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# Dermatoglyphic Patterns in Syndromes Frequently Associated with Mental Retardation

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# Dermatoglyphic Patterns in Syndromes Frequently Associated with Mental Retardation

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Dermatoglyphics is the study of the papillary ridges of the skin, i.e., the seratted-like skin found only on the flexor surfaces (bottom) of the hands and feet. Generally, papillary (epidermal) ridges begin to form during the third month of fetal development, and are well developed by the fourth month. Palmar creases develop somewhat earlier, i.e., during the second and third month. Once formed, the patterns of ridges and creases remain essentially unchanged throughout life. These patterns are individually unique, differing even between so-called identical twins. Dermatoglyphics does not concern itself with secondary skin markings, i.e., flexion creases and scars.

People have been aware of the ridges of their skin for thousands of years, as is attested by ancient stone carvings and cave paintings. The finger print was used as a mark added to or in lieu of an individual's signature as early as the eigth century, and in more recent times. Perhaps the earliest scientific descriptions are found in the works of Grew in 1684, Bidloo in 1685, and Malpighi in 1866. Purkinje in 1823 first made an attempt at classifying finger prints. Galton developed a method in 1892 which is the foundation of the current system of classification.

The first suggestion of the possible use of finger prints as a means of identification was advanced by Faulds in 1880. In the United States, the first set of finger prints for identification purposes was made by de Forest in 1902. Since that time, finger printing has become the most widely used system of personal identification in the world. However, identification is only one aspect of the field of dermatoglyphics. A relatively recent development has been the study of dermatoglyphic characteristics of individuals with congenital anomalies. The purpose of this paper is to explain the techniques of dermatoglyphics, and to review studies of dermatoglyphic findings in conditions frequently associated with mental retardation.

Dermatoglyphic Methodology

The classical method for recording ridge patterns has been to spread printer's ink thinly on a glass surface. The ridge pattern to be studied (finger, toe, palm, or sole) is then pressed against this glass, and subsequently onto paper, where it leaves a visible imprint. Recently, methods have been devised which eliminate the messy ink process. For instance, one newer method is to rub a chemical into the skin and then to place it on sensitized paper. Another method records the ridge patterns by photographing the skin placed on a glass prism. The method is really immaterial as long as good patterns are obtained, which is the case with all three methods mentioned.

Finger Patterns

The ridge patterns of the digits of the hand studied in dermatoglyphics are found on the underside of the distal (tip) end, beyond the terminal flexion crease, as shown in Figure 1. One of three basic pattern types, called whorls, loops, and arches, may be found. The average frequency of the pattern types, as established by the F. B. I., is whorls in 30 %, loops in 60 %, and arches in 10 % of the population. Each pattern type will be described below.

Whorls. The pattern in Figure 2 is a whorl. It is characterized by having two triradii or deltas, i.e., two triangular areas formed by ridges. The center of the patters is the core. There are three variations of the whorl known as composites. Each composite has at least two triradii, a few have three, and even fewer have four. Composites are classified according to the variations in their shape and are called central pocket loops, double loops, and accidentals. These composites are illustrated in Figures 3, 4, and 5.

Loops. A second type of basic pattern is the loop as shown in Figure 6. These loops occur in connection with a single triradius. The loop patterns are subdivided according to the direction in which they slant, i.e., a loop whose base originates on the ulnar (little finger) side of a finger is an ulnar loop, and one that comes from the radial (thumb) side is a radial loop. The triradius can always be found on the side opposite the base of the loop. If the illustration in Figure 6 were from the right hand it would be an ulnar loop, and if it were from the left hand, it would be a radial loop.

Arches. The third and last type of the basic patterns is the arch. There are two types of arches as shown in Figures 7 and 8. The plain arch has no triradius, but the tented arch (so called because its shape resembles a tent) has a triradius in the middle at the base of the pattern..

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Place Figures 1, 2, 3, 4, 5, 6, 7, and 8 about here

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The three pattern types described above have been studied in normal and clinical populations. Comparisons have been made as to total number of arches, loops, and whorls on all ten digits combined or on each digit separately. A study by Walker (1957) provides an example of how this may be done. She compared the finger prints of 150 mongoloids to those of a comparison group of 540 normals (table 1). Walker developed a ratio where the percentage in which a certain pattern type occurs in a study group is divided by the percentage in which this pattern is found in the general population. For example, from the data in Table 1, the ratio for whorls on all ten digits of the hand would be 11.9/33.4 which, after rounding, would become 0.36. If the ratio is less than 1, the pattern is more frequent in the study group than in the control group, and the opposite is true for a value greater than 1. Walker indices of mongoloids for each pattern on each digit computed from Walker's (1957) data are shown in Table 2. Sometimes, the logarithms of Walker indices are depicted graphically in histograms (bar-graphs).

Place Tables 1 and 2 about here

Pattern types can also be analyzed as to certain finer characteristics. This has been done by counting the number of dermal ridges between a triradius and the center of the pattern to which it belongs, as shown in the loop pattern in Figure 9. Since the simple arch has no triradius, it has, by this method, a ridge count of zero. Loops have a ridge count of approximatley 12 ridges. Because the whorl has two or more triradii, only the ridges of the one farthest away from the center of the pattern is counted, and there are usually around 19 of them. The total-ridge-count

(T.R.C.) is obtained by counting the number of ridges on each digit and summing across all ten digits. There is a normal sex difference, as males have an average T.R.C. of 145.0, and females of 127.2, according to Holt (1955). Studies have compared the normal population with groups having chromosomal anomalies, and have shown striking differences. These will be discussed in a later section.

Place Figure 9 about here

<u>Toe Patterns</u>

Dermatoglyphically, toes are studied in the same manner as fingers. The only difference is in the names of the direction of the loops. Tibial loops originate from the big toe side and correspond to radial loops; fibular loops originate on the little toe side and hence are equivalent to ulnar loops. The same patterns found on fingers are found on toes.

<u>Palm Patterns</u>

Another phase of dermatoglyphics is concerned with palm prints. In order to understand palmar dermatoglyphics, one must first become acquainted with palmar anatomy. As shown in Figure 10, the area at the base of the thumb and toward the wrist is the thenar eminence. Between the five digits, and near their bases, are the four interdigital pads. Although the skin creases themselves are not technically a part of dermatoglyphics, they are useful as land marks since they show general ridge direction. Those at the base of the five digits are called the metacarpo-phalangeal creases. Next comes the horizontal (distal transverse) crease nearest to the fingers, and below it is the proximal transverse crease. The crease around the thenar eminence is the radial longitudinal line. The series of creases at the wrist are called bracelet creases. It is interesting that the 4-fingered or simian line, prominent in Down's Syndrome, occurs when the distal transverse, proximal transverse, and radial longitudinal creases are joined together.

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Place Figures 10 and 11 about here.

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As shown in Figure 11, the palm always has five triradii on its surface, each being found at the base of the corresponding digits. The triradii of the four fingers are found very close to their respective bases, and are lettered a, b, c, and d, beginning with the radial (thumb) side and working to the ulnar (little finger) side. The fifth (axial) triradius, t, is normally found at some distance from the base of the thumb near the midline. Upon rare occassions there may be one or two additional axial triradii in the mid palm, or none at all. The major lines of the palm begin at these various triradii and are named for the triradius from which they originate. Therefore the A-line originates from the triradius a, and has a characteristic course, as shown in Figure 11. The different line courses can be compared as to direction and course among various groups of subjects.

There are six basic areas of the palm studied in dermatoglyphics, i.e., the four interdigital areas, the hypothenar area and the thenar area, as shown in Figure 12. They have patterns which are very similar to the patterns found on the finger tips, and are classified in a similar manner. Each area may have a true pattern (pattern with one or more triradii), i.e., a whorl, loop, or tented arch. There are also three other patterns which may be present: plain arches, open fields (which are merely straight lines or flattened arches), and vestiges (straight line ridges at right angles to other ridges). A miscellaneous category also exists which is used when two or more patterns are found in one of the basic palmar areas.

An important measurement in the palm is the atd angle which is formed by connecting three of the five triradii, i.e., a, t, and d. This angle, measured at t, has been found to vary between the average population and groups of people with chromosomal anomalies, as will be discussed later. Figure 13 illustrates the atd angle of the normal population, 46 degrees.

The position of the distal axial triradius, t, is also studied in comparative dermatoglyphics. It is assesed by measuring the distances between the wrist crease and triradius t, and between the wrist crease and the metacarpo-phalangeal crease found at the base of the third (middle finger) digit, as shown in Figure 14. The distance to t is expressed as a percentage of the total distance by dividing the distance from wrist to t by the distance from wrist to proximal third digit crease. Arbitrarily, this percentage is used to classify the position of the axial triradius, t. Walker (1957) outlined a percentage system curently used in medical studies. She proposed that percentages from 0 to 14.9 % be called t; from 15.0 % to 39.9 % t'; and those greater than 40 % t". The atd angle has also been used to assess this distance. Penrose (1954) classified atd angles less than 45 degrees as t, those between 45 and 56 degrees as t', and those greater than 56 degrees as t".

Another palmar measurement, the a-b ridge count, measures the number of dermal ridges between triradii a and b.

