defined dorsal margin. All sets of bone in this phase are having premature and sporadic attempts of formation of ventral rampart. Also all sets of bone in this phase having clear lower extremity and upper extremity formation started. All the bone sets were exactly in line with the Todd's phase requirements.

The percentage distribution of samples of both sexes presenting with the features of Todd's phase V are given in figure 7.

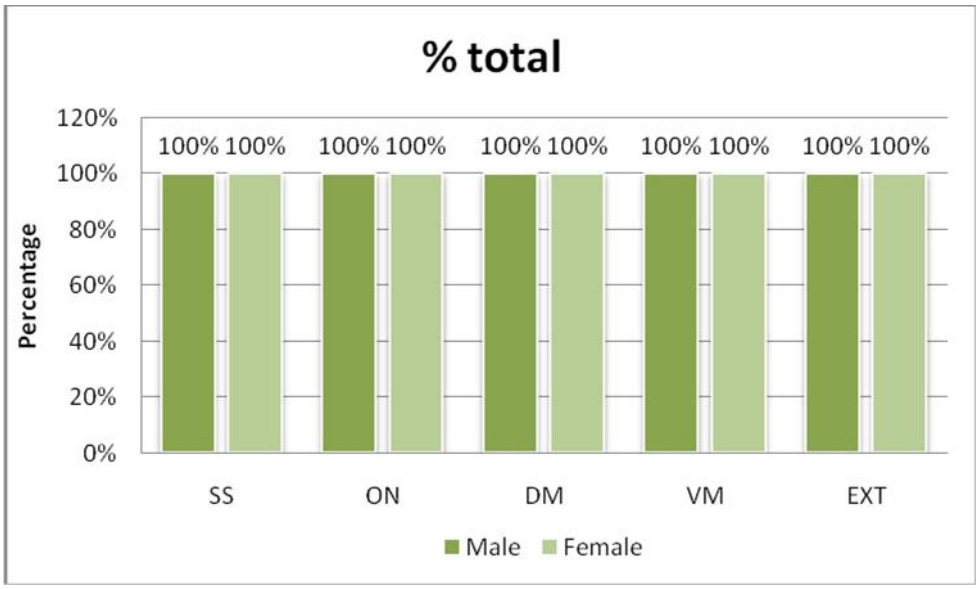


Figure 7: % distribution in phase V

Both the male and female bone samples presented with all the features that Todd's criteria of phase V and the percentage distribution of samples of both sexes presenting with the features is 100% and it is shown in figure 7.

Age 30-35 years:

Presentation in phase VI:

Symphyseal surface	---	granular appearance retained
Ossific nodules	---	present
Dorsal margin	---	well defined
Ventral margin	---	ventral rampart complete
Extremities	---	increasing definition of both Extremities

Samples belonging to age group of 30 to 35 years are 18 in number out of total 100 samples, in which 11 bone samples are males constituting 61% and the remaining 7 bone samples are females constituting 39% in phase VI (as shown in table below).

Table 7: phase VI analysis

	Features	Male (11)	Female (7)
Phase VI	SS	11	7
	ON	11	7
	DM	11	7
	VM	11	7
	EXT	8	6

In my present study, all sets of bone are having granular appearance of Symphyseal surface. All sets of bone are having ossific nodules, well defined dorsal margin and complete ventral rampart. All sets of bone are having clear lower extremities, dorsal aspect of upper extremity is clear, but ventral aspect of upper extremity is incomplete in 4 samples(sample no. 41, 63,65 &70)(3 males & 1 female).

The percentage distribution of samples of both sexes presenting with the features of Todd's phase VI are given in figure 8.

