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RESEARCH ARTICLE

A DERMATOGLYPHIC STUDY ON SICKLE CELL ANEMIA PATIENTS OF NORTH COASTAL ANDHRA PRADESH, SOUTH INDIA

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ABSTRACT

Background

Sickle cell disease (SCD) or sickle cell anemia (SCA) is an autosomal recessive genetic blood disorder, characterized by red blood cells that assume an abnormal, rigid, sickle shape. Dermatoglyphics, the patterns of ridges on the skin of the fingertips, palms, and soles are mostly related with inheritance. These patterns may represent the genetic make up of an individual and therefore their predisposition to certain diseases. Thus the purpose of this research is to find out the characteristic dermatoglyphic patterns in sickle cell anemia which could be useful in early diagnosis of the disease.

Methods

The study was conducted on 59 (34 male and 25 female) sickle cell subjects and was compared with the data from 60 (30 male and 30 female) healthy controls. Qualitative parameters observed were percentage frequency of finger print patterns (loops, whorls and arches), patterns of interdigital area and flexion creases. Statistical analysis was done using chi square test and estimation of Odds ratio (OR) was done to quantify the magnitude of association.

Results

In sickle cell group, the ulnar loops and whorls were more frequent whereas the arches were less frequent. No radial loop pattern was observed in female sickle cell patients. Results indicated that A-B, B-C and C-D ridge count in male and female patients has decreased comparatively to control group, but the reduction is not significant. The total finger ridge count (TFRC) was significantly increased in male patients and was decreased in female patients when compared with controls respectively. Regarding the unusual palmar flexion creases, there was significant increase in the Sydney and simian creases in both males and females of sickle cell.

Interpretation & conclusions

To conclude with, the results of the present study, most of them were in agreement with the literature in the field. With the available data, although other parameters were not statistically significant, the current work emphasizes that high frequency of TFRC in males and high frequency of Sydney creases in females were seen as reliable indicators helpful in scientific screening of sickle cell patients.

INTRODUCTION

Dermatoglyphics or the study of "skin carvings" is a term coined by Cummins and Midlo in 1926 that aptly reflects the physical manifestations of the palmar and plantar surfaces of all primates. These configurations of ridge systems have been the subject of numerous scientific investigations in Biological anthropology, Genetics and more recently in medicine. The dermatoglyphic patterns make their appearance on volar aspect of palm as early as 12th to 13th week of gestation. Development of ridges was found to be affected by both genetic and environmental factors. Dermatoglyphics is accepted as a simple and inexpensive method for predicting the phenotype of a possible future illness. However due to inherent variability of ridge pattern it is possible to arrive at

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any conclusion only in certain group of patients. Dermatoglyphic pattern has positive correlation in a number of genetic diseases. Genetic linkage and determination of dermatoglyphics is apparent (Panchekina *et al.,* 2000), and it has in fact been described one of the best available diagnostic tool in genetic disorders (Bosco *et al.,* 2001). The importance of dermatoglyphic studies in clinical medicine is that, during development, ridge formation is affected by maternal environment, gene deviants, and chromosomal aberrations. Once formed, they are age and environment stable, becoming a reliable indicator of genetic damage. Some genetically inherited diseases showing association with dermatoglyphics include mental retardation (Stevenson *et al.,* 1997: Than *et al.,* 1998), leukemia (Verbov, 1970), rubella embryopathy (Achs, Harper and Siegal, 1966), Ankylosing spondylitis (Cvjeticanin *et al.,* 2000), Essential hypertension (Pursnani *et al.,* 1989) Systemic lupus erythromatosus (Schur, 1990), Congenital heart disease (Ahuja *et al.,* 1982) and Rheumatic fever (Sanyal *et al.,* 1978), Diabetes mellitus (Rajanigandha *et al.,* 2006), Thalassemias , Downs syndrome (Boroffice, 1978) and Cancers such as Breast (Sridevi *et al.,* 2010), Cervical (Vaishali *et al.,* 2006) and Prostate (Oladipo *et al.,* 2009). Nervous system disorders of functional ethiopathogenesis have also been positively correlated with dermatoglyphics; these include Schizophrenia and Schizotypal personality (Weinstein *et al.,* 1999; Van-os *et al.,* 2000).