Place Figures 12, 13, and 14 about here

<u>Sole Patterns</u>

The anatomical features of the sole must also be described before the dermatoglyphic features can be understood. As shown in Figure 15, the heel area is the calcar region. The middle section of the sole is divided into four quadrants, by making a horizontal and a longitudinal division. The horizontal division permits a distal (toe) half and a proximal (heel) half to be defined. The longitudinal division results in a hypothenar eminence (little toe side) and a thenar eminence (big toe side). Therefore, the middle section of the sole has four parts: the distal hypothenar area, the proximal hypothenar area, the distal thenar area, and the proximal thenar area.

Place Figures 15 and 16 about here

The interdigital pads are found behind the toes and have triradii. As shown in Figure 16, there are six triradii on the sole, one behind each digit, and one between the distal thenar and hypothenar areas. These are lettered a, b, c, d, e, and p, respectively.

Although the patterns of any of the areas of the sole may be studied, usually only four areas are considered. These areas are the distal thenar and first interdigital pad area (collectively called the hallucal area) and the interdigital pads II, III, and IV. The same basic patterns may be present here as in the palm, i.e., whorls, loops, tented arches, plain arches, open fields, vestiges, and the miscellaneous class of multiple patterns. Sole patterns are studied and compared in the same manner as palmar patterns.

Dermatoglyphic Patterns Associated with Specific Anomalies

Having explained the major dermatoglyphic patterns that are usually studied, we will now review dermatoglyphic studies of syndromes frequently associated with mental retardation. It should be recalled, however, that only a limited number of dermatoglyphic areas and patterns have been studied in most of these conditions, and there still remains a vast amount of work to be done. Also, one should remember that the number of individuals with various disorders that have been studied is usually quite small, which may be one of the reasons why the findings sometimes differ from study to study.

Chromosomal Anomalies

The disorders most frequently studied in medical dermatoglyphics involve various autosomal or sex chromosomal anomalies.

Autosomal Trisomy 13-15. Dermatoglyphic pecularities of trisomy 13-15 have been found in the arches and radial loops in the finger, the distal axial triradius and atd angle in the palm, and the hallucal area of the sole. Penrose (1966) showed that people with trisomy 13-15 had rather striking finger print patterns. he found that 19.0 % of the 17 subjects he studied had arches, compared to 5.0 % of his control group of 1,000. He also found 16.4 % of the study group to have radial loops, compared to only 5.4% of the control series. As to palmar characteristics, Uchida et al. (1962) reported that 100 % of her 6 trisomy 13-15 subjects had a distal axial triradius exceeding 34 %, while this was found in only 9.5 % of the 685 controls. Penrose (1966) observed a "very distal axial triradius", and also found that the sums of the right and left maximal atd angles were 168 and 196 degrees respectively in 17 affected males and females, compared to 93 and 98 degrees in 1,000 controls. He also reported a radial displacement of the palmar triradius, a. On the sole, Uchida et al. (1962) reported a unique "S-shaped modification of a simple arch fibular" in the hallucal area of one or both soles of 4 of the 6 affected persons studied. Penrose (1966) confirmed the presence of this pattern, but found a thenar tibial loop to be even more characteristic, being present in 46.5 % of his experimental group compared to 9 % of the control series. This pattern was found to be associated with triradius f in the study group and with triradius e in the control group.

Autosomal Trisomy 17-18. Dermatoglyphic analysis of persons with trisomy 17-18 has shown that they have mostly arches on their fingers. Studies conducted by Uchida et al. (1962) found that at least one arch was present in 100 % of the 15 people studied, compared to 17.1 % in the 685 controls. This assumes even greater significance upon further analysis, as 93.3 % of the 15 subjects had arches on at least six digits and 46.6 % had them on all ten digits, In contrast, only 0.0131 % of 685s controls had arches on at least six digits, and only 0.0015 %of these on all ten. Penrose (1966) confirmed these findings with similar data. Interesting, Uchida et al. found 28.6 % of 35 relatives of persons with trisomy 17-18 to have at least one arch, compared with 17.1 % of 685 controls.

Autosomal Trisomy 21 and Down's Syndrome Generally. More dermatoglyphic studies have been done on Down's syndrome than on any other specific disorder. However, it should be recalled that early (pre-1958) studies of mongolism were carried out without benefit of chromosome (karyographic) analyses, which may account for some of the differences reported, as the 3 types of Down's syndrome (trisomy 21, translocation, and mosaic) have different dermatoglyphic characteristics.

Cummins (1936) first discovered that mongoloids had uniques dermatoglyphic characteristics, including fewer finger whorls; fewer transverse ridges in the palm; and more true patterns in the palmar, hypothenar, second, and third interdigital areas. He also observed that the thenar/first and fourth interdigital patterns showed fewer whorls. In 1939, he reported an axial triradius, t", in 72 % of the 60 mongoloids studied versus a reported "one in eight" in the normal population.

Walker (1957) conducted an extensive dermatoglyphic study of 150 undifferentiated mongoloid children. Her finger print data has already been shown in Tables 1 and 2. She found an axial triradius, t", in 85.8 % and 84.4 % of the respective left and right hands of the mongoloids, compared to 10.2 % and 13.3 % in a control series of 540. Another significant palmar finding was that in the third interdigital area there were true patterns (loops or whorls) in 54.0 % of left and 85.5 % of right palms, compared to 31.3 % and 55.5 % for the control group. She found an arch tibial on at least one sole in "nearly half" the mongoloid children, compared to about 0.5 % in nonmongoloids. This is compatible with Soltan and Clearwater's (1965) finding of a tibial arch in 56.0 % of 100 mongoloids. Walker (1957) also studied the number of dermal ridges found in the loop distal patterns of the hallucal area of the sole. She found a greater frequency of small loops of less than 21 ridges in mongoloids, i.e., 33.8 % and 31.2 % in the respective left and right hallucal areas, compared to 9.7 % and 11.7 % in the controls.

A very interesting study by Soltan and Clearwater (1965) compared the dermatoglyphic findings of translocation and trisomy types of mongolism. Significant differences were found in the hallucal area of the sole, where a large distal loop (greater than 20 ridges) was found in 31.3 % of the D/G translocations, 11.9 % of G/G translocations, and 8.0 % of the trisomies. Although there was a significant difference in terms of the large distal loop, they found that when a comparison was made in terms of mean ridge count, there was no significant difference. Table 3 compared the finger print patterns of the various autosomal disorders with a control group, as reported by Penrose (1966).

<u>Sex Chromosomal Anomalies--Turner's Syndrome</u>. The significant dermatoglyphic findings in Turner's syndrome are concerned with the fingers and palm. Ulnar loops were found by Forbes (1964) to have an increased frequency on the first two digits. In 29 subjects, this frequency was 69.50 % compared to 58.05 % in 5,000 controls. Holt and Lindsten (1964) reported a decreased frequency of finger arches in 49 cases of Turner's Syndrome, but this was not confirmed by Forbes (1964). Holt and Lindsten had also

found the total ridge count to be increased. Forbes (1964) found the atd angle to average 59 degrees in the 29 affected persons studied, compared to 43 degrees in the 5,000 controls. In an experimental group of 15, Uchida and Soltan (1963) found that 33% had bilateral distal axial triradii, and that 20 % had a single distal axial triradius, with a mean triradial distance of the entire series of 29.b % In the control group of 685, 5.0 % had the distal axial triradius bilaterally, and 4.0 % had this triradius unilaterally with a mean triradial distance of 19.6 % for the entire control group.

Sex Chromosome Anomalies--XXYY Variant of Klinefelter's Syndrome. The XXYY variant of Klinefelter's syndrome has ususual dermatoglyphic characteristics, as opposed to the classical XXY Klinefelter's Syndrome in which Uchida and Soltan (1963) found no unusual dermatoglyphic anomalies. The variant was studied in 7 affected persons by Uchida et al. in 1964, and in 5 persons by Alter et al. (1966). Arches were present on 15 % of the fingers of the total of 12 cases compared to 7 % and 8 % of the respective 100 male and 100 female controls. Also, 92 % of the 12 affected persons had hypothenar pattern peculiarities compared to 47.3 % of the 200 controls. In addition, a sixth palmar triradius ( ulnar) was found in 63 % of the 12 XXYY, compared with 33 % of the 200 in the control series. A fourth interdigital pattern was found in 70 % of the palms of Alter's group of 5 XYYY people, and in 47.5 % of the 200 controls. The mean total ridge count was found to be 94.5 in the combined group of 12 compared with 131.5 and 121.1 in the respective 100 male and 100 female controls. Alter et al suggest that dermatoglyphic examinations may be useful in screening persons with the XXYY variant of Klinefelter's Syndrome.

Sex Chromosome Anomalies--Total Ridge Count. A great deal of work has been done in comparing the total ridge counts (T.R.C.) of persons with various sex chromosome anomalies. Table 4 shows the T.R.C. of 11 relatively well-known sex chromosome anomalies as well as that of normal males and females as reported by Penrose (1967). Also included is a mathematical equation devised by Penrose to predict the T.R.C. The equation $E = 187 - 30X - 12Y$ (E is expected T.R.C., and X and Y stand for the number of X and Y chromosomes Present) comes very close to the observed results.

