

Development of Dermatoglyphics in India

SAMPRIITI DEBNATH[†] & JAYDIP SEN[‡]

*Department of Anthropology,
University of North Bengal, Raja Rammohunpur,
Darjeeling-734013, West Bengal, India
E-mail: jaydipen@rediffmail.com*

KEYWORDS: Dermatoglyphics, Fingerprint, History, Applications, India

ABSTRACT: Dermatoglyphics, also known as fingerprinting, is study of patterns of epidermal ridges on palmar and plantar surfaces of the hands and feet. It has been developed as a useful tool towards the understanding of some basic questions in biology, medicine, genetics, evolution and personal identification. Grew, Bidloo, Malpighi, Purkinje, Azizul Haque and Hem Chandra Bose and many other researchers were pioneers of the scientific study of fingerprinting. Dermatoglyphics has been extensively applied in different fields such as in the study of population variation, disease association, disputed paternity and among the non-human primates. Researchers from India have made significant contributions in the field of dermatoglyphics. The present paper is an attempt to document the development of dermatoglyphics with special reference to India.

INTRODUCTION

Dermatoglyphics is the study of patterns of epidermal ridges on palmar and plantar surfaces of the hands and feet. The permanence and uniqueness of dermatoglyphic patterns and traits on each anatomical area of an individual has been well established (Wertheim and Maceo, 2002; Budowle *et al.*, 2006). Over the past 150 years, dermatoglyphics has been extensively used as a tool for understanding some basic questions in biology, medicine, genetics, evolution and personal identification. Impressions of the last finger joints are known as fingerprints and its uses to identify individuals and also to understand population variation have become very common. Its role in personal identification remains an invaluable tool worldwide (Barnes, 2011). In recent years the study of dermatoglyphics has obtained great importance in criminal researches, law and justice, population variation and also in the study of some congenital and genetic diseases and also dermatoglyphics characteristics in

relation with some diseases like down's syndrome, Alzheimer's disease, multiple sclerosis and schizophrenia (Dorjee *et al.*, 2014).

Historical background

The scientific study of papillary ridges of the hands and feet began with the work of Joannes Evangelista Purkinje, a Czech physiologist and biologist (1787-1869). The first systematic study of fingerprint patterns has been attributed to him. It was in his 1823 thesis titled "*Commentary on the Physiological Examination of the Organs of Vision and the Cutaneous System*" that Purkinje classified fingerprint patterns into nine categories and named them accordingly (Lambourne, '84), Purkinje's contribution was significant in the history of fingerprinting because his nine pattern types became the precursor to the Henry classification system (Galton, 1892; Herschel, '16; Holder *et al.*, 2011). Other significant researchers included Bidloo (1685), Malpighi (1686) and Grew (1864), and these were prior to Purkinje (Dorjee *et al.*, 2014).

[†] UGC-NET Senior Research Fellow,

[‡] Professor (Corresponding Author)

Counting of palmer dermal ridges in determining quantitative fingerprint characteristics, study of different shapes of dermal ridges in fingers and patterns (such as loop, arch, whorl) as qualitative characteristics have gained importance over the years. The use of friction ridge skin impressions as a tool for identification has been around for thousands of years in several cultures. In countries like China, Japan and India, the use of friction ridge skin as an identifying character is well documented. In China as early as 300 B.C., friction ridge skin impressions were used as proof of individual identity. This practice was also in vogue in Japan as early as A.D. 702, and in the United States since 1902. Friction ridge impressions on earthenware estimated to be 6000 years old were discovered in an archaeological site located in northwest China. These prints perhaps are the oldest friction ridge skin impressions which have been dated (Barnes, 2011). These evidences prove that the importance of dermatoglyphics goes back to ancient China and it was mainly used in the deeds during the sale of land and also used in the custom of selling children as the safeguard against impersonation. However, in India it was mainly reserved for royalty (Sodhi and Kaur, 2003).

In the late 17th century, observations on the human skin started to be published by European researchers. The first published detailed description of friction ridge skin was by Grew (1864). This was a paper published in the *Philosophical Transactions of the Royal Society of London* (Janaki, 2011). The book "*Anatomical Copper-plates with Appropriate Explanations*" authored by J.C.A. Mayer and published in the year 1788 was in all probability the first book containing detailed drawings of friction ridge skin patterns.

Henry Faulds in 1880 was the first person to assess the value of friction ridge skin for individualization and crime detection (Faulds, 1890). Faulds was also the first researcher to point out that fingerprints remain unchanged during an individual's lifetime (Sodhi and Kaur, 2005). In 1883, Kollmann studied the embryological development of friction ridge skin and proposed that ridges were formed by lateral pressure between nascent ridges and that ridges were discernible in the fourth month of fetal life and fully formed in the sixth (Kollmann, 1883). He

was also the first researcher to identify the presence and locations of volar pads on the hands and feet (Hale, '52). It was in the year 1892 that Sir Francis Galton published his classic book entitled "*Fingerprints*". Much of Galton's work was directed towards usages of fingerprint identification but he also expanded the Purkinje's nine finger patterns to his own classification of fingerprints and palm prints. He conducted extensive research on the significance of skin ridge patterns and demonstrated their permanence and use as means of identification. He also demonstrated the hereditary significance of fingerprints and biological variations in finger print patterns among different racial groups. His book "*Fingerprints*" significantly advanced the science of fingerprint identification and as the author of the first book on fingerprints, Galton established that friction ridge skin was unique and persistent. Next year i.e., 1893, Sir Edward Henry published another classic text on dermatoglyphics entitled "*The Classification and Uses of Fingerprints*" and established the modern era of finger print identification (Henry, '00). The classification of Henry now forms the basis for most of the classification systems. Some other notable and famous contributors to fingerprints in the early 19th century were C.S. Collins from England, A. Bertillon in Europe and De Forest and Mary Holland in the United States. Another leading fingerprint researcher during this period was a statistician named Juan Vucetich (Chapman, '92).