Genetically inherited abnormal hemoglobin - Sickle cell anemia (SCA), which is inherited as an autosomal recessive fashion, was the first genetic disease to be characterized at the molecular level. Sickling of red blood cells in patients with sickle cell anemia is caused by the polymerization of molecules of deoxygenated hemoglobin S ($\alpha_2\beta_2^S$) into rigid, rod-like polymers. Fetal hemoglobin ($\alpha_2\gamma_2$), which lacks β-globin chains, inhibits sickling in vitro by interfering with the polymerization of hemoglobin S. This condition mainly occurs due to a single amino acid substitution (HB S) in which 6th position of glutamic acid in β chain is replaced by valine. The gene for β globin is located on chromosome 11 (11p15.5). Individuals with two normal hemoglobin alleles (AA) will have normal red blood cells. Heterozygous (AS) individuals have the sickle cell trait and homozygous (SS) individuals suffer from sickle cell disease (SCD). The disease usually occurs in periodic painful attacks, eventually leading to damage of some internal organs, stroke, or anemia, and usually resulting in decreased lifespan. It is common in countries with a high incidence of malaria. Once formed these patterns do not change throughout life and hence are used for personal identification (Schaumann and Alter, 1976). Hence, the present investigation has been undertaken to find out the role of finger prints, palm prints and palm creases in the diagnosis of disease and the correlation between the quantitative dermatoglyphics and sickle cell anemia.

MATERIALS AND METHODS

Finger and palm prints from a total of fifty nine (25 females and 34 males) sickle cell anemia patients from local Government King George Hospital, were referred to the department of Human Genetics, Andhra University for confirmation of their abnormal hemoglobin patterns using cellulose acetate membrane electrophoresis. Age and sex matched sixty samples (30 males and 30 females) were taken as controls.

Finger prints were obtained by the ink and paper method and were analyzed according to Cummins and Midlo (1961) and Holt (1961). Hands were thoroughly washed with water and soap and dried before taking prints. This was done to remove dirt from the hands. Screening was done on the white duplicating paper containing the prints and viewed with the aid of a magnifying glass. No distinction was made between the varieties of whorl (W) patterns; also tented arch was just recorded as an arch (A). Loop was recorded as either ulnar loop (UL) or radial loop (RL). All the patterns are as defined by Penrose (1963). A straight line was drawn to join A and B triradii, B and C triradii and C and D triradii, and the number of intersecting ridges counted. These give A-B, B-C and C-D ridge counts respectively. ATD triradii were also joined as shown in Fig. 1 to determine the ATD angles. The various digits were designated as follow: Thumb I; Index finger-II; Middle finger-III; Ring finger-IV; Little finger-V. L and R stand for left and right respectively. Comparisons were made in all the parameters between right and left hands, males and females and between patients and controls. The data of the study subjected to statistical analysis is expressed as mean ± SD. Statistical analysis was done using chi-square test to find the probability values. Estimation of Odds ratio (OR) was done to quantify the magnitude of association. The p-value < 0.05 was considered as statistically significant.

RESULTS

The percentages of the digital patterns in both sickle cell and the normal groups are summarized in Table 1. Ulnar loop has the highest percentage in both males and females of the sickle-cell and normal groups, the average percentage being 49.68% in Sickle cell group and 53.83 % in the control group. This is followed by whorl, arch and radial loop. The order of increase is same in females of the two groups and normal males. Whereas in sickle cell males the order of increase is whorl > ulnar loop > arch > radial loop. Although little differences in values occur, it is not statistically significant. Table 2 shows the percentages of digital patterns in male sickle-cell and control groups. No radial loop pattern was found in the first and second digits of the right hand in sickle-cell group. None of the groups had radial loop in the second digit of right and first digit of left hands. It can also be observed in this table that whorl has the highest percentage (51.16% and 64.71%) in the first digit of both hands in male sickle cell group. Ulnar loop follows: The order in sickle cell groups is as follows: whorl > Ulnar loop > arch > radial loop. This order is the same in the remaining digits of the right and left hands except in RIII, RV and LV, where the order is ulnar loop > whorl > arch > radial loop. The order of increase in normals is ulnar loop > whorl > arch > radial loop, except in RIV and LIV. The percentages of digital patterns in female Sickle-cell group and female normals were shown in Table 3. No radial loop pattern was found in females of sickle-cell group. None of the groups had radial loop in the first, third and fourth digits of both hands. It can also be observed in this table that ulnar loop has the highest percentage (84%) in the third digit of right hand in female sickle cell group. whorl follows: The order in both sickle cell and normal groups is as follows: Ulnar loop > whorl > arch > radial loop. This order is the same in the remaining digits of the right and left hands except in LI and LIV of sickle cell and RIV and LIV of normals, where the order is whorl > ulnar loop > arch > radial loop. Table 4 shows the percentage frequencies of the total population (sickle cell