Penrose suggested that the number of finger ridges is affected by the state of hydration of the fetus, i.e., the hydration of the digital pads, in the eighth week of life, and that the number of X chromosomes is directly proportional to the amount of this dehydration, since as the degree of dehydration is increased, the total ridge count is decteased. He gave four possible explanations for this:

1. As the X-chromosome is nearly three times larger than the Y-chromosome, the state of fetal hydration could be affected by the chromosomal size of the larger X-chromosome, so that the increased number of X-chromosomes causes proportionately more dehydration.

2. The hydration could be related to X-chromosome inactivation in that an increased number of X-chromosomes diminishes the X-chromosome effect and causes a state of dehydration directly proportional to the number of X-chromosomes.

3. The amount of hydration may be due to a variation in shape and cellular fluid of the digits as controlled by the chromosomal genes.

4. The hydratory state may be influenced by autosomal genes *

located on several autosomal chromosomes, which could counter-balance the effect of the extra sex chromosomes resulting in a certain amount of hydration of the fetus.

Alter (1965) observed that an increased number of sex chromosomes appeared to be associated with an increased frequency of arches, and therefore a lower T.R.C.. It should be realized that the real cause is unknown, and that these explanations are only hypothetical to date.

Miscellaneous Anomalies

Dermatoglyphic studies have been conducted on a variety of groups with specific disorders. The significance of these studies is difficult to evaluate at present. The disorders studied include anencephalus, broad thumb great toe syndrome, cerebral palsy, congenital heart disease, de Lange Syndrome, epilepsy, Holt-Oramm Syndrome, neurofibromatosis, phenylketonuria, pseudohypoparathyroidism, psoriasis, Rubella Syndrome, schizophrenia, Thalidomide-poisioned children, undifferentiated mental retardation, Wilson's Disease, cleft lip and palate, Duchenne muscular dystrophy, ectodermal dysplasia, juvenile diabetes mellitus, Huntington's Chorea, and Parkinson's Disease. Each will be briefly discussed.

Anencephalus. 50 persons with anencephaly have been studied by Hilman (1953). The most striking differences were found in the finger print patterns with whorls in 29.4 %, ulnar loops in 66.6 %, radial loops in 1.8 % and arches in 2.2 %. This compares with the 540 controls of Walker (1957) which had whorls in 33.4 %, ulnar loops in 36.3 %, radial loops in 19.4 %, and arches in 10.9 %. These differences are statistically significant.

Broad Thumb-Great Toe Syndrome. Dermatoglyphic aspects of the recently described broad thumb-great toe (Rubinstein-Taybi) syndrome were studied by Giroux and Miller (1957). They foun that the thenar/first interdigital area had a true pattern (loop or whorl) in 88.8 % of the 18 subjects, compared to 11.3 % of the 1,000 people in the control group. Also, 63 % of persons with this syndrome had true patterns in the hypothenar area compared with 37 % of the controls. The atd angle was found to be 52.6 degrees for the left and 55.6 degrees for the right hand in the affected children, compared to 46.5 degrees and 45.7 degrees, respectively, in the control group.

Cerebral Palsy. Cerebral palsy is a rather broad category with multiple causes and multiple manifestations. Martin et al. (1960) studied the dermatoglyphic aspects of 148 cases of cerebral palsy. Similarities were found between the 37 cases with diplegic cerebral palsy and mongolism in the dermal patterns. The other 111 cases of cerebral palsy consisted of 26 with quadriplegia, 60 with hemiplegia, and 25 with the athetoid form. These 111 cases closely resembled the control. As Alter (1967) pointed out, this indicates that the diplegic form of cerebral palsy has occurred during the first three months of embryonic life when the dermal patterns are formed, and that the other forms of cerebral palsy occur somewhat later in life.

Congenital Heart Disease. Dermatoglyphic studies involving persons with congenital heart disease have revealed an increased incidence of a distal axial triradius. Hale et al. (1961) first reported a significantly greater frequency of a distal axial triradius in 157 pairs of palms of people with congenital heart disease as compared with 143 pairs of palms of persons with acquired heart disease. Takashina et al. (1966) substantiated this in a study of 44 patients with congenital heart disease compared to

362 patients with acquired heart disease. They found that 64.0 % of the persons with congenital heart disease had a distal axial triradius, compared to 17.0 % of the people with acquired heart disease. Sanchez Cascos (1964,1965) compared patterns of persons with different types of congenital heart disease, and found the total differences in the finger and palmar patterns to be statistically significant. The finger print findings varied with the specific heart defect. The palmar findings showed an increased atd angle of 51 degrees in the 150 subjects compared with 41 degrees in the 50 controls. As in cerebral palsy, this indicates that the defect was present in the first three months of embryonic life when the dermal patterns were formed.

De Lange Syndrome. Smith (1966) studied 21 persons with the de Lange Syndrome. Differences reported include an increased incidence of radial loops in the affected group, a decreased incidence of whorls, and a larger atd angle as compared to the 171 controls.

Epilepsy. A single study by Brown and Paskind (1940) has been done on persons with epilepsy. An attempt was made to distinguish epilepsy presumably of genetic origin from that caused by exogenous factors. No significant dermatoglyphic differences were found.

Holt-Oram Syndrome. A study of 13 individuals affected with the Holt-Oram Syndrome by Gall et al. (1966) disclosed an increased incidence of a distal axial triradius. The sample size is too small for meaningful statistical significance.

Neurofibromatosis. Blotevogel (1933) found that 61.5 % of 13 affected males, and 35.7 % of the 14 affected females had central pocket loops compared to 6.0 % of a control group of militia men and to 3.0 % of printis of individuals in the Hamburg Police files.

Phenylketonuria. The palmar dermatoglyphics of 70 individuals with phenylketonuria was studied by Hirsch, (1965). He found some differences which were not confirmed by Alter (1967) study of 100 cases.

Pseudohypoparathyroidism. In 19 persons with pseudohypoparathyroidism or pseudopseudohypoparathyroidism, Forbes (1964) found that 5.4 % of the study group had radial loops on the index fingers compared to 25.0 % in the control group. Fifty % of the affected individuals had an atd angle greater than 57 degrees, compared to 8.5 % in the controls.

Psoriasis. In dermatoglyphic studies of persons with psoriasis, Cummins and Midlo (1961) have shown an increased frequency of whorls on the fourth digit and an increased prevalance of interdigital patterns. However, these findings were not statistically significant.

Rubella Syndrome. Comparative dermatoglyphic studies in children whose mothers had Rubella during the first three months of pregnancy have been conducted by Achs et al. (1966) and Alter (1966). Despite small samples (19 and 28 respectively), both studies agreed in finding a greater prevalence of a distal axial triradius in the study group, as well as a greater frequency of the simian line. Achs also found an increased frequency of finger radial loops, which Alter did not. Alter found a greater frequency of finger print whorls, and a reduced a-b ridge count in the study group as compared with the 200 control subjects. These aspects were not studied by Achs.

Schizophrenia Dermatoglyphic studies by Beckman and Norring (1963) of 100 male and female persons with schizophrenia showed at male schizophrenics had a statistically significant increase in finger print whorls, compared with the 100 males in a control group. It is interesting that this difference was only found in the males.

Thalidomide-Poisioned Children. It has been reported by Alter (1967) that thalidomide does its fetal damage during the 37th to 54th day of fetal life as calculated from the date of the last menstrual period. Dermatoglyphic patterns of children whose mothers took thalidomide during this period have been studied by Davies and Smallpiece (1963) and Pfeiffer (1964). In three such infamts, Davies and Smallpiece reported complete or partial simian lines in all hands. Pfeiffer's study of 74 cases (as reported by Holt, 1965) showed a progressive reduction of radial loops on the digits of the hand, peculiar distortions of ridge arrangements directly proportional to the severity of limb involvement, and an absence of thenar patterns.

Undifferentiated Mental Retardation. In a mass study of 271 male and 241 female mentally retarded persons, Fang (1952) found a statistically significant decrease in the a-b ridge count of the study group when compared to the 926 controls. Hirsch and Geipel (1960) excluded persons with Down's syndrome from their study group of 238 mentally retarded people and compared these dermatoglyphic features with that of 600 normals. They found that their study group had a higher incidence of multiple axial triradii, a greater frequency of hypothenar, thenar/first inter-digital patterns, and a larger amount of transitional palmar

palmar creases. Both these studies infer that there were embryonic changes which occurred during the first three months of pregnancy in the mentally retarded group.

Wilson's Disease. A study comparing 20 persons with Wilson's disease to 200 normals (Hodges and Simmon, 1962) showed an ulnar loop on the right thumb in 35.0 % of the subjects, compared to

60.5 % of the controls. Among the subjects, 40 % had whorls on the right thumb compared to 28 % of the normals, and 25 % had radial loops of the right thumbs compared to 7 % of the controls. The results were significant.

Dermatoglyphic studies of individuals with the cleft lip and palate, Duchenne muscular dystrophy, ectodermal dysplasia, juvenile diabetes mellitus, and rheumatic fever by Uchida and Soltan (1963) disclosed no abnormalities. Huntington's chorea and Parkinson's disease were studied dermatoglyphically by Barbeau et al. (1965) and the finger print patterns revealed no significant differences. Single cases of patients with craniofacial dysplasia, arthromyogryposis multiplex, and the oral-facial-digital syndrome have been studied, but because of the sample size, comparative studies are invalid.