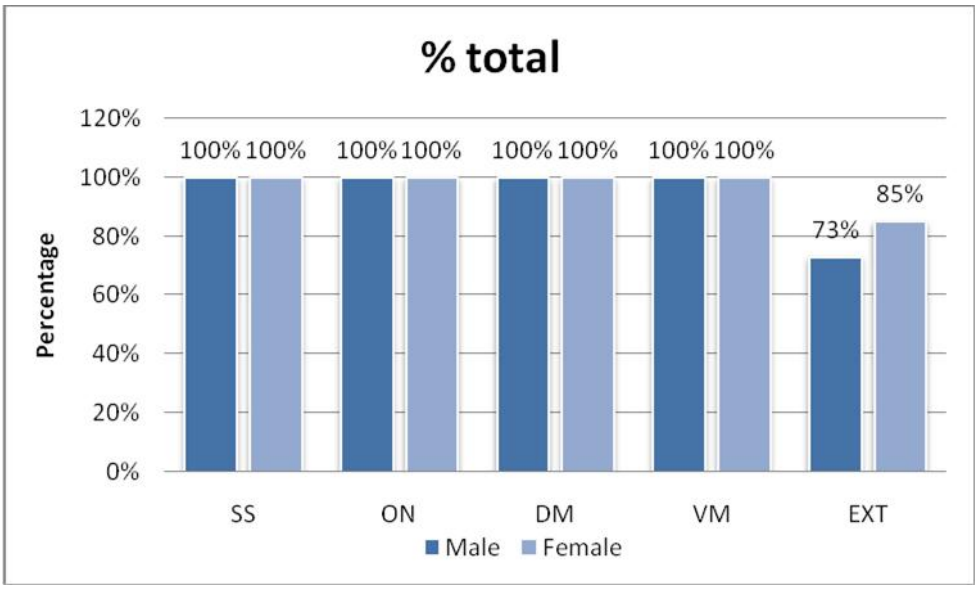


Figure 8: % distribution in phase VI

As depicted in figure 8, In male sets of bone, extremity shows 73% while other criteria satisfies 100%, in female sets of bone, extremity shows85% while other criteria satisfies 100%.

Mean percentage in phase VI is 96%.

Age 35 - 39 years:

Presentation in phase VII:

Symphysealsurface --- fine texture with diminishing activity

Ossific nodules --- present

Dorsal margin --- well defined

Ventral margin --- complete ventral rampart with tendon intervention

Extremities --- both extremities well defined

Samples belonging to age group of 35 to 39 years are 14in number out of total 100 samples, in which 12 bone samples are males constituting 86% and the remaining 2 bone samples are females constituting 14% in phase VII (as shown in table below).

Table 8: phase VII analysis

	Features	Male (12)	Female (2)
Phase VII	SS	8	2
	ON	12	2
	DM	12	2
	VM	12	2
	EXT	9	2

In the study, all sets of bone are having fine granular texture with diminishing activity in symphyseal surface except in 2 samples (sample no. 29 & 66) presented with two ridges and one groove. All sets of bone are having ossific nodules, well defined dorsal margin and complete ventral rampart formation. Tendon intervention present mainly in upper part of ventral margin except in 3 samples (sample no. 29, 39& 61). All sets of sample bones are having both clear upper and lower extremities. The percentage distribution of samples of both sexes presenting with the features of Todd's phase VII are given in figure 9.