Table 1: Distribution of digital patterns in sickle cell and controls

Patterns	Sickle Cell (%)			Normals (%)		
	Males	Females	Average	Males	Females	Average
Arch	5.89	16.8	11.34	7.33	11.67	9.60
Whorl	49.41	25.6	37.50	37.33	31.00	34.16
Ulnar Loop	41.76	57.6	49.68	52.34	55.33	53.83
Radial Loop	2.94	0.00	1.48	3.00	2.00	2.50

Table 2: Distribution of digital patterns for each digit of both hands in males of sickle cell and controls

	Right Hand (%)									
	R I		R II		R III		R IV		R V	
Pattern	SS	N	SS	N	SS	N	SS	N	SS	N
Arch	2.95	3.33	11.77	26.77	-	6.67	5.88	3.33	8.82	6.67
Whorl	58.82	43.34	47.05	30.00	32.35	23.33	70.59	53.34	35.29	30.00
Ulnar Loop	38.23		41.18	43.33	61.77	66.67	20.59	43.33	52.95	63.33
Radial Loop	-	3.33	-	-	5.88	3.33	2.94	-	2.94	-
	Left Hand (%)									
	L I		L II		L III		L IV		L V	
Pattern	SS	N	SS	N	SS	N	SS	N	SS	N
Arch	-	3.33	8.82	13.33	5.88	6.66	5.88	3.34	8.82	-
Whorl	64.71	36.67	44.11	36.67	47.06	26.66	61.76	60.00	32.35	33.34
Ulnar Loop	35.29	60.00	41.18	36.67	44.12	63.34	29.41	30.00	52.95	66.66
Radial Loop	-	-	5.89	13.33	2.94	3.34	2.95	6.66	5.88	-

Table 3: Distribution of digital patterns for each digit of both hands in females of sickle cell and normals

	Right Hand (%)									
	R I		R II		R III		R IV		R V	
Pattern	SS	N	SS	N	SS	N	SS	N	SS	N
Arch	-	13.34	24.00	20.00	12.00	13.33	12.00	3.33	16.00	6.67
Whorl	44.00	43.33	20.00	33.33	4.00	13.33	40.00	53.34	12.00	13.33
Ulnar Loop	56.00	43.33	56.00	43.34	84.00	73.34	48.00	43.33	72.00	76.67
Radial Loop	-	-	-	13.33	-	-	-	-	-	3.33
	Left Hand (%)									
	L I		L II		L III		L IV		L V	
Pattern	SS	N	SS	N	SS	N	SS	N	SS	N
Arch	12.00	6.66	28.00	23.33	20.00	10.00	20.00	16.67	24.00	10.00
Whorl	56.00	40.00	16.00	30.00	8.00	16.67	48.00	50.00	8.00	16.67
Ulnar Loop	32.00	53.34	56.00	40.00	72.00	73.33	32.00	33.33	68.00	66.67
Radial Loop	-	-	-	6.67	-	-	-	-	-	6.66

Table 4: Distribution of digital patterns for each digit of both hands in sickle cell and normal groups (both males and females)

	Right Hand (%)									
	R I		R II		R III		R IV		R V	
Pattern	SS	N	SS	N	SS	N	SS	N	SS	N
Arch	1.47	8.33	17.88	23.38	6.00	10.00	8.94	3.33	12.41	6.67
Whorl	51.41	43.33	33.52	31.66	18.17	18.33	55.29	53.34	23.64	21.66
Ulnar Loop	47.11	46.66	48.59	43.33	72.88	70.00	34.29	43.33	62.47	70.00
Radial Loop	-	1.66	-	6.66	2.94	1.65	1.47	-	1.47	-
	Left Hand (%)									
	L I		L II		L III		L IV		L V	
Pattern	SS	N	SS	N	SS	N	SS	N	SS	N
Arch	6.00	4.99	18.41	18.33	12.94	8.33	12.94	10.00	16.41	5.00
Whorl	60.36	38.33	30.06	33.33	27.53	21.67	54.88	55.00	20.17	25.00
Ulnar Loop	33.64	56.68	48.59	38.34	58.06	68.33	30.70	31.67	60.47	66.66
Radial Loop	-	-	2.94	10.00	1.47	1.67	1.48	3.33	2.94	3.33