The study of friction ridge skin permanence was first initiated by Hermann Welcker, a German anthropologist. He started studying the print of his own right hand in 1856 and then again in 1897 (Cummins and Midlo, '43). Harris Hawthorne Wilder ('02) in the early 20th century pioneered the comprehensive studies on the methodology, inheritance and racial variation of palmar and plantar papillary ridge patterns, as well as finger prints. The history of finger print system was subsequently summed up by Lauter ('12) in his paper entitled "*History of the Finger-print System*" published in the *Annual Report of Smithsonian Institute*.

Development of dermatoglyphics in the 20th century

It was in the year 1926 that Cummins and Midlo coined the word '*Dermatoglyphics*' (from two Greek

words 'derma' meaning 'skin' and 'glyphe' meaning 'carving'). They also studied Down's syndrome and the characteristic hand formations and observed that the hand with significant dermatoglyphic configurations could identify Down's syndrome in the new born. Cummins also observed the impressions of a thumb print on clay in 1927. Heindl ('29) was the first to report finger printing for identification purposes in Germany. Cummins in 1930 was first to show finger print carvings of the Stone Age. De Forest ('38) traced dactyloscopy in the United States of America. A significant work in the form of a book was published by Wilton ('38) which was entitled "*Finger Prints History, Law and Romance*". In 1938, Myers further documented the history of identification of finger prints (Myers, '38). In the year 1943, Cummins and Midlo published one of the most significant books on dermatoglyphics entitled "*Fingerprints, Palms and Soles*". The early function of the fetal hand has been studied by Humphrey in 1964 (Popich and Smith, '70). Gall and Associates ('66), studied the shape of volar pads to determine fingertip patterns (Mulvihill and Smith, '69). According to Penrose ('68), the ridges are aligned at right angles to compression forces and take the shortest routes on embryonic surfaces, and alterations in the fluid balance at an early embryonic stage can result abnormal configurations (Mulvihill and Smith, '69). Penrose in 1968 provided the memorandum on dermatoglyphics nomenclature. In 1999 Julius Spier published the book "*The Hands of Children*" and also several significant discoveries were made by him in the field of psycho-sexual development, diagnosis of imbalances and problems using hand patterns (Spier, 2013).

The dermatoglyphic discriminants for Trisomy 21 and for three other syndromes (D, E and 4P) were developed by Penrose and Loesch in 1971 (Preus, '72). Relationships between dermatoglyphics, genetic markers and genetic variations have been studied by Chakraborty among different populations (Rothhammer *et al.*, '77, '79). Kobylansky *et al.* ('83) conducted a study entitled "*The reciprocal influence of the different finger pattern types on their ridge count values*". Other notable studies were by Salam *et al.* ('84), Iqbal *et al.* ('85) and Weinreb ('86). Martin and Portables ('86) studied the dermatoglyphic patterns of Spanish people while digital and palmar

dermatoglyphics of individuals diagnosed with Alzheimer's disease was studied by Luxenberg *et al.* ('88). Durham and Koehler ('89) studied congenital heart defects in Down's syndrome patients using dermatoglyphics. Other studies in the 20th century on disease associations were by Arrieta *et al.* ('90) and Brehme and Jantz ('90). Kamali *et al.* ('91) analyzed dermatoglyphics traits from thirteen Iranian populations. Palyzova *et al.* ('91) conducted a study on dermatoglyphics in relation with juvenile hypertension. Fananas *et al.* ('96) studied finger and a-b palmar ridge count dermatoglyphic features among schizophrenics. Finno-Ugric speaking populations were studied for the dermatoglyphic features by Jantz *et al.* ('92). Other significant studies include those of Arrieta *et al.* ('92, '93), Mardia *et al.* ('92), Loesch and Huggins ('92), Berr *et al.* ('92), Cho ('93) and Sokal and Livshit ('93). There are a number of significant research papers done in the field of genetics and medicine using dermatoglyphics. Tornjova and Randelova ('94) conducted a study on dermatoglyphics among Bulgarian children, Reed ('95) studied associations between blood pressure and dermatoglyphics among adults. Ravindranath and Thomas ('95) studied the total ridge count, absolute finger ridge count and finger print patterns of individuals suffering from diabetes mellitus. A study on the fluctuating nature of dermatoglyphic asymmetry was conducted by Naugler and Ludman ('96). Gutierrez *et al.* ('98) studied congenital dermatoglyphic malformations, while Simsek *et al.* ('98) and Cweticanin and Polovina ('99) reported the associations of dermatoglyphic variables with cerebral palsy. Katznelson *et al.* ('99) evaluated the effects of Trisomy 21 chromosomal morbidity among males and females based on dermatoglyphic traits and their indices of diversity and asymmetry. Jelovac *et al.* ('99) studied dermatoglyphic features in the early embryonal stages. Igbigdi and Msamati ('99) observed palmar and digital dermatoglyphic patterns among Malwians. Slabbekoorn *et al.* (2000) studied gender identity and sexual orientation with dermatoglyphics. Rodewald (2001) observed congenital abnormalities with high accuracy from features of the fingers and palms alone. Igbigdi and Msamati (2002) reported planter digital dermatoglyphic characteristics among Zimbabweans. Schaumann and Alter ('76) have

summarized the findings of dermatoglyphic patterns related to various disease conditions in their excellent book entitled “*Dermatoglyphics in Medical Disorders*”. A pertinent review has also been published by Kaur *et al.* (2013).