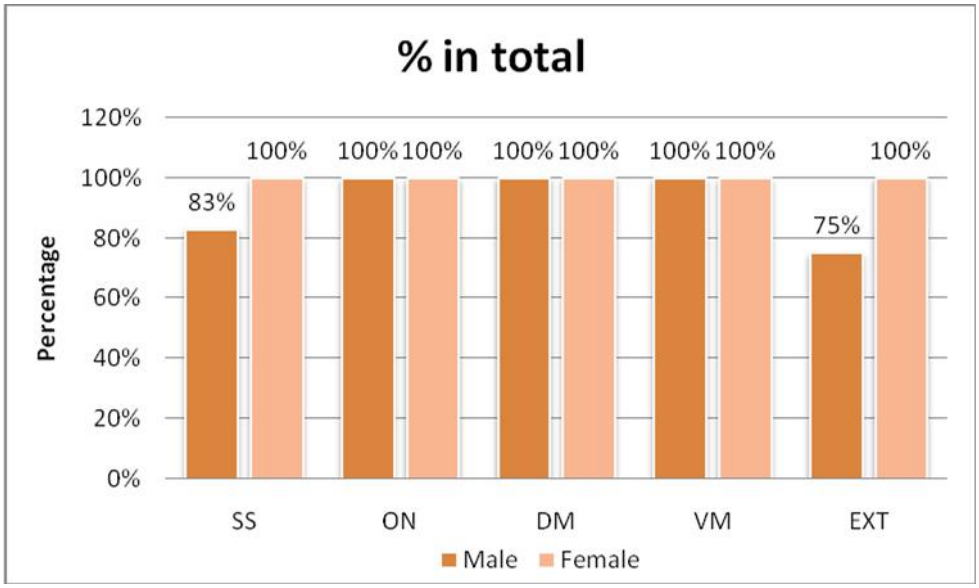


Figure 9: % distribution in phase VII

As depicted in figure 9, In male sets of bone, symphyseal surface shows 83% while other criteria satisfies 100%, in female sets of bone, extremity shows75% while other criteria satisfies 100%.

Mean percentage of phase VII is 96%.

Age 40 - 44 years:

Presentation in phase VIII:

Symphyseal surface	---	smooth and inactive; no rim
Ossific nodules	---	present
Dorsal margin	---	no lipping
Ventral margin	---	no lipping
Extremities	---	oval outline complete with clear Outline extremities

Table 9: phase VIII analysis

	Features	Male (9)	Female (3)
Phase VIII	SS	8	3
	ON	9	3
	DM	9	2
	VM	9	2
	EXT	7	3

In my study, all sets of bone are having smooth symphyseal surface except in one sample(sample no.42) had rim presentation in the symphyseal surface, all sets of bone had ossific nodules, no lipping in dorsal margin except in one sample(sample no. 77), has lipping in dorsal margin. All sets of bone are having complete ventral rampart without lipping except in one sample (sample no. 77), has lipping in ventral margin. All sets of bone are having oval outline with clear extremities except in two samples (sample no. 45 & 81), are having both extremities clear without oval outline.

The percentage distribution of samples of both sexes presenting with the features of Todd's phase VIII are given in figure 10.

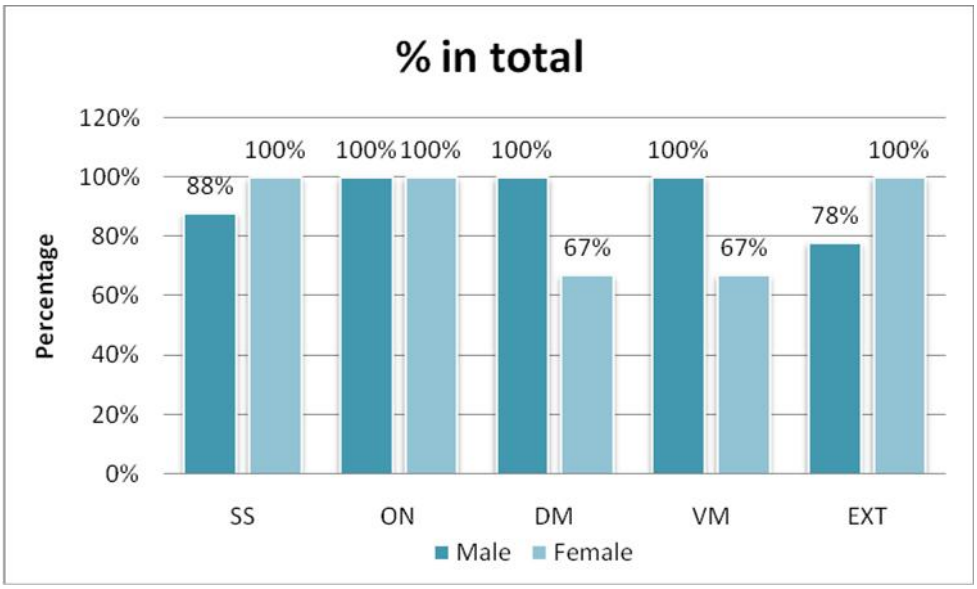


Figure 10: % distribution in phase VIII

As depicted in figure 10, In male sets of bone, symphyseal surface shows 88% and extremity shows 78% while other criteria satisfies 100%. In female sets of bone, dorsal margin shows 67% and ventral margin shows 67% while other criteria satisfies 100%.

Mean percentage in phase VIII is 90%.