## Conclusion

Comparative dermatoglyphics has arisen within the past thirty years, with a concentrated effort in the past ten years. Because of the increased emphasis on dermatoglyphic studies, it is essential for the Bio-Medical oriented person to understand the basic principles of dermatoglyphics in order to comprehend the various studies.

A review of the major dermatoglyphic patterns has been presented. Also, the dermatoglyphic anomalies of various disorders to date has been reviewed. It must be remembered that in most instances, a limited number of dermatoglyphic areas and patterns in the specific disorder and that the complete dermatoglyphic studies of each disorder has not been done.

Dermatoglyphics are not diagnostic of a disorder. It should be remembered that a normal person could have dermatoglyphic patterns identical to those characteristic for one of the disorders described. However, dermatoglyphics are a diagnostic tool, i.e., a characteristic which must be weighed with other characteristics in order for a diagnosis to be made.

Because dermal patterns are formed by the third month of fetal life and do not change from that point in life, dermatoglyphics do indicate the time in life in which certain changes occurred. Perhaps this is why that so many genetic disorders show characteristic dermatoglyphic patterns as the genetic anomaly is present at the time of conception. If dermatoglyphic anomalies exist this could be of great importance to the physician in making a differential diagnosis, as he might rule out certain disorders which cause damage after the first three months of fetal life. They could also be important in helping the clinician understand more about the various disorders in helping him learn the time in life in which the disorder occurred.

It has been proposed that dermatoglyphics be used to screen a population. I believe that this is feasible, as dermal patterns are readily accessible, inexpensive to record, and comparatively easy to interpret. Perhaps by using dermatoglyphics as a mass screening tool, many heretofore undiagnosed disorders may be diagnosed and treated.