DERMATOGLYPHICS IN INDIA

For a long time in India, technology had been applied to detections and investigations of crime and in administration of justice and law. Although the discipline of forensic science was not in its present form, several scientific methods were applied to solve various criminal investigations. This can be noticed from the writings of Kautilya’s ‘*Arthashastra*’ which was written about 2300 years ago. It is presumed that Indians knew about the individuality and persistency of fingerprints, which they used as signatures and so they studied several papillary lines. Herschel (1858) was first to experiment with fingerprints in India (Priya *et al.*, 2013). Minakata (1894) observed that use of fingerprints in an ancient kingdom of southern India has been proved by Chinese records. The use of fingerprints as signatures has been introduced centuries ago for the illiterate people in India. It was considered only a ceremonial act by some people till it was scientifically proved that identification from fingerprints was infallible.

The Indian pioneers

On June 1897, the Council of the Governor General of India gave consent to the report of a committee suggesting that henceforth fingerprints should be used for classification of criminal records and also emphasized that the method of fingerprinting was simple, cost-effective and more accurate than the earlier used anthropometric techniques (Sodhi and Kaur, 2005). The world’s first fingerprint bureau was set up at Calcutta (now Kolkata) in 1897, mainly by the efforts of two pioneering Indian police officers, namely, Azizul Haque and Rai Bahadur Hem Chandra Bose. All the criminal records in this Bureau were streamlined according to the formula worked out by Sir Edward Richard Henry (Sodhi and Kaur, 2005). However, very few researchers are aware of the fact that Haque and Chandra Bose both greatly contributed towards the formulation of Henry’s fingerprint classification (Haylock, ’79). It may be mentioned here

that Henry’s method is the most widely used method today for maintaining criminal records. A system of telegraphic code had been invented by Bose which was later on adopted by the Scotland Yard (Sodhi and Kaur, 2005). The system had been described by Bose in his book entitled, “*Hints on Finger-Prints with a Telegraphic Code for Finger Impressions*” which was first published in 1916 (Bose, ’16). S. N. Roy, Esq., I.C.S., Deputy Secretary, Home Department, in a note dated 8 July 1929 wrote: “*This (telegraphic code) was a work involving arduous labour and although Scotland Yard published a similar telegraphic code in 1921, it is noteworthy that the Rai Bahadur’s work was the first of its kind*”. Bose modified the existing fingerprint classification formula, which was based on the ridge pattern of all ten digits because it was not practical to telegraph all ten imprints of the person in question and against this, he devised a classification formula based on single digit impressions (Sodhi and Kaur, 2005). In June 1926, Harry Battley took over as Head of the Fingerprint Department of Scotland Yard and with the assistance of Detective Sergeant Frederick Rupert Cherrill classified a few hundred slips according to the new method in 1928-29 (Sodhi and Kaur, 2005). Next year in 1930 Battley published his book entitled “*Single Fingerprints*” by Her Majesty’s Stationery Office. This work was superseded by Bose, who had not only devised the single-digit classification formula much earlier and also got it published earlier (Sodhi and Kaur, 2005). Bose’s first book in 1916 had become so much popular that there was a persistent demand to bring out a second edition. Subsequently he published the book “*The Finger Print Companion*” in 1927. The second edition of the book contained the newly discovered system of single digit classification and the reprinted version of “*Hints on Finger Prints*”. In this book Bose solicited comments from a few English police officers. Most noteworthy was J. E. Armstrong, Deputy Inspector General of Police, Bengal, who wrote: “*If the Rai Bahadur has indeed made this new discovery in the science of identification by fingerprints, as I believe he has, it will be one more triumph for him and perhaps his greatest*”.

While sanctioning the honorarium for Hem Chandra Bose, the Standing Finance Committee,

during its proceedings of 6 August 1929 recorded: “During his long service in the Bengal Finger Print Bureau he (Bose) acquired a unique knowledge of the science and introduced various improvements which had been of great use to the police administration not only in India but throughout the world. Particular mention might be made of the system of classification for a single digit impression which had been acknowledged to be a masterpiece of finger print work by many experts in Europe....”. The Government Councilor of Germany’s Ministry of Interior wrote about Bose (International Public Safety, ’25): “Rai Bahadur Hem Chandra Bose . . . recently published a new method for the classification of a single digit impression which, it seems to me, as worth of special attention.... Although it was not possible to present the new method at the International Police Exhibition arranged at Karlsruhe in June last, yet the closer connection formed on the occasion of this exhibition between the police administration of India and Baden offered an opportunity of acquainting wider circles of experts with his method”.

According to Sodhi and Kaur (2005), contributions of Bose to the science of finger printing had been summed up in a communication (No. 650 PI, dated 5 February ’29) from the Government of Bengal to the Government of India, Home Department. It was written: “During his long service in the Bengal Bureau he (Bose) acquired unique knowledge of the science and introduced various improvements in the methods of sub classifying finger impressions of which the following are deserving of special mention:

- (1) The method of comparing imperfect impressions with only a few naked ridges.
- (2) The sub-classification using numerical methods.
- (3) The method of estimating the probability of fixing identity using the ridge characteristics.
- (4) The sub-classification of the accidental type.
- (5) The improved system of indexing.
- (6) The introduction of a telegraphic code for finger impressions.
- (7) The classification system for a single digit impression”.