Age 45 - 49 years:

Presentation in phase IX:

Symphyseal surface	---	Rim present
Ossific nodules	---	may be present
Dorsal margin	---	uniformly lipped
Ventral margin	---	irregularly lipped
Extremities	---	oval out line well defined

Samples belonging to age group of 45 to 49 years are 7 in number out of total 100samples,in which 6 bone samples are males constituting 86% and the remaining 1 bone sample is a female constituting 14% in phase IX (as shown in table below).

Table 10: phase IX analysis

	Features	Male (6)	Female (1)
Phase IX	SS	3	1
	ON	6	1
	DM	6	1
	VM	5	1
	EXT	6	1

In my study, mostly all sets of bone presented rim with minimal central erosion in symphyseal surface except in 3 samples (sample no. 43, 53 &73). They had smooth symphyseal surface only without central erosion. All sets of bone were having uniformed lipping in dorsal margin, irregular lipping in ventral margin except in one sample (sample no. 43) had smooth surface with complete ventral rampart without lipping .

The percentage distribution of samples of both sexes presenting with the features of Todd's phase IX are given in figure 11.

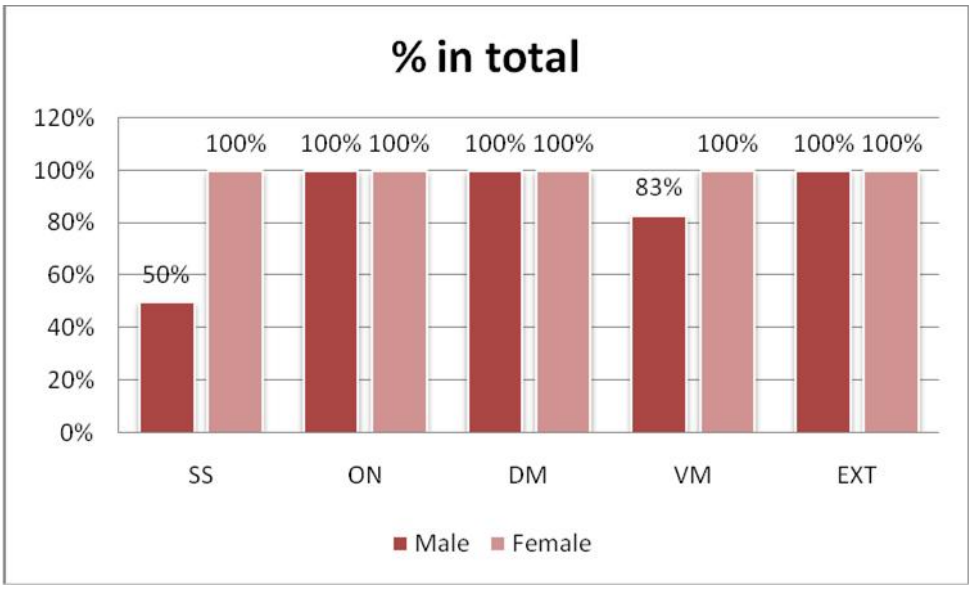


Figure 11: % distribution in phase IX

As depicted in figure 11, In male sets of bone symphyseal surface changes shows 50% ventral margin changes shows 83% while other criteria satisfies 100%. In female sets of bone all criteria satisfies 100%.

Mean percentage of phase IX is 93%.

Table 11: Mean percentage of phase analysis

phase	Age	Male (%)	Female (%)	MEAN (%)
I	18-19	100	100	100
II	20-21	98	100	98
III	22-24	97	90	93
IV	25-26	100	100	100
V	27-30	100	100	100
VI	30-35	95	97	96
VII	35-39	92	100	96
VIII	39-40	93	87	90
IX	40-44	87	100	93

From the above table it can be inferred that for both sexes

Mean percentage of phase I, IV& V is 100%.

Mean percentage of phase II is 98%.

Mean percentage of phase VI & VII is 96%.

Mean percentage of phase III &IX is 93%.

Mean percentage of phase VIII is 90%.

Average mean percentage of all the 9 phases of Todd's phase analysis for both sexes is 90% & above. It is significant and it proves that Todd's phase analysis of pubic symphyseal metamorphological changes can be effectively used in both sexes for estimation of age.