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Figure 1

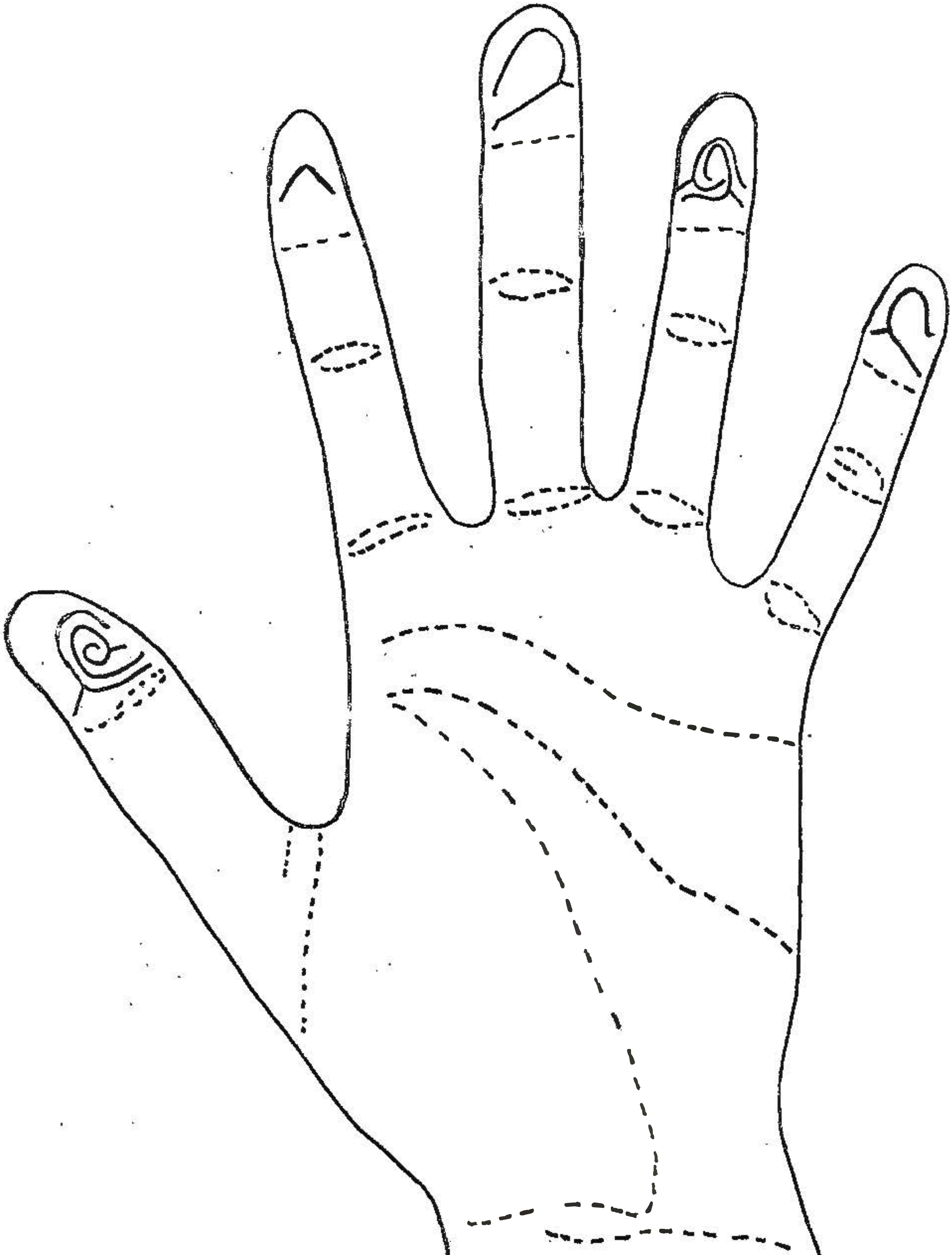


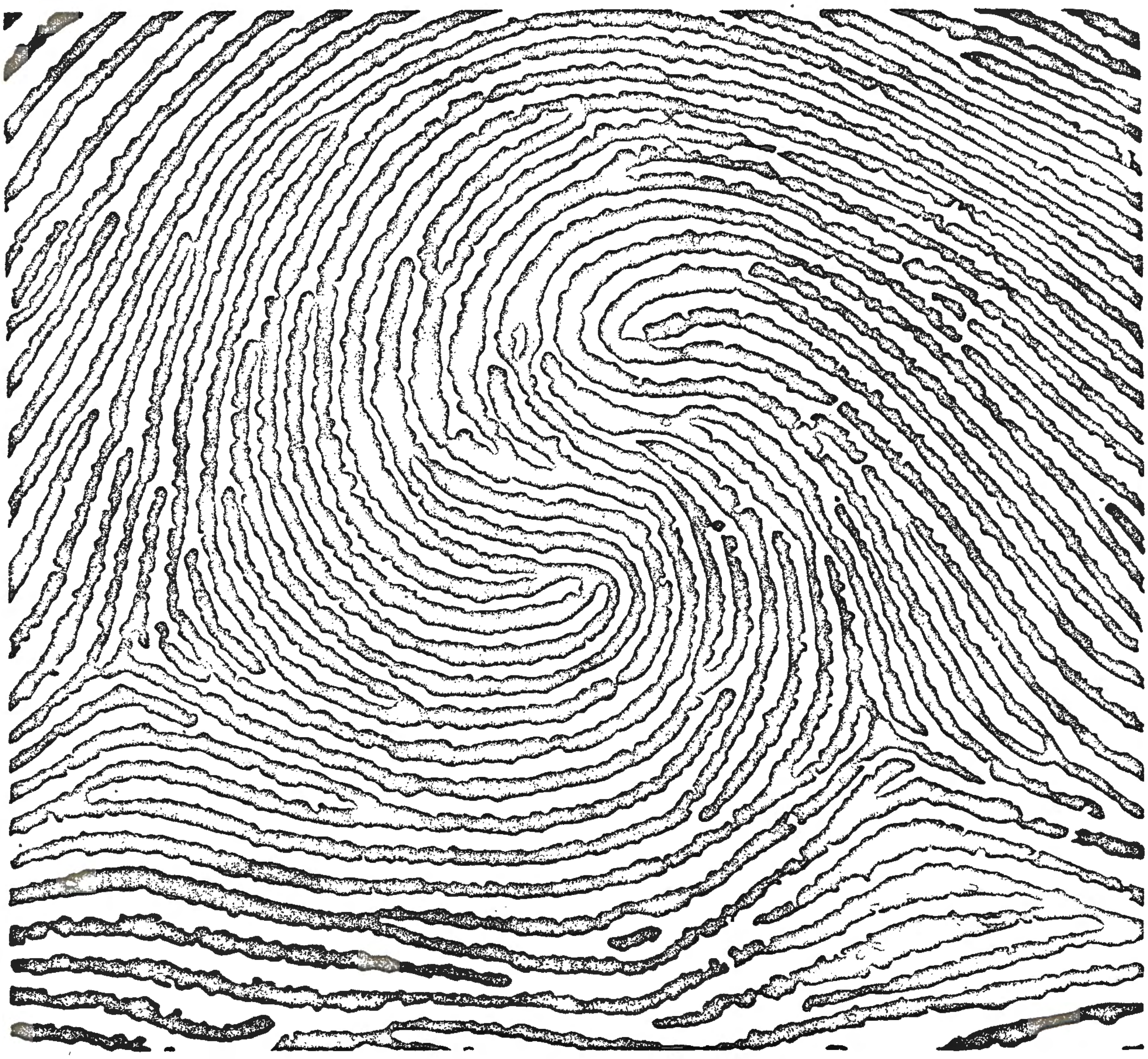
Figure 2

PLAIN WHORL

Figure 3

CENTRAL POCKET LOOP

Figure 4



DOUBLE LOOP

Figure 5

ACCIDENTAL

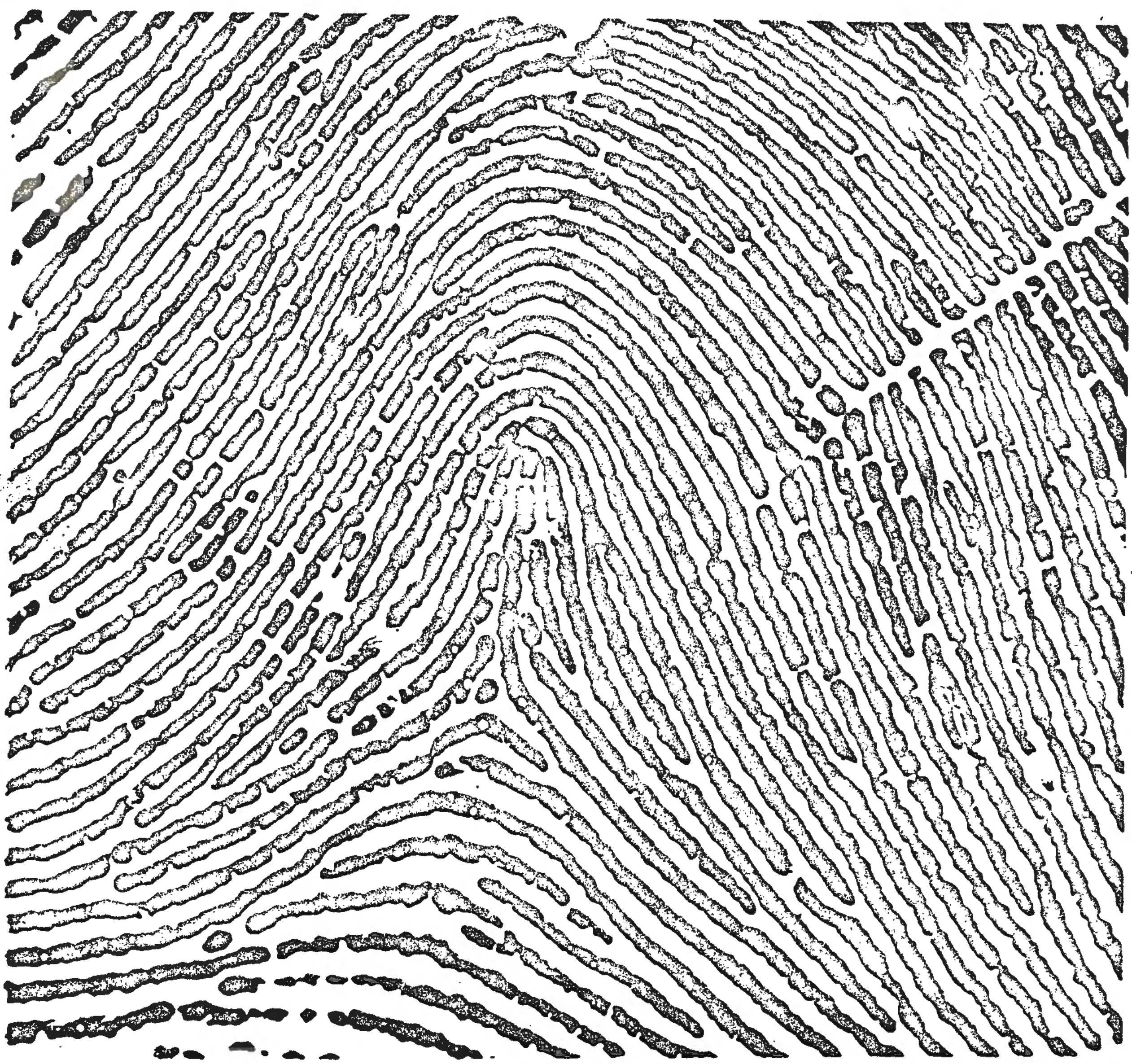
Figure 6

LOOP

Figure 7

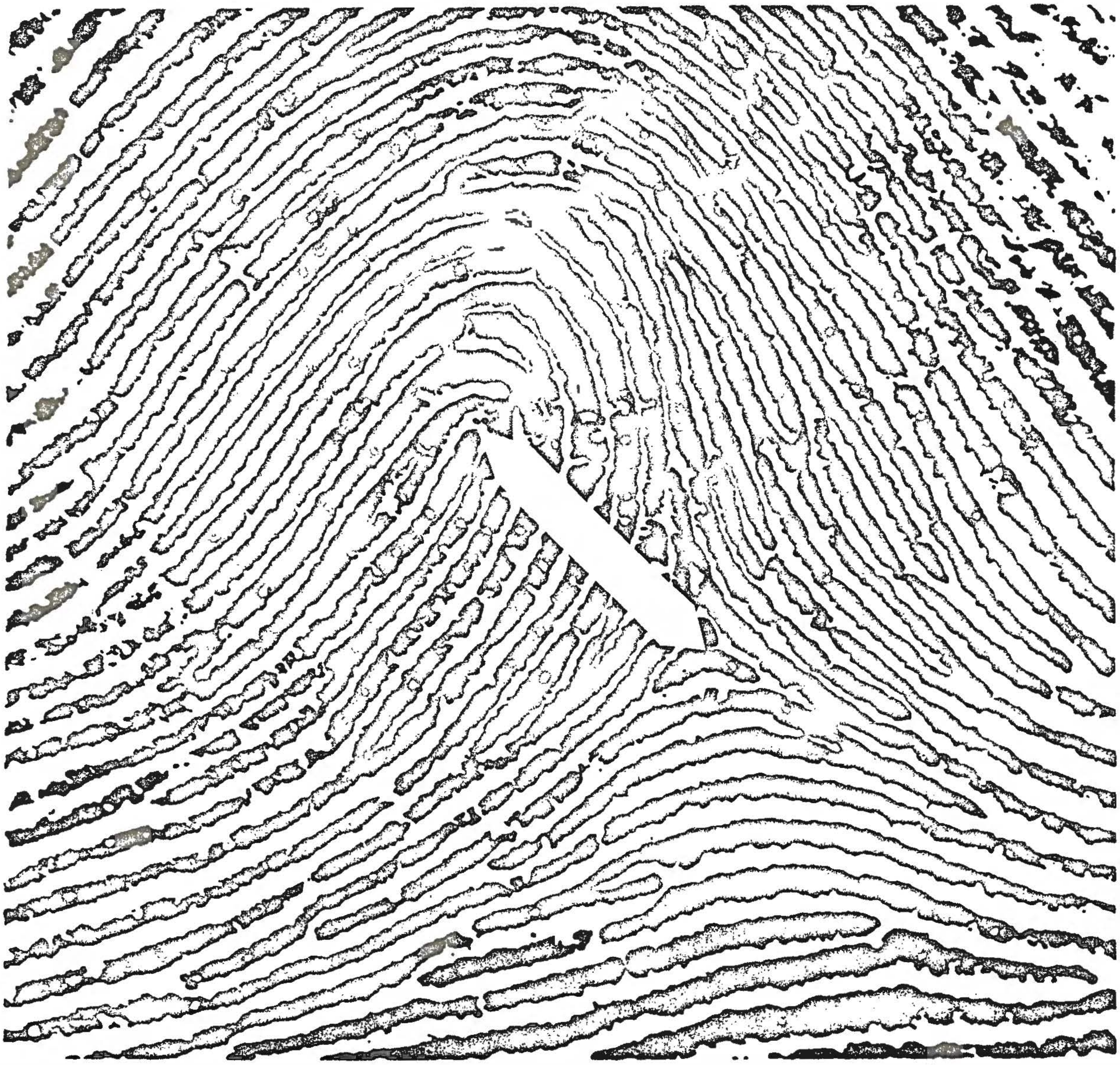
PLAIN ARCH

Figure 8



TENTED ARCH

Figure 9



LOOP

Table 1

Comparison of Frequency of Finger Print Patterns in Mongoloids and Normals, According to Walker (1957)

| Pattern Type | Mongoloid | Control |
|---|---|---|
| Whorl | 11.9 % | 33.4 % |
| Ulnar loop | 82.4 % | 36.3 % |
| Radial loop | 2.3 % | 19.4 % |
| Arch | 3.4 % | 10.9 % |