Table 5: Means and standard errors of palmar atd and dat angles in males and females of sickle cell and normals

	Palmar atd angles				Palmar dat angles			
	Right (Mean ± S.E)		Left (Mean ± S.E)		Right (Mean ± S.E)		Left (Mean ± S.E)	
Sex	SS	N	SS	N	SS	N	SS	N
Males	43.03±0.92	40.20±0.85	43.56±1.02	39.70±1.10	56.79±0.93	60.07±0.71	56.70±0.78	59.43±0.91
Females	43.32±0.87	43.43±1.21	45.36±1.40	43.00±0.82	56.24±0.89	54.47±1.18	55.08±0.96	54.73±1.14

$P < 0.05$

Table 6: Means and standard errors of palmar atd and dat angles in sickle cell and normal group

Study Group	atd angles			dat angles		
	Right	Left	Total	Right	Left	Total
	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E
Sickle cell	43.15 ± 0.64	44.32 ± 0.84	43.74 ± 0.53	56.56 ± 0.65	56.02 ± 0.61	56.29 ± 0.44
Normal	41.82 ± 0.76	41.35 ± 0.71	41.58 ± 0.52	57.27 ± 0.77	57.08 ± 0.79	57.17 ± 0.55

$P < 0.05$

Table 7: Mean and standard errors of palmar inter-digital ridge count in sickle cell and normal group

Study Group	A-B		Total	B-C		Total	C-D		Total
	Right	Left		Right	Left		Right	Left	
Sickle Cell	34.39±0.75	35.07± 0.88	34.73 ± 0.57	22.64±0.96	22.27±1.12	22.46 ± 0.74	30.90±1.35	28.71±1.49	29.80 ± 1.00
Normal	36.05±1.19	36.63±1.15	36.34 ± 0.83	23.72±1.23	22.37±1.30	23.04 ± 0.90	30.57±1.44	30.13±1.57	30.35 ± 1.06

$P < 0.05$

Table 8: Statistical constants for quantitative finger dermatoglyphic characters among sickle cell and normal groups

Study Group	Sex	URC Mean ± S.E.	RRC Mean ± S.E.	TFRC Mean ± S.E.	AFRC Mean ± S.E.
Sickle cell	Males	36.66 ± 3.15	60.79 ± 2.49	67.48 ± 2.60	98.59 ± 4.56
	Females	14.84 ± 2.51	51.94 ± 3.54	52.60 ± 3.58	66.64 ± 5.28
	Total	27.41 ± 1.06	57.04 ± 2.11	61.18 ± 2.23	85.05 ± 2.23
Normal	Males	25.93 ± 3.64	59.17 ± 3.11	65.73 ± 3.08	85.83 ± 5.50
	Females	23.18 ± 3.44	58.72 ± 3.37	64.03 ± 3.22	82.58 ± 5.66
	Total	24.56 ± 2.50	58.94 ± 2.28	64.88 ± 2.23	84.21 ± 3.93

URC - Ulnar Ridge Count; **RRC** – Radial Ridge Count; **TFRC** – Total Finger Ridge Count; **AFRC** – Absolute Finger Ridge Count

Table 9: Frequency distribution (%) of the palm creases in sickle cell anemia and control groups

Study Group	Sex	Normal crease	Simian crease	Sydney crease
Sickle cell	Males	76.47	8.82	14.71
	Females	82.00	4.00	14.00
	Total	71.20	8.47	20.33
Normal	Males	60.00	16.67	23.33
	Females	75.00	16.67	8.33
	Total	67.50	16.67	15.83
Sickle cell	Left	74.58	1.86	13.56
	Right	83.05	1.70	15.25
Normal	Left	75.00	10.00	15.00
	Right	60.00	23.33	16.67

Table 10: Odds Ratio and 95% Confidence Interval estimates of finger patterns in sickle cell and control groups