CONCLUSION:

On completion of study it is well established that Todd's ten phase analysis of pubic symphysis metamorphological changes is effective in both sexes for estimation of age. Summary of my study are as follows:

intervention

Symphyseal surface has ridges and furrows in Todd's phase I, II, III, IV, V whereas in phase I there is no dorsal, ventral and extremity changes, in phase II dorsally filling grooves are without extremity formation, in phase III more definite dorsal plateau begins with ventral beveling, phase IV showed complete dorsal plateau and ventral beveling and lower extremity formation, lastly in phase V ridges are with granular changes, complete dorsal margin and ventral rampart formation.

Granular Symphyseal surface is indicative of phase V, VI, VII. Granular Symphyseal surface with ventral rampart formation is indicative of phase VI, granular symphyseal surface with complete ventral rampart is indicative of phase VII.

Smooth Symphyseal surface is indicative of phase VIII.

Symphyseal surface with rim is indicative of phase IX.

Eroded symphyseal surface is indicative of phase IX and X.

Ossific nodules are most probably present in all phases of Todd's except phase I.

Dorsal margin changes are present in all Todd's 10 phases, but complete dorsal plateau indicative of phase IV, V, and VI. Dorsal plateau with ventral beveling is indicative of phase IV, dorsal plateau with ventral rampart formation is indicative of phase V and dorsal plateau with complete ventral rampart is indicative of phase VI. Lipped dorsal margin is indicative of phase IX.

Ventral margin changes include ventral beveling, ventral rampart formation and lipping of ventral margin. Ventral beveling mainly falls under phase III and IV, ventral rampart to phase V and VI. Complete ventral rampart is a feature of phase VI. Lipped ventral margin indicative of phase IX.

Extremities changes present in phase IV – X. Lower extremity formation is a feature of phase IV, clear lower extremity and starting of upper extremity formation is a feature of phase V, clear upper and lower extremity indicative of phase VI and VII. Oval outline with clear both extremities matches with phase VIII and IX.

Inferred points from the study are

PHASE I	--	Rugged ridges with horizontal grooves.
PHASE II	--	Dorsally filling of grooves with starting of ventral beveling.
PHASE III	--	Dorsal plateau with ventral beveling.
PHASE IV	--	Complete dorsal plateau, ventral beveling and lower extremity formation.
PHASE V	--	Complete dorsal margin, starting of ventral rampart and both extremities.
PHASEVI & VII	--	Well defined dorsal margin and ventral rampart and clear both extremities with granular surface.
PHASE VIII	--	Smooth surface with oval outline.

PHASE IX -- Rim with lipping.

PHASE X -- Erosion.

This study findings reveal features of meta-morphological changes falls in line with the Todd's phase analysis and mean percentage of phase analysis is above 90% in all phases for both sexes. Hence it is proved that the age estimation from pubic symphysis changes for humans aged from 18-49 years can be effectively quantitated by using Todd's phase analysis method for both males and females as a matter of routine practice in local population.

RECOMMENDATION

This type of study to be conducted in varied places with more samples to prove or disprove usage of Todd's criteria in assessing age, using symphyseal changes.

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Sl. No.	Pm no & date of collection	Age in records	Symphyseal surface	Ossific nodules	Dorsal margin	Ventral margin	extremities	Observed age	Phase
1	675/4-6-14	33/f	Granular	present	Defined	Ventral rampart complete	Upper and lower clear	30-35	VI
2	701/8-6-14	42/f	Smooth	present	Defined	Ventral rampart complete	Oval out line	39-44	VIII
3	779/18-6-14	25/m	Diminition of ridges and furrows	present	Dorsal plateau complete	Ventral beveling present	Lower commencing definition	25-26	IV
4	784/19-6-14	21/m	Dorsally filled, rugged, horizontal ridges separated by grooves	present	begins	none	none	20-21	II
5	822/25-6-14	27/m	No ridges and furrows	present	defined	Sporadic attempt at ventral rampart	Lower-clear upper-start	27-30	V