Some significant landmarks in the study on dermatoglyphics in India

A criminal case in Bengal in 1898 was the first case in which finger print evidence was used to secure a conviction (Sodhi and Kaur, 2003). In the mid-1930’s it was Prof. P.C. Biswas who did pioneering studies in dermatoglyphics for his thesis under Fischer. Another stalwart was Prof. I.P Singh who was the first Indian scholar to write a thesis on dermatoglyphics. His area of study was the inheritance of fingerball patterns and was guided by none other than Prof. Biswas. More than 500 reports on ethnic variations in dermatoglyphics have been published in two decades from 1961 to 1981 by Prof. Biswas alone (Dash Sharma, ’84). Miki *et al.* (’60) and Miki and Hasekura (’61) were perhaps the pioneering workers on the Lepchas and Khasis, respectively. Some of the devoted Indian researchers who have enriched the domain of dermatoglyphics are Biswas (’39), Biswas and Bardhan (’66), Dash Sharma (’66), Mukherjee (’66), Mukherjee *et al.* (’80) and Malhotra (’87). The studies of Singh (’61), Kumbani (’63, ’64), Sen (’68), Shukla and Rastogi (’76), Singh and Bhasin (’79, 2004) and Singhrol and Roy (’81) are also mentionable. Malhotra and Rao (’82) analyzed the estimates of five familial correlations including twins using the model and methods of path analysis. A study on finger, palmar, middle and basal phalangeal dermatoglyphics among the Oraon population was done by Dash Sharma and Sahu (’73). Ghosh (’82) observed finger and palm prints of the Naik Gond, a Dravidian speaking tribe of Chandrapur, Maharashtra. A few dermatoglyphic characters such as pattern types, number of finger triradii, total finger ridge count, main-line index and a-b ridge count which have been studied have expressed the usual trends of sexual dimorphism. Some other major studies in the field of dermatoglyphics from the country were by Karmakar and Malhotra (’81, ’88), Rao *et al.* (’83), Khatoon (’86) and Mukherjee (’90). Important studies on ridge counts and triradii on human palms have been done by Malhotra and Rao (’82) and Malhotra *et al.* (’87). Parvatheesam *et al.* (’93) observed some of the qualitative and quantitative palmar dermatoglyphic characters of Relli caste and Manne Dora tribals of Andhra Pradesh (India). Taneja *et al.* (’93) observed the fingertip and palmar dermatoglyphics among populations of North India.

In a significant study, Krishnan and Reddy ('94) compared Indian populations with other populations on the basis of their variability in geographical area, gender, ethnic and social group. In North Bengal pioneering studies have been done by Sarkar ('69, '71, '72) on Oraon, Munda, Meche, Rajbanshi, Brahmins, Kayastha, Vaida, Namasudra and Muslim individuals. Recent studies among the populations of North Bengal are by Sen and Mondal (2008), Sen *et al.* (2011) and Biswas (2011). Disease associations with dermatoglyphics have also been studied by Bhanu and Malhotra ('72), Karmakar and Malhotra ('81, '88), Mukherjee ('90) and Bhasin and Khanna ('94). Several studies have been conducted on the Bodo ethnic groups namely Boro Kachari, Mech, Deuri, Chutiya, Garo, Hajong, Lalung, Moran, Mikir, Rabha by Das ('59), Deka and Bora ('73), Deb ('79), Das *et al.* ('80) and Das *et al.* ('85a,b). Dermatoglyphic features of Brahmin, Kayastha and Kalita from Assam were studied by Das and Das ('65), Das ('79) and Das *et al.* ('86a,b).

*Recent developments in the study of
dermatoglyphics in India*

Several new dimensions and applications of dermatoglyphics in India have been observed in the research studies done during the last two decades. Indian researchers have proved the associations of different diseases with dermatoglyphic features which were initially observed in India by Mutalik *et al.* ('69), Verma ('70) and Annapurna *et al.* ('78). Significant studies on congenital heart disease (Ahuja *et al.*, '82) and on breast cancer (Chintamani *et al.*, 2007) have also been done. Recent studies on population variation have been done by Reddy and Reddy (2001), Karmakar *et al.* (2005), Narahari *et al.* (2008) and Sen and Mondal (2008). Inheritance patterns of dermatoglyphic traits have been studied by Sengupta and Karmakar (2004) who concluded that there was an evidence of the existence of a major gene on these dermatoglyphic traits. Some other studies in this area have been done by Singh *et al.* ('78), Kusuma *et al.* (2002) and Karmakar *et al.* (2006).

CONCLUSION

Over the past 150 years, dermatoglyphics has been developed as a very useful tool for studying

and understanding the basic questions in biological anthropology, evolution, medicine and genetics. Moreover, in case of personal identification dermatoglyphics plays a major role. It has been found out that dermatoglyphics as all the other physical features of the human body is inherited genetically as per the Mendelian laws (Kumbhani, 2007). Therefore it gained high importance in human genetics, evolution and personal identification. Wide application of dermatoglyphics in several fields of science and investigation has made it very precious as a useful tool for many years and in this development process the contribution of Indian pioneers cannot be forgotten.

REFERENCES CITED

- Ahuja, Y. R., V. Annapurna, Y. R. Reddy, G. D. Reddy, V. S. Rao and P. N. Rao. 1982. Dermatoglyphic Studies in Congenital Heart Disease in India. *Acta. Anthropogenet.*, 63: 141-150.
- Annapurna, V., Y. R. Ahuja, Y. R. Reddy, G. D. Reddy, V. Sudhakar Rao and P. Niranjana Rao. 1978. Dermatoglyphic Studies in Rheumatic Heart Disease. *Hum. Hered.*, 78:72-78.
- Arrieta, M. I., B. Criado, R. Hauspie, B. Martinez, N. Lobato and C. M. Lostao. 1992. Effects of Genetic and Environmental Factors on the a-b, b-c and c-d Interdigital Ridge Counts. *Hereditas.*, 117:189-194.
- Arrieta, M. I., B. Criado, B. Martinez, M. N. Lobato, A. Gil and C. M. Lostao. 1993. Fluctuating Dermatoglyphic Asymmetry - Genetic and Prenatal Influences. *Ann. Hum. Biol.*, 20(6):557-563.
- Arrieta, M. I., B. Martinez, A. Simon, L. Salazar, B. Criado and C. M. Lostao. 1990. Quantitative and Qualitative Finger Dermatoglyphics in the Basque Valley of Urola, Spain. *Anthropol. Anz.*, 48:65-84.
- Barnes, J. G., J. M. Drazen, S. Rennard and N. C. Thomson. 2011. *History, The Fingerprint Sourcebook*. US Department of Justice.
- Berr, C., N. Okra-Podrabinek, D. Feteanu, S. Taurand, M. P. Hervy, F. Forette, F. Piette, R. Sebag-Lanoe and A. Alperovitch. 1992. Dermatoglyphic Patterns in Dementia of the Alzheimer Type: A Case-Control Study. *J. Epidemiol. Comm. Health*, 46:512-516.
- Bhanu, B.V. and K. C. Malhotra. 1972. Palmar C-line Polymorphism Among Gaudas of Goa and Ezhavas of Kerala. *Man in India.*, 52:261-267.
- Bhasin, M. K. and A. Khanna. 1994. Biological traits and their association with diseases: A review of studies from Indian region. In: V. Bhasin (Ed.) *People, Health and Disease: The Indian scenario*. Kamla Raj Enterprises, Delhi. sp. 103-104.