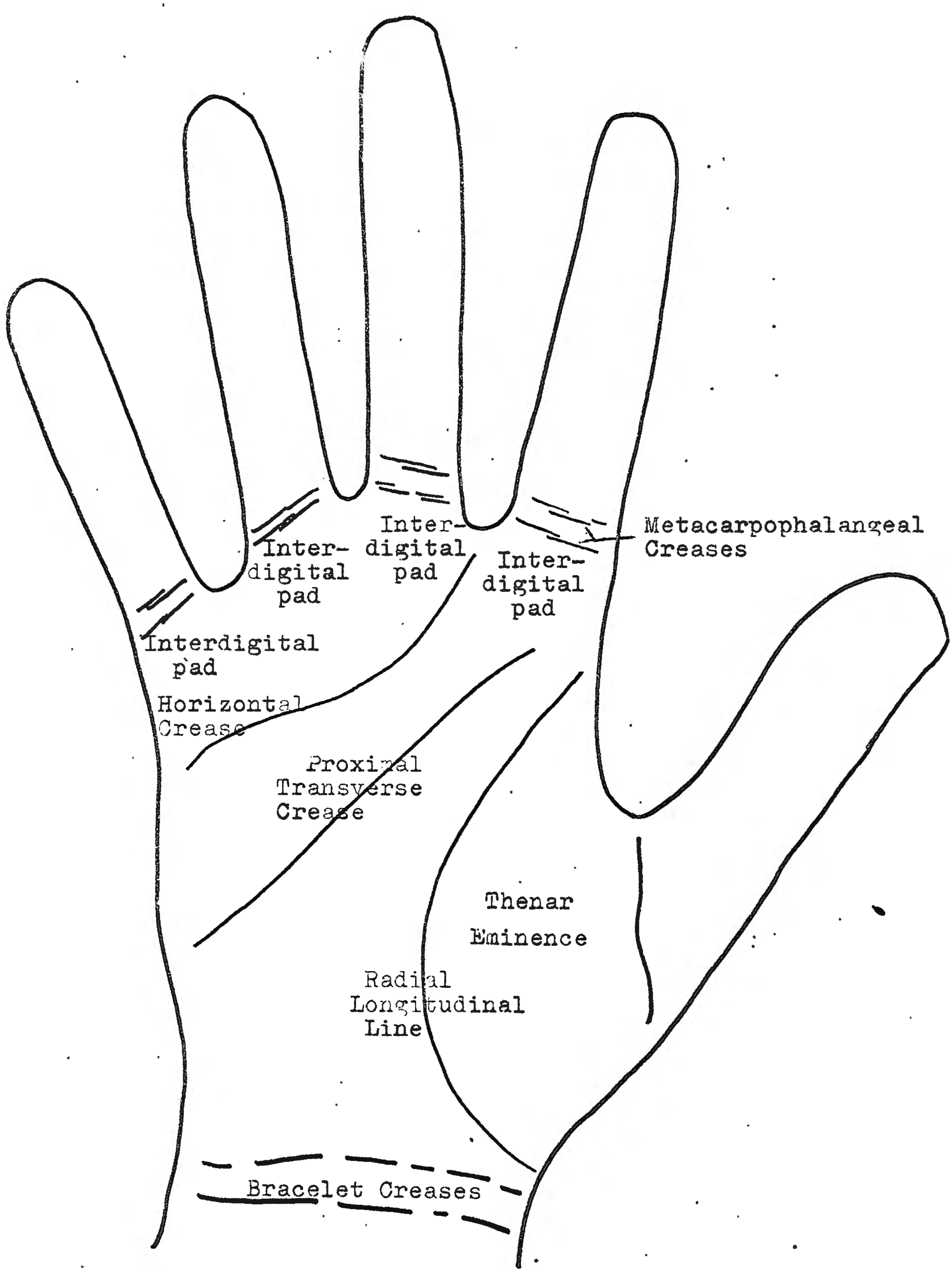
Table 2

Walker Indices of a Sample of 150 Mongoloids,

According to Walker (1957)

| Patterns | Left Digits | | | | | Right Digits | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Little | Ring | Middle | Index | Thumb | Thumb | Index | Middle | Ring | Little |
| Whorl | 1.53 | 0.89 | 0.78 | 0.36 | 0.73 | 0.67 | 0.42 | 0.58 | 0.68 | 1.29 |
| Ulnar loop | 0.90 | 0.97 | 1.17 | 2.27 | 1.16 | 1.23 | 2.65 | 1.22 | 1.16 | 0.90 |
| Radial loop | 29.00 | 5.67 | 0.65 | 0.12 | 0.75 | 0.13 | 0.08 | 0.32 | 19.00 | 15.33 |
| Arch | 0.65 | 1.70 | 0.13 | 0.31 | 0.69 | 1.06 | 9.09 | 0.17 | 2.09 | 1.10 |

Figure 10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digital
pad
Inter-
digital
pad
Inter-
digital
pad
Metacarpophalangeal
Creases
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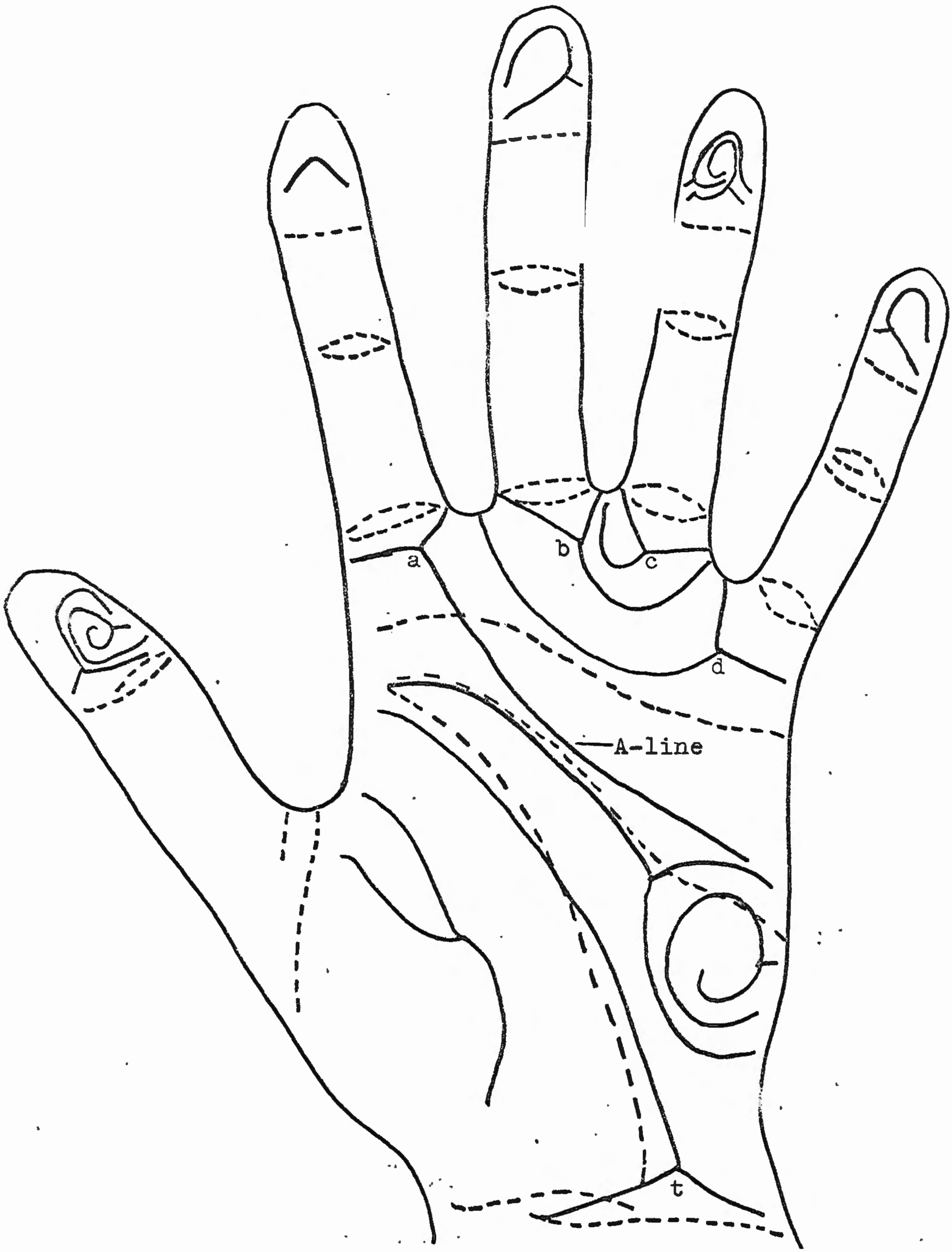
Crease
Proximal
Transverse
Crease
Thenar
Eminence
Radial
Longitudinal
Line
Bracelet Creases