6	826/26-6-14	26/f	Dorsally obliteration of ridges and furrows	present	defined	Foreshadowing of ventral bevel	Lower commencing definition	25-26	IV
7	848/30-6-14	26/f	Diminution of ridges and furrows	present	complete	Great increase of ventral beveled area	Lower-clear; upper extremity forming	27-30	V
8	849/30-6-14	35/f	2 ridges and furrows present	Present	complete	Sporadic attempt at vent. rampart	Lower-clear;upper-incomplete	27-30	V
9	857/1-7-14	32/f	granular	present	complete	Sporadic attempt at vent. rampart	Lower exterimity formation start	27-30	V
10	859/1-7-14	21/m	Grooves filling dorsally	Present	begins	none	none	20-21	II
11	869/4-7-14	29/m	No ridges and furrows	present	defined	Completion of ventral rampart	Lower-clear; upper-almost clear	30-35	VI
12	875/7-7-14	38/m	granular	present	defined	complete	Both clear	35-39	VII

13	877/7-7-14	38/m	granular	Present	defined	complete	Both clear	35-39	VII
14	883/8-7-14	23/m	Obliteration of ridges and furrows	Present	Dorsal plateau present	Ventral beveling present	none	22-24	III
15	921/16-7-14	37/m	granular	Present	defined	complete	Both clear	35-39	VII
16	956/22-7-14	30/m	2ridges and 1groove	Present	Present but not complete	Vent. Rampart formation present	Lower-clear upper-start	27-30	V
17	980/25-7-14	18/m	Rugged, horizontal ridges separated by grooves	None	none	none	No definition	18-19	I
18	1108/19-814	32/m	granular	Present	defined	complete	Both clear	30-35	VI
19	1169/1-9-14	37/m	smooth	Present	defined	Vent. rampart present with intervention	Both clear	35-39	VII
20	1170/1-9-14	29/f	granular	Present	defined	Complete ventral rampart	Both clear	27-30	V

21	1185/5-9-14	19/f	Rugged, horizontal ridges separated by grooves	None	none	none	No definition	18-19	I
22	1190/8-9-15	28/m	No ridges and furrows	Present	defined	Complete vent. Rampart	Both clear	27-30	V
23	1200/11-9-15	26/m	2ridges and 1 groove	Present	Dorsal plateau present	Great increase of vent. Beveled area	Lower commencing definition	25-26	IV
24	1226/15-9-14	40/f	smooth	Present	defined	complete	Oval out line	40-44	VIII
25	1264/22-9-14	29/f	granular	Present but small	defined	Almost complete	Lower-clear; upper-intervention of bony nodule	27-30	V

26	621/15-5-15	20/f	Dorsally filled, Rugged, horizontal ridges separated by grooves	present	begins	none	none	20-21	II
27	1298/30-9-14	27/f	2ridges and 1 groove	Present	Complete through dorsal plateau	Sporadic attempt of vent. rampart	Lower-clear; upper-ventral side not formed	27-30	V
28	1428/28-10-14	21/m	Grooves filling dorsally	Present	begins	Foreshadowing of vent. bevel	none	20-21	II
29	1520/18-11-14	35/m	3ridges and 2 grooves	Present	defined	Vent. Rampart complete	Both clear	30-35	VII
30	1521/19-11-14	28/m	2ridges and 1groove	Present	Complete through dorsal plateau	Sporadic attempt of vent. rampart	Lower-clear; upper-intervention of bony nodule	27-30	V

31	1542/26-11-14	34/f	granular	Present	defined	Vent. Rampart with irregular upper 1/3 margin	Lower-clear; upper-intervention of bony nodule	35-39	VII
32	52/14-1-14	33/m	granular	present	complete through dorsal plateau	Ventral rampart present	Both clear	35-39	VII
33	109/28-1-14	32/m	granular	Present	Defined	Diminishing activity	Both clear	35-39	VII
34	137/2-2-14	46/m	Rim present	Present	lipping	Irregular lipping	Oval out line	44-50	IX
35	141/3-2-15	18/m	Rugged, horizontal ridges separated by grooves	None	none	none		18-19	I
36	146/4-2-15	38/f	granular	Present	defined	complete	Both-clear	35-39	VII
37	150/5-2-15	45/m	Rim, central erosion	Present	lipping	Irregular lipping	oval	44-45	IX
38	162/7-5-15	20/m	Grooves filling dorsally	Appear	begins	Foreshadowing of vent. beveling	none	20-21	II