Patterns	Study Groups		Odds Ratio	Confidence Interval (C.I)	p-value
	Sickle cell	Normals			
Arch	62	57	0.96	0.63-1.47	0.8481
Whorl	232	205	1.28	0.99-1.65	0.0507
Ulnar Loop	286	323	1.33	0.55-3.36	0.4940
Radial Loop	10	15	-	-	-

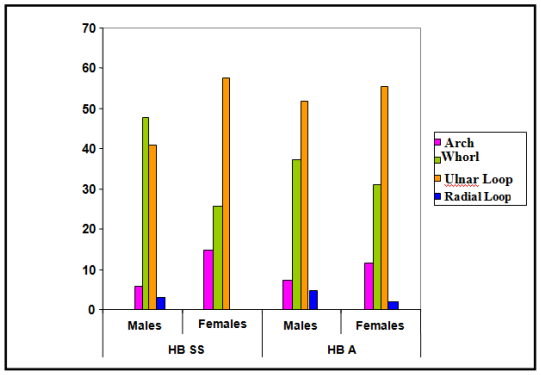

Figure 1: Distribution of finger ball patterns in sickle cell and control groups

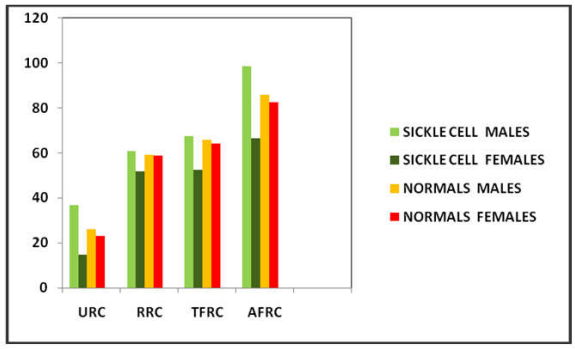

Fig. 2: Distribution of finger dermatoglyphic characters in sickle cell and normal's

patients and controls). No radial loop pattern was found in first and second digits of right and first digit of left hand in sickle cell group. Ulnar loop has the highest percentage (72.88%) in the third digit of right hand in sickle cell group. The order of increase in sickle cell group is as follows: ulnar loop > whorl > arch > radial loop except in RI, RIV and LI, LIV. The order of increase in normals is same expect in RIV and LIV. The means and standard errors of the palmar atd and dat angles of both hands in males and females in sickle cell and normal groups are shown in Tables 5. When compared between sickle cell and normal's, there was significant difference in the mean between the two groups such that the sickle cell subjects had higher mean in both right and left palms of males (43.03 and 43.56) and in the left palm of females (45.36). The value was found to be similar when right palm of female sickle cell group was compared with normal

group. Regarding the palmar dat angles of both hands compared between males and females, there was significant difference in the mean between the two groups such that in males normal subjects had higher mean in both right and left palms with 60.07 and 59.43 and in females the sickle cell subjects had higher mean in both right and left palms with 56.24 and 55.08 respectively. The means and standard errors of the palmar atd angles of both hands in sickle cell and normal groups are shown in Tables 6. When compared between normals and sickle cell groups, the mean atd angle was found to be higher in sickle cell group (43.74). Whereas the mean dat angle was found to be higher in normals (57.17).

Analysis of the palmar inter-digital ridge count in Table 7 shows that in both left and right palms of sickle-cell and normal groups, the mean A-B, B-C and C-D ridge counts were similar. However, when compared between patients and normals, there was a significant difference, such that the normals were found to have a higher mean in all the three inter-digital ridge counts (36.34, 23.04, 30.35) respectively. In Table 8, mean for different quantitative finger dermatoglyphic characters between males and females in normals and sickle-cell group were shown. When compared between males and females of sickle cell group, the mean of URC, RRC, TFRC and AFRC was found to be higher in males and when compared between normal males and females, the values were found to be similar. Table 9 shows the percentage distribution of the palmar creases in both sickle cell and control groups. Regarding the unusual palmar flexion creases, there was a significant increase i.e 20.33% Sydney and 8.47% simian crease in both males and females of sickle cell. The remaining 71.20% of sickle cell cases showed normal creases. To quantify the magnitude of association of dermatoglyphics with the disease condition compared to the control group, the odds ratio for each finger pattern versus the other was shown in Table 10. The odds ratio of arch type vs whorl type was 0.96 and the odds ratio of loop type vs whorl type was 1.28 ($P<0.05$). Finger ball pattern of both hands showed a statistically significant increase in whorls in patients when compared to controls ($p<0.05$). The odds ratio of ulnar loop vs radial loop was also at an increased risk of sickle cell anemia, with an overall odds ratio of 1.33.