Figure 11



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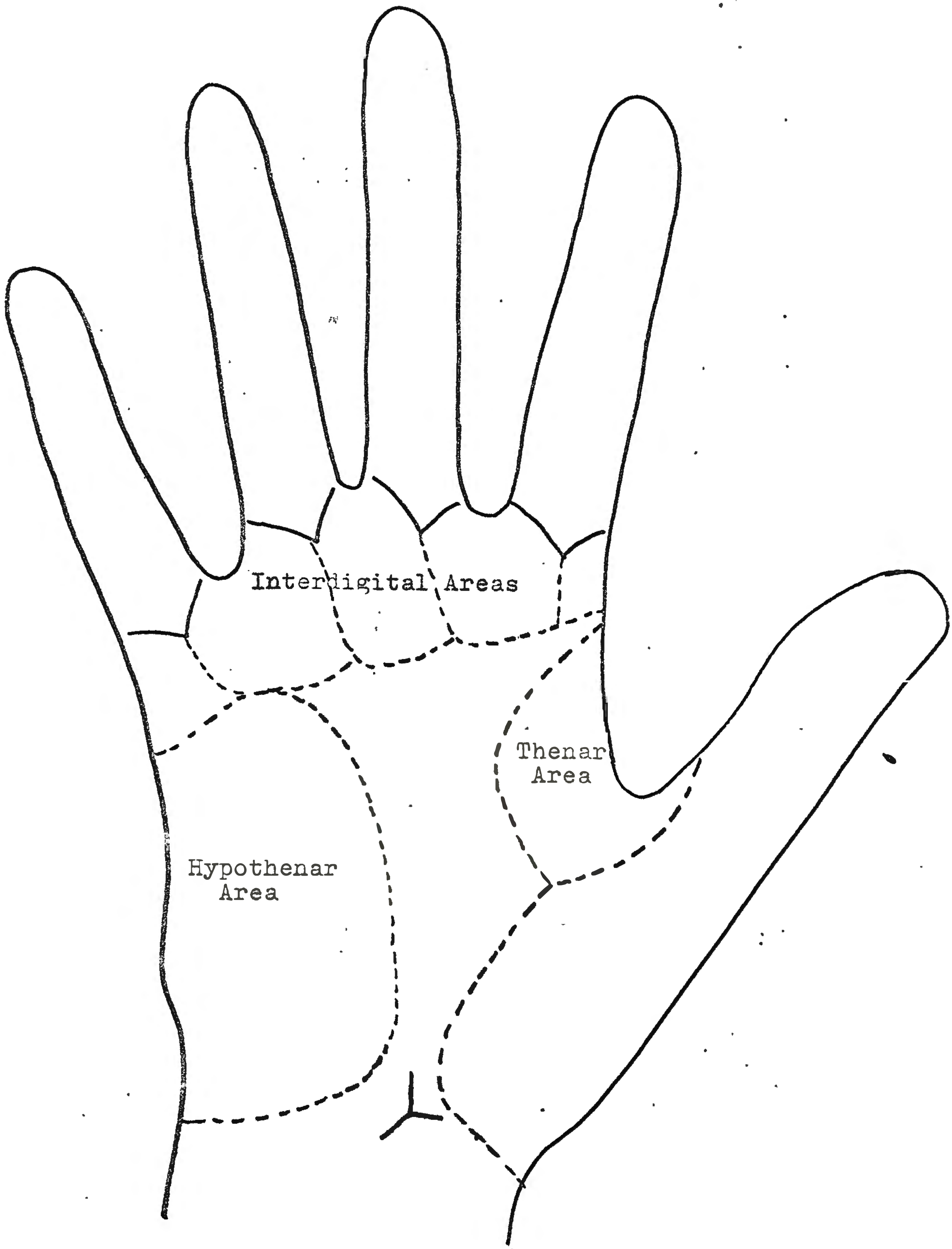