39	163/7-2-15	38/m	granular	Present	Intervention present in middle part	Intervention present in upper 1/3	Both - clear	35-39	VII
40	167/8-2-15	31/f	granular	Present	complete	Vent. Rampart complete	Increasing definition of both extremities	30-35	VI
41	177/11-2-15	30/m	granular	Present	complete	Formation of ventral rampart	Lower-clear; upper-incomplete	30-35	VI
42	186/14-2-15	60/m	Rim present, erosion at vent. Aspect	present	defined	complete	oval	39-44	VIII

43	187/14-2-15	33/m	smooth	Present	defined	Vent. Rampart complete	oval	40-44	IX
44	188/15-2-15	46/m	Rim with central erosion	present	lipping	Irregular lipping	Oval out line	44-50	IX
45	194/16-2-15	42/m	granular	present	defined	complete	Both-clear	39-44	VIII
46	197/17-2-15	23/m	Progressive obliteration of ridges and furrows	Appear	Dorsal plateau formation present	Ventral beveling more pronounced	none	22-24	III
47	235/26-2-15	25/m	Diminution of ridges and furrows	present	Complete dorsal margin through formation of dorsal plateau	Great increase of vent. Beveled area	Lower commencing definition	25-26	IV
48	257/3-3-15	35/f	granular	present	defined	Completion of vent. rampart	Both-clear	30-35	VI
49	260/3-3-15	25/f	Diminution of ridges and furrows	present	Dorsal plateau formation complete	Ventral beveling present	Lower commencing definition	25-26	IV

50	261/4-3-15	44/m	erosion	present	lipping	Irregular lipping	oval	40-45	VIII
51	263/4-3-15	44/m	smooth	present	lipping	No lipping	oval	40-45	VIII
52	264/4-3-15	38/m	granular	present	defined	Vent. Rampart with irregular upper margin	Lower-clear; upper-intervention by bony nodule	35-39	VII
53	265/4-3-15	50/m	smooth	present	lipping	Irregular lipping	oval	44-49	IX
54	269/5-3-15	16/m	Rugged, horizontal ridges separated by grooves	None	none	none		18-19	I
55	289/11-3-15	24/m	Diminution of ridges and furrows	present	complete	Great increase of vent. Beveled area	Lower extremity formation present	25-26	IV
56	294/12-3-15	30/f	granular	Present	complete	Vent. Rampart present	Both-clear	30-35	VI

57	295/12-3-15	22/f	Progressive obliteration of ridges and furrows	Appeared	Dorsal plateau formation present	Ventral beveling more pronounced	none	22-24	III
58	301/13-3-15	19/f	Rugged, horizontal ridges separated by grooves	Appeared	begins	none	none	18-21	I
59	302/13-3-15	34/m	granular	Present	defined	Premature attempts of formation of ventral rampart	Lower-clear; upper-dorsal side-complete	30-35	VI
60	313/16-3-15	45/m	Rim present; centrally granular	Present	lipping	No lipping	oval	45-50	IX

61	354/26-3-15	36/m	granular	Present	defined	Vent. Rampart with upper 1/3 intervention by tendon	clear	35-39	VII
62	355/26-3-15	31/f	granular	present	Complete with dorsal plateau	Sporadic attempts at formation of vent. rampart	Lower-clear; upper-intervention by bony nodules	30-35	VI
63	367/29-3-15	34/f	granular	Present	Complete	Premature attempts of formation of ventral rampart	Lower-clear; upper-dorsal side-incomplete	30-35	VI
64	380/3-4-15	20/m	Rugged, horizontal ridges separated by grooves	Present	begins	Sporadic attempts at formation of vent. rampart	none	22-24	II

65	411/7-4-15	32/m	granular	Present	complete	Completion of ventral rampart	Lower-clear; upper-incomplete	30-35	VI
66	413/7-4-15	36/m	3 ridges and 2grooves present	Present	defined	Completion of ventral rampart	Lower-clear; upper-intervention by bony nodules	35-39	VII
67	417/8-4-15	42/m	granular	Present	defined	defined	oval	39-44	VIII
68	421/9-4-15	26/m	Diminution of ridges and furrows	Present	Complete dorsal margin through dorsal plateau	Great increase of vent. Beveled area	Lower commencing definition	25-26	IV
69	423/9-4-15	30/m	granular	Present	defined	Completion of ventral rampart	Both – clear	30-35	VI
70	465/17-4-15	33/m	granular	Present	Well defined	Sporadic attempts at formation of vent. rampart	Lower-clear; upper-incomplete	30-35	VI