- Biswas, S. 2011. Finger and Palmar Dermatoglyphic Study Among the Dhimals of North Bengal, India. *Anthropol.*, 32:235-238.
- Biswas, P. C. 1939. Über Hand-und Fingerleisten von Indern. *Ztschr. f. Morphol. u. Anthropol.*, 35:519-550.
- Biswas P. C. and A. Bardhan. 1966. Palm Prints and Schizophrenia. *Anthropol.*, 3:1-12.
- Bose, H. C. 1916. *Hints on Finger-Prints with a Telegraphic Code for Finger Impressions*. Thacker Spink and Company, Calcutta and Simla.
- Brehme, H. and R. L. Jantz. 1990. Palm and Sole Inter Digital Ridge-count Correlations. *Zeitschrift. Morph. Anthropol.*, 78:243-256.
- Budowle, B., J. Buscaglia, and R.S. Perlman 2006. Review of the Scientific Basis for Friction Ridge Comparisons as a Means of Identification: Committee Findings and Recommendations. *Forensic. Sci. Commun.*, 8:1.
- Chapman, Carey L. 1992. Dr. Juan Vucetich: His Contribution to the Science of Fingerprints. *J. of For. Ident.*, 42:286-94.
- Chintamani, R., A. Khandelwal, S. Mittal, A. Saijanani, A. Tuteja, D. Bansal, D. Bhatnagar and S. Saxena. 2007. Qualitative and Quantitative Dermatoglyphic Traits in Patients With Breast Cancer: A Prospective Clinical Study. *B.M.C. Cancer.*, 13(7):44.
- Cho, C. 1993. Ridge Counts on Palmar Inter Digital Areas in Koreans. *Korean. J. Genet.*, 15:365-368.
- Cummins, H. and C. Midlo. 1961. *Finger prints, palms and soles: an introduction to dermatoglyphics*. New York: Dover Publications.
- Cw'eticanin, M. I. and A. Polovina. 1999. Quantitative Analysis of Digitopalmar Dermatoglyphics in Male Children With Central Nervous System Lesion by Quantification of Clinical Parameters of Locomotor Disorder. *Acta. Med. Croatica.*, 153:5-10.
- Das, B.M. 1959. Fingerprints of Hajong. *Man in India*, 39:20-27.
- 1979. Physical Variation in Three Assamese Castes. *Anthrop. Anz.*, 37:204-10.
- Das, B. M. and R. Das. 1965. Palm Prints of the Kalita. *Man in India*, 45:301-305.
- Das, B. M., P. B. Das, R. Das and S. Sengupta. 1980. Descriptive Physical Anthropology of the Kayastha Caste of Kamrup, Assam. *Bull. Dept. Anthropol. Dibrugarh University.*, 9:101-111.
- Das, B. M., P. B. Das, R. Das, H. Walter and H. Danker-Hopfe. 1985a. Anthropological Studies in Assam, India. 1. Observations on Five Mongoloid Populations. *Anthropol. Anz.*, 43:193-204.
- 1985b. Anthropological Studies in Assam, India. 2. Observations on Muslims. *Anthropol. Anz.*, 43:299-310.
- 1986a. Anthropological Studies in Assam, India. 3. Observations on Three Brahmin Groups. *Anthropol. Anz.*, 44:35-43.
- 1986b. Anthropological Studies in Assam, India. *Anthropol. Anz.*, 44:239-48.
- Dash, Sharma., P. 1966. A Note on the Palmar Dermatoglyphics of the Ladakhi Males. *Eastern Anthropologist.*, 19:75-80.
- 1984. Current Status of Dermatoglyphic Studies in South Asia. In J. Lukacs (ed.) *The People of South Asia: the biological anthropology of India, Pakistan and Nepal*. Springer, Boston, MA. pp. 217-237.
- Dash, Sharma, P. and B. Sahu 1973. Finger, Palmar, Middle and Basal Phalangeal Dermatoglyphic Study of the Oraons of Ranchi. *Ind. J. Anthropol. Soc.*, 81:260-267.
- de Forest, H. P. 1938. The First Finger Print File in the United States. *Finger Print Ident. Mag.*, 19:16-20.
- Deka, R. and A. Bora. 1973. An Investigation of the Fingerprints of the Mikirs. *Bull. Dept. Anthropol. Dibrugarh University.*, 11-12:47-50.
- Dorjee, B., N. Mondal and J. Sen. 2014. Applications of Dermatoglyphics in Anthropological Research: A Review. *South Asian Anthropol.*, 14:171-180.
- Durham, N. M. and J. L. Koehler. 1989. Dermatoglyphic Indicators of Congenital Heart Defects in Down's Syndrome Patients: A Preliminary Study. *J. Intel. Disab. Res.*, 33:343-348.
- Fananas, L., J. van Os, C. Hoyos, J. McGrath, C. S. Mellor and R.M. Murray. 1996. Dermatoglyphic a-b Ridge Count as a Possible Marker for Developmental Disturbance in Schizophrenia: Replication in Two Samples. *Schizophrenia Res.*, 20:307-314.
- Faulds, H. 1880. On the Skin - Furrows of the Hand. *Nature*, 22:605.
- Galton, F. 1892. *Finger Prints*. MacMillan: New York.
- Ghosh, G. C. 1982. Dermatoglyphics of the Naik Gond. *Anthropol. Anz.*, 1:217-221.
- Gutierrez, B., J. van Os, V. Valles, R. Guillamat, M. Campillo and L. Fananas. 1998. Congenital Dermatoglyphic Malformations in Severe Bipolar Affective Disorder: Analyses of Familiar Morbidity Risk. *Psychiatry Res.*, 78:133-140.
- Hale, A. 1952. Morphogenesis of Volar Skin in the Human Fetus. *J. Anatomy.*, 91:147-173.
- Haylock, S. E. 1979. Khan Bahadur Azizul Haque. *Fingerprint World*, 5:28-29.
- Heindl R. 1929. Die Ersteddeutsch Arbeitüber das Fingerabdruckverfahren also Politzeiliches Identifizierungsmittel. *Arch. F. Krimino.*, 85:30-69.
- Henry, E. R. 1900. *Classification and Uses of Finger prints*. HM Stationery Office, London, United Kingdom.
- Herschel W. J. 1916 *The Origin of Finger-printing*. Oxford University Press: London.
- Holder, E. H., L. O. Robinson and J. H. Laub. 2011. *The Fingerprint Sourcebook*. US Department of Justice, Office of Justice Programs, National Institute of Justice.