DISCUSSION

Sickle cell disease is the most common of the hereditary blood disorders. Dermatoglyphic data has long been recognized as valuable genetic marker both in the study of population relationships as well as in clinical studies. Because of their inherent advantages over other biological markers, dermatoglyphics have been utilized by investigators from a number of different scientific disciplines. The examination of dermatoglyphics does not involve physical pain or economical burden for patients (Stough and Seely 1969). The other most important parameter of dermatoglyphics is the inheritance. All the physical features of the human body including the dermatoglyphics are inherited as per the laws propounded by Mendel. Since, very little work was done on dermatoglyphic features in sickle cell anemia, the present study was undertaken to determine an association between dermatoglyphic traits and sickle cell anemia.

In the sickle cell male group, the arches and radial loops were less frequent whereas the ulnar loops and whorls were more frequent (Fig. 1). The result is closely related with the fact that the total fingerprint ridges and the absolute finger ridges were more numerous in the sickle cell male group (Fig. 2). Interestingly, we found that radial loops were completely absent in female sickle cell group. Our study reported an increase in the value of 'atd' angle in sickle cell patients (mean 43˚) as compared to controls (mean 41˚). Although little differences in values occur, it is not statistically significant. The mean 'dat' angles were found to be similar between the two groups. Our results indicate that A-B, B-C and C-D ridge counts in male and female patients has decreased comparatively to control group, but the reduction is not significant. The total finger ridge count (TFRC) was significantly increased in male patients and was decreased in female patients when compared with controls. Palmar analysis of sickle cell cases showed 8.47% of simian creases and 20.33% of sydney creases. The remaining 71.20% were normal. The present study is correlated with previous work (Oladipo *et al.,* 2007) which observed significant high frequency ($P<0.05$) of whorls and low frequency of radial loops and the mean of A-B, B-C and C-D ridge counts in sickle cell anemia patients as compared to controls was observed to be similar . In both the studies no difference was observed in the frequency of presence of pattern in all 5 inter digital areas. The dermatoglyphic characteristics of the Indian sickle cell anemia group are different from those of the Nigerian sickle cell group are as follows: increase in the value of atd angle is compared with the Nigerian study, which reported a decrease in the value of 'atd' angle; 8.47% of simian and 20.33% of Sydney creases were recorded in our study whereas only 2.2% of Sydney and none of the simian creases were reported in Nigerian study. The results show that dermatoglyphics are helpful in the diagnosis of sickle cell anemia because several dermatoglyphic characteristics in patients with sickle cell are statistically different from those in normal persons. And on the whole our study along with that of Oladipo *et al.,* 2007 has shown certain specific association between sickle cell and ridges indicating that genes are responsible for this disease. The dermatoglyphic parameters which have shown association with sickle cell as diagnostic aid will be of limited use at this stage, more detailed studies in different populations are desirable. The features of dermatoglyphics also express the correlation in many somatic, physiological, neurological and cytological afflictions and syndromes. In trisomy G the typical ulnar loops, simian crease, distal displacement of axial triradius, high value of main line index have been recorded. High frequency of arches are often associated with Cat-Cry-Syndrome (Schaumann and Alter, 1976); the Simian crease is much more frequent in patients with Down's syndrome (Uchida and Soltan 1963); the total fingerprint ridges are numerous in patients with Turner's syndrome (Penrose, 1963) and high finger ridge count is commonly recorded with trisomy of X chromosome.

Conclusions

Dermatoglyphic traits like A-B, B-C, C-D ridge counts, atd and dat angles of sickle cell patients did not differ from those of control persons. But in sickle cell male group, whorls were found to be more frequent than controls relating with the fact that the total fingerprint ridges were more numerous in the

sickle cell males. No radial loops were observed in females of sickle cell. Regarding the unusual palmar flexion creases, there was significant increase in the Sydney creases in females of sickle cell when compared with normal females. But these parameters might not be the biomarkers for screening of sickle cell anemia in males and females. However further research using sample frame across geographic and sociocultural groups with a large sample size gives us more valuable clues which would probably help in early diagnosis of the disease.

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