Figure 13

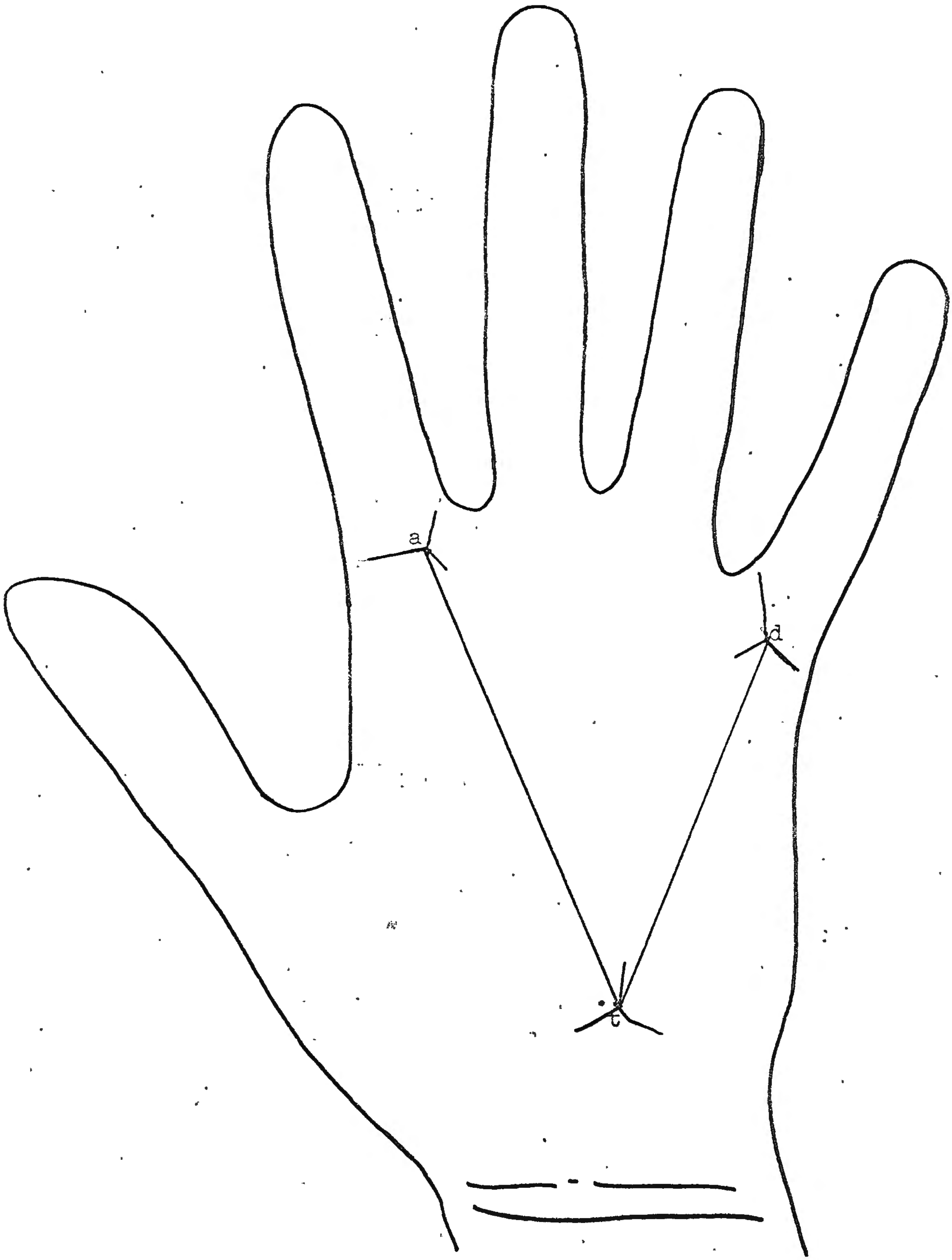

Figure 14

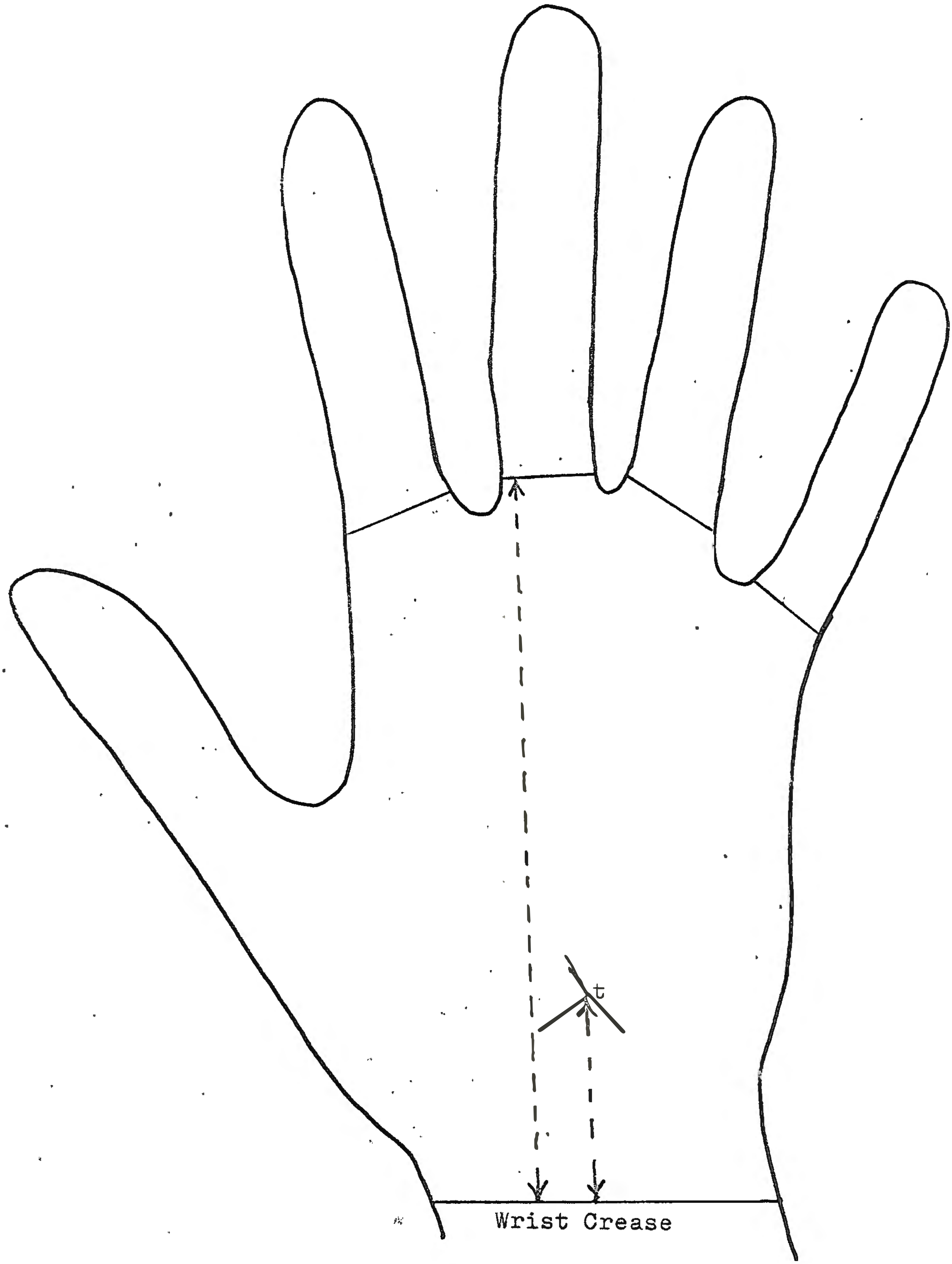

Figure 15

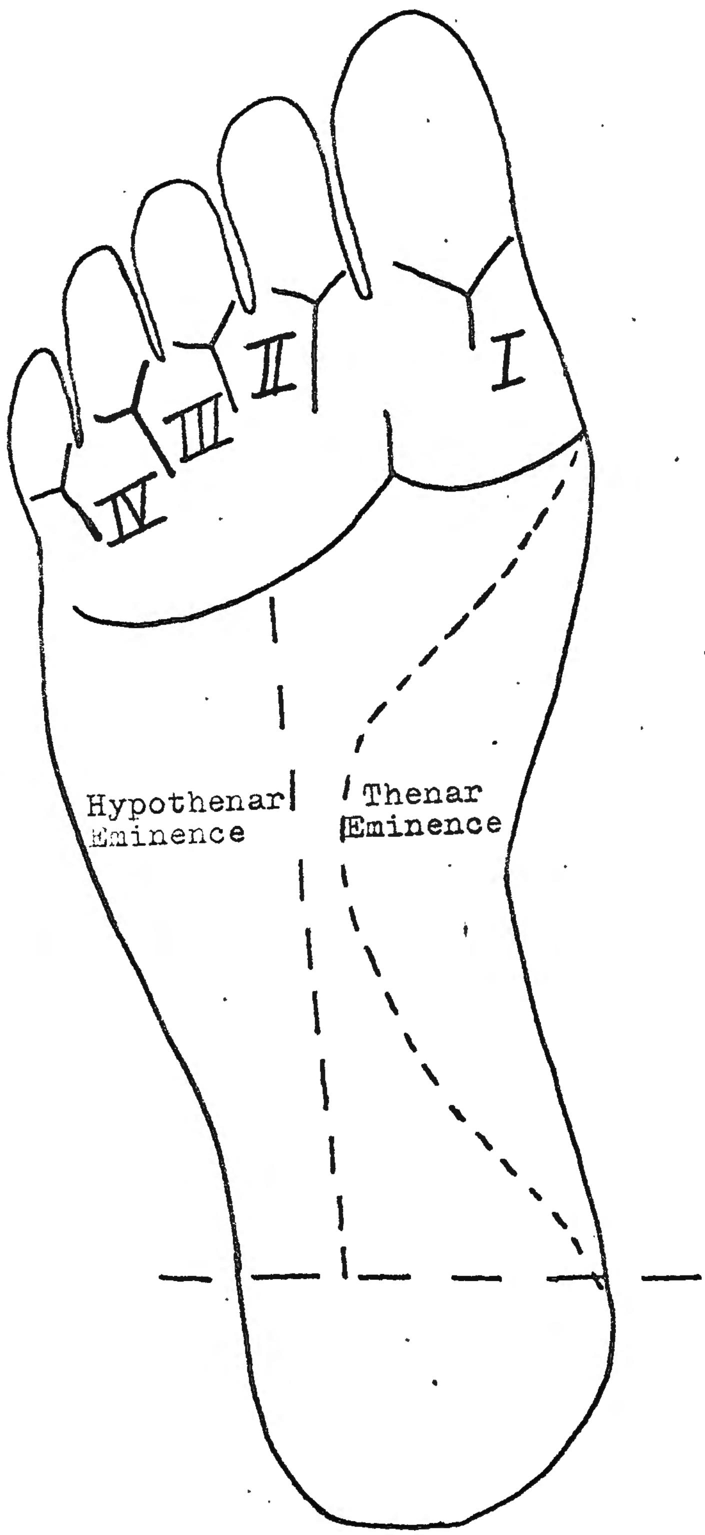

Figure 16

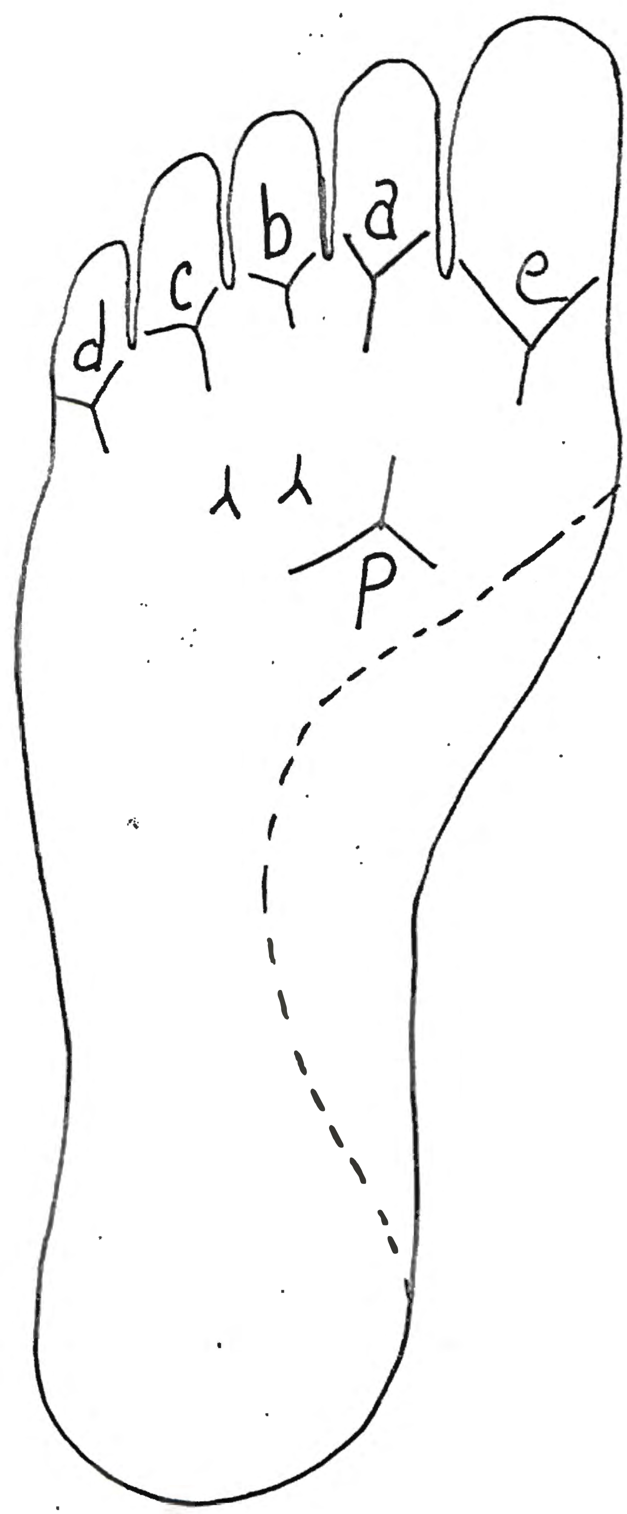

Table 3

Comparison of Basic Finger Print Patterns in Three Types of Autosomal Anomalies and a Normal Control Group, According to Penrose (1966)

| Patterns | Trisomy 13-15 | Trisomy 17-18 | Trisomy 21-22 | Control |
|---|---|---|---|---|
| Whorl | 19.8 % | 0.8 % | 12.7 % | 26.1 % |
| Ulnar loop | 44.8 % | 13.6 % | 82.8 % | 63.5 % |
| Radial loop | 16.4 % | 4.4 % | 1.8 % | 5.4 % |
| Arch | 19.0 % | 81.2 % | 2.7 % | 5.0 % |

Table 4

Sex-Chromosome Pattern and Mean Total Ridge Count,

According to Penrose (1967)

| Chromosome Pattern | Mean T.R.C. | Standard Deviation | Sample Size | Predicted T.R.C. |
|---|---|---|---|---|
| X | 178.6 | 44.0 | 40 | 157 |
| XY | 145.0 | 50.1 | 825 | 145 |
| XYY | 133.6 | 46.2 | 14 | 133 |
| XX | 127.2 | 52.5 | 825 | 127 |
| XXY | 114.8 | 49.6 | 25 | 115 |
| XXYY | 106.1 | 51.6 | 7 | 103 |
| XXX | 109.8 | 54.7 | 23 | 97 |
| XXXY | 93.0 | 49.2 | 9 | 85 |
| XXXYY | 73.0 | N.A. | 1 | 73 |
| XXXX | 110.0 | 66.7 | 2 | 67 |
| XXXXY | 49.9 | 51.1 | 9 | 55 |