- Igbigi P. S. and B. C. Msamati. 1999. Palmar and Digital Dermatoglyphic Patterns in Malawian subjects. *East Afr. Med. J.*, 76:668-671.
- 2002. Palmar and Digital Dermatoglyphics of Indigenous Black Zimbabweans. *Med. Sci. Monit.*, 8:757-761.
- Iqbal, S., S. Premalatha and A. Zahra. 1985. Dermatoglyphics in Vitiligo. *Int. J. Dermatol.*, 24:510-513.
- Janaki, V. R. 2011. Conventional Dermatoglyphics – Revived Concept: A Review. *Int. J. Pharm. Bio. Sci.*, 2:446-458.
- Jantz, R. L., H. Brehme and A. W. Eriksson 1992. Dermatoglyphic Variation Among Finno Ugric Speaking Populations: Methodological Alternatives. *Am. J. Phys. Anthropol.*, 89:1-10.
- Jelovac, N., J. Milicic, M. Milas, G. Dodig, S. Turek and Z. Ugrenovic. 1999. Dermatoglyphic Analysis in Bipolar Affective Disorder and Schizophrenia- “Continuum of Psychosis” Hypothesis Corroborated?. *Coll. Antropol.*, 23:589-596.
- Kamali, M. S., J. Mavalwala, A. A. Khanegah and B. V. Bhanu. 1991. Qualitative Dermatoglyphic Traits as Measures of Population Distance. *Am. J. Phys. Anthropol.*, 85:429-450.
- Karmakar, B. and K. C. Malhotra. 1981. Ethnic Variation in Hypothenar Triradii. *South. Asian Anthropol.*, 2:71-74.
- 1988. Palmar Dermatoglyphics in Schizophrenia, In: I. J. S. Bansal (ed.) *Human Biology-Recent Advances (Vol. 2). Today and Tomorrow's*. Printers and Publishers, New Delhi. pp. 95-108.
- Karmakar, B., L. Malkin and E. Kobylansky. 2005. Asymmetry and Diversity of Dermatoglyphic Traits: Population Comparison in Five Endogamous Groups of West Bengal, India. *Anthropol. Anz.*, 63:365-391.
- Karmakar, B., K. Yakovenko and E. Kobylansky. 2006. Mode of Inheritance of Dermatoglyphic Pattern Intensity Index on Fingers in Five Indian Populations: A Comparative Study Between Individual Trait and Its Factor. *Am. J. Hum. Biol.*, 18:377-386.
- Katznelson, M. B., M. Bejerano, K. Yakovenko and E. Kobylansky. 1999. Relationship Between Genetic Anomalies of Different Levels and Deviations in Dermatoglyphic Traits. Part 4: Dermatoglyphic Peculiarities of Males and Females with Down Syndrome. Family Study. *Anthropol. Anz.*, 57:193-255.
- Kaur, V., T. P. Kaur, M. Sharma, T. Yadav and A. Malhotra. 2018. Dermatoglyphics, the Hidden Potential in Dentistry - A Review. *J. Adv. Med. Dental Sci. Res.*, 6(10):110-113.
- Khatoun, S. 1986. *Study of Twins and Reliability of Creases in Twin Zygosity Diagnosis*. Ph. D. Thesis. University of Sagar, Sagar (India).
- Kobylansky, E., S. Micle, B. Arensburg and H. Nathan. 1983. The Reciprocal Influence of the Different Finger Pattern Types on Their Ridge Count Values. *Anthropol. Anz.*, 41:209-215.
- Kollmann, A. 1883. *Der Tastapparat der Hand der Menschlichen Rassen Undder Affen in Seiner Entwicklung und Gliederung*. Leipzig and Hamburg.
- Krishnan, T. and B. M. Reddy. 1994. Geographic and Ethnic Variability of Finger Ridge Counts: Biplots of Male and Female Indian Samples. *Ann. Hum. Biol.*, 21:155-169.
- Kumbnani, H. K. 1963. Finger Dermatoglyphics - Study of Pandits of Kashmir. *Anthropologist*, 10:21-28.
- Kumbnani, H. K. 1964. The Occurrences of Symmetrical and Asymmetrical Terminations of Main Line D, C, B and A in Mohammedans of Rajasthan. *Acta. Gen. Med. Gemell. Twin Res.*, 13(1):90-98.
- 2007. Dermatoglyphics: A Review. *Anthropologist (Special)*:3:285-295.
- Kusuma, Y. S., B. V. Babu and J. M. Naidu. 2002. Finger Ridge Count Correlations Among Four Tribes of Andhra Pradesh, India. *Coll. Antropol.*, 26:319-323.
- Lambourne, G. 1984. *The Fingerprint Story*. Harrap. London.
- Lauter, B. 1912. *History of the Finger-print System*. Annual Report, Smithsonian Institute. 631-652.
- Loesch, D. Z. and R. M. Huggins 1992. Fixed and Random Effects in the Variation of the Finger Ridge Count: A Study of Fragile X Families. *Am. J. Hum. Genet.*, 50:1067-1076.
- Luxenberg, J. S., C. C. Plato, K. M. Fox, R. P. Friedland, S. L. Rapoport and J. F. Reynolds. 1988. Digital and Palmar Dermatoglyphics in Dementia of the Alzheimer Type. *Am. J. Med. Genet.*, 30:733-740.
- Malhotra, K. C. and D. C. Rao. 1982. Path Analysis of Total Palmar Pattern Ridge Counts. *Am. J. Phys. Anthropol.*, 58:187-189.
- Malhotra, K. C., B. Karmakar, B. M. Reddy and M. Vijaykumar. 1987. Ulnar Triradius (tu) Border Triradius (tb) and Extralimital Triradius (text), the Neglected Triradii on Human Palm. *Dermatoglyphics*, 15:1-6.
- Mardia, K. V., Q. Li and T. J. Hainsworth. 1992. On the Penrose Hypothesis on Fingerprint Patterns. *Math. Med. Biol.*, 9:289-294.
- Martin, J. and D. Portables. 1986. Quantitative Finger Dermatoglyphics in a Spanish Population. *Anthropol. Anz.*, 44:227-238.
- Miki, T., T. Tanaka, H. Hasekura and T. Furuhashi. 1960. Investigations on the Finger Prints of the Lepchas and the Khasis. *I. Proc. Jpn. Acad.*, 36:291-294.
- Miki, T., and H. Hasekura. 1961. On the Palm Pattern of Lepchas and Khasis. *Zinruigaku Zasshi.*, 69:67-71.
- Minakata, K. 1894. The Antiquity of the Finger Print Method. *Nature*, 51:199-200.
- Mukherjee, A. 1990. Inbreeding Effects on Bilateral Asymmetry of Dermatoglyphics Patterns. *Am. J. Phys. Anthropol.*, 81:77-89.
- Mukherjee, D. P. 1966. Inheritance of Total Number of Triradii on Fingers, Palms and Soles. *Ann. Hum. Genet.*, 29:349-353.
- Mukherjee, D. P. P. C. Reddy and M. Lakshmanudu. 1980.