71	466/17-4-15	24/f	Progressive obliteration of ridges and furrows	present	Dorsal plateau formation present	Ventral beveling present	Lower-clear	22-24	III
72	467/18-4-15	22/m	Progressive obliteration of ridges and furrows	Present	Dorsal plateau formation present	Foreshadowing of vent. bevel	none	22-24	III
73	474/19-4-15	39/f	smooth	Present	lipping	lipping	irregular	45-49	IX
74	486/20-4-15	36/m	smooth	Present	Defined	defined	oval	39-44	VIII
75	534/30-4-15	30/f	granular	Present	defined	Complete vent. rampart	Increasing definition of both extremities	30-35	VI
76	536/30-4-15	21/m	Dorsally filled	Present	begins	none	none	20-21	II
77	546/2-5-15	34/f	smooth	Present	lipping	lipping	oval	39-44	VIII
78	547/2-5-15	18/f	Rugged, horizontal ridges separated by grooves	None	none	none	none	18-19	I

79	555/4-5-15	27/m	granular	Present	defined	Complete vent. rampart	irregular	27-30	V
80	558/4-5-15	38/m	granular	Present	lipping	lipping	oval	39-44	VIII
81	562/5-5-15	39/m	smooth	Present	Defined	defined	Both-clear	40-44	VIII
82	565/5-5-15	37/m	Rim with central granular	Present	defined	Complete vent. rampart	oval	39-44	VIII
83	574/7-5-15	34/m	granular	Present	defined	complete	oval	30-35	VI
84	575/7-5-15	31/m	granular	present	defined	complete	Lower-clear; upper-intervention by bony nodules	30-35	VI
85	576/7-5-15	24/m	Progressive obliteration of ridges and furrows	Present	Dorsal plateau present	Vent. Beveling present	None	22-24	III

86	577/7-5-15	32/m	granular	Present	defined	Sporadic attempts at formation of vent. rampart	Both-clear	30-35	VI
87	583/8-5-15	19/f	Rugged, horizontal ridges separatedby grooves	None	none	none	none	18-19	I
88	585/8-5-15	28/m	granular	Present	defined	Vent. Beveling present	Lower-clear; upper-incomplete	27-30	V
89	602/12-5-15	25/m	Progressive obliteration of ridges and furrows	Present	Dorsal plateau present	Vent. Beveling present	Lower-clear; upper-incomplete	22-24	III
90	604/12-5-15	27/f	granular	Present	defined	Vent. Beveling present	Lower-clear; upper-incomplete	27-30	V

91	617/14-5-15	32/m	granular	Present	defined	Sporadic attempts at formation of vent. rampart	Both-clear	30-35	VI
92	618/15-5-15	20/m	Dorsally filled, Rugged, horizontal ridges separated by grooves	present	begins	none	none	20-21	II
93	638/18-5-15	21/m	Dorsally filled, Rugged, horizontal ridges separated by grooves	Present	begins	none	none	20-21	II

94	641/19-5-15	21/m	Dorsally filled, Rugged, horizontal ridges separated by grooves	Present	begins	none	None	20-21	II
95	650/22-5-15	24/f	granular	Present	Dorsal plateau present	Ventral rampart complete	Lower-clear; upper-forming	27-30	V
96	656/23-5-15	32/m	SMOOTH	Present	defined	ventral rampart COMPLETE	OVAL	35-39	VII
97	669/25-5-15	20/m	Progressive obliteration of ridges and furrows		begins	none	none	20-21	III
98	676/26-5-15	27/m	granular	Present	defined	Sporadic attempt at ventral rampart	Lowe-clear; upper – incomplete	27- 30	V

99	813/22-6-15	18/f	Rugged, horizontal grooves	None	none	none	None	18-19	I
100	830/24-6-15	29/m	granular	Present	Dorsal plateau present	Sporadic attempt at ventral rampart	Lowe-clear; upper – incomplete	27-30	V