- Dermatoglyphic Effects of Inbreeding. *J. Ind. Anthropol. Soc.*, 15:67-79.
- Mulvihill, J. J. and D.W. Smith. 1969. The Genesis of Dermatoglyphics. *J. Paediatr.*, 75:579-589.
- Myers, H. J. II. 1938 The First Complete and Authentic History of Identification in the United States. *Finger Print Ident. Mag.*, 20:3-31.
- Mutalik, G. S., M. V. Phadke and V. A. Lokhandwalla. 1969. Use of Dermatoglyphics in Paediatric Diagnosis. *Indian Pediatr.*, 6:313-319.
- Naugler, C. T. and M. D. Ludman 1996. A Case Control Study of Fluctuating Dermatoglyphic Asymmetry as a Risk Marker for Developmental Delay. *Am. J. Med. Genet.*, 66:11-14.
- Narahari, S., S. K. Malati and K. R. S. S. Dev. 2008. The Khond: A Dermatoglyphic Study. *Anthropologist.*, 10:207-210.
- Parvatheesam, C., B., V. Babu and G. Sudhakar. 1993. Palmar Dermatoglyphics of Relli and Manne Dora Populations of Andhra Pradesh. *J. Hum. Ecol.*, 4:155-157.
- Penrose, L. S. 1968. Memorandum on Dermatoglyphic Nomenclature. *Birth Defects: Original Article Series.* 4:1-12.
- Palyzová, D., Kuklík, M., Beránková, M. and B. Schaumann. 1991. Dermatoglyphics in Juvenile Hypertension. *Anthropol Anz.*, 49:361-366.
- Popich, G. A. and D. W. Smith. 1970. The Genesis and Significance of Digital and Palmar Band Creases: Preliminary Report. *J. Pediatr.*, 77:1017-1023.
- Preus, M. 1972. Dermatoglyphics and Syndromes. *Am. J. Diseases Children*, 124:933-943.
- Priya, N. S., P. Sharada, N. Chaitanya Babu and H. C. Girish 2013. Dermatoglyphics in Dentistry: An Insight. *World J. Dent.*, 4:144-147.
- Rao, V. V., A. Ramesh, M. Vijayakumar and J. S. Murty 1983. Digital Dermatoglyphics in Some Tribal Populations of Andhra Pradesh, India. *Acta. Anthropogenetica.*, 7:27-34.
- Ravindranath, R. and I. M. Thomas. 1995. Finger Ridge Count and Finger Print Pattern in Maturity Onset Diabetes Mellitus. *Indian J. Med. Sci.*, 49:153.
- Reddy, S. K., and R. V. Reddy. 2001. Genetic Distance and Variation Among Reddis of Andhra Pradesh: Quantitative Finger Dermatoglyphics. *J. Hum. Ecol.*, 12:95-100.
- Reed, T. 1995. On the Association Between Adult Blood Pressure and Dermatoglyphics as Prenatal Markers of Development. *J. Hyperten.*, 13:595-601.
- Rothhammer, F., R. Chakraborty and E. Llop. 1979. Dermatoglyphic Variation Among South American Tribal Populations and Its Association With Marker Gene, Linguistic, and Geographic Distances. *Birth Defects.*, 15:269-276.
- 1977. A Collation of Marker Gene and Dermatoglyphic Diversity at Various Levels of Population Differentiation. *Am. J. Phys. Anthropol.*, 46:51-59.
- Salam, E. A., A. Hafiez, Z. Kerdasi, F. Aiad and K. Z. Mahmoud. 1984. Genetic Studies in Varicocele Infertility II: Dermatoglyphic Pattern. *Andrologia.*, 16:102-110.
- Sarkar, D. 1969. A Study of Fingerball Dermatoglyphics in West Bengal. *Man in India*, 49:378-387.
- 1971. Dermatoglyphics Study of Some Caste and Tribes of Jalpaiguri District, West Bengal. *Anthropol.*, 18:49-56.
- 1972. A Dermatoglyphics Study Among the Mech of Jalpaiguri District, West Bengal. *Anthropol.*, 18:49-56.
- Schaumann, B. and M. Alter 1976. *Dermatoglyphics in Medical Disorders*. New York. Springer-Verlag.
- Sen, D. 1968. Dermatoglyphics of Palm and Finger Balls of the Kashmiri Muslims. In: P.C. Biswas and A. Sharma (Eds.) *Proceedings Volume of International Symposium on Dermatoglyphics*. Delhi University, Delhi. pp. 215-227.
- Sen, J. and N. Mondal. 2008. Sex Variation and Mongoloid Strain in Dermatoglyphic Patterns Among the Rajbanshi: An Indigenous Community of North Bengal. *Int. J. Anthropol.*, 23:37-49.
- Sen, J., T. Kanchan and N. Mondal. 2011. A Comparison of Palmar Dermatoglyphics in Two Ethnic Indian Populations of North Bengal, India. *J. Forensic Sci.*, 56:109-117.
- Sengupta, M. and B. Karmakar. 2004. Mode of Inheritance of Finger Dermatoglyphic Traits Among Vaidyas of West Bengal, India. *Ann. Hum. Biol.*, 31:526-540.
- Shukla, B. R. K. and S. Rastogi. 1976. The Palmar Dermatoglyphics of the Rastogis of Lucknow. *Eastern Anthropol.*, 12:45-57.
- Simsek, S., N. Karakaya and T. Fistik 1998. Dermatoglyphic Analysis in Children with Cerebral Palsy. *Neurobiology*, 6:373-380.
- Singh, I. P. and M. K. Bhasin 1979. Ethnic and Geographic Frequency Distribution of Dermatoglyphic Traits in India - A Review. *Birth Defects Original Article Series.*, 15:347-387.
- 2004. *A Manual of Biological Anthropology*. Kamla-Raj Enterprises, Delhi.
- Singh, R. D. 1961. Digital Pattern Frequency and Size Variation in Some Castes of Uttar Pradesh. *Eastern Anthropol.*, 14:169-181.
- Singh, D. N., S. Hara, K. Davis, and E. P. Crump. 1978. Inheritance of Extra Triradii of Palmar Interdigital Areas II and IV. *Ann. Genet.*, 21:157-160.
- Singhrol, C. S. and M. Roy. 1981. Frequency of Patterns on the Plantar Configurational Areas of the Distal Sole Among Telis of Chhattisgarh. *Proceedings of the Indian Science Congress Association, Part III (Mysore)*.
- Slabbekoorn, D., S. H. Van Goozen, G. Sanders, L. J. Gooren and P. T. Cohen-Kettenis. 2000. The Dermatoglyphic Characteristics of Transsexuals: Is There Evidence for

- an Organizing Effect of Sex Hormones. *Psychon. Euro. Endocrinol.*, 25:365-75.
- Sodhi, G. S. and J. Kaur. 2003. World's First Conviction on Fingerprint Identification. *National. Crime. Records Bureau. Gaz.*, 15:1-3.
- 2005. The Forgotten Indian Pioneers of Fingerprint Science. *Curr. Sci.*, 88(1):185-191.
- Sokal, R. and G. Livshits. 1993. Geographic Variation of Six Dermatoglyphic Traits in Eurasia. *Am. J. Phys. Anthropol.*, 90:393-407.
- Spier, J. 2013. *The Hands of Children: An Introduction to Psycho-Chirology*. Routledge.
- Taneja, V., N. Taneja, C. Anand, and N. K. Mehra 1993. Dermatoglyphic Patterns of Patients With Rheumatoid Arthritis. *Indian J Med. Res.*, 98:143-146.
- Tornjova Randelova, S. G. 1994. Some Aspects on the Dermatoglyphics of Normal and Defective Children in Bulgaria. *Anthropol Anz.*, 52:351-355.
- Verma, I. C. 1970. Dermatoglyphics in Clinical Pediatrics. *Indian J. Pediatr.*, 37:583-589.
- Weinreb, H. J. 1986. Dermatoglyphic Patterns in Alzheimer's disease. *J. Neurogenet.*, 3(4):233-246.
- Wertheim, K and A. Maceo 2002. The Critical Stage of Friction Ridge and Pattern Formation. *J. Forensic. Ident.*, 52:35-85.
- Wilder, H. H. 1902. Palms and Soles. *Am. J Anatomy.*, 1:423-441.
- Wilton, G. W. 1938. *Fingerprints: History, Law and Romance*. W. Hodge and company, limited: London.