PREVENTION AID IN QUALITATIVE ANALYSIS OF DERMATOGLYPHIC PATTERNS IN RELATION TO TYPE 2 DIABETES MELLITUS: A PILOT STUDY

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SUMMARY

Objectives: The significant differences in the fingerprint pattern frequencies in type 2 diabetes mellitus (T2DM) patients and controls could be a possible way to identify patients with a risk of developing T2DM. The results could be used in the earlier diagnosis and treatment. The study was undertaken to find out the reliability of fingerprint patterns as a possible predictive tool for T2DM diagnosis.

Methods: A total of 1,260 fingerprints were acquired using the optical contact sensor DactyScan 26i. The results of the qualitative analysis of the fingerprint pattern frequencies have been compared between T2DM patients and controls and also between the fingers to each other. We have detected the frequency of patterns: plain arch (Ap) and tented arch (At), radial loop (Lr), ulnar loop (Lu), double loop (Ld), spiral whorl (W), and plain whorl (concentric) (Wp). Statistical analysis was performed using Pearson's chi-square by Statistica ver. 12.

Results: We found statistically significant differences ($p < 0.05$) in the frequency of individual dermatoglyphic patterns among patients with diabetes and healthy controls as follows: in the left thumb (L1) in a radial loop, double loop and spiral whorl pattern; in the left middle finger (L3) in a tented arch and radial loop; in the right ring finger (R4) in a tented arch, spiral and plain whorl; and in the right little finger (R5) in a tented arch and spiral whorl.

Conclusion: Fingerprint pattern frequencies might be used as another screening tool and indicator in T2DM prevention. Qualitative analysis of fingerprint patterns could be useful regarding the additional prevention diagnostics of T2DM in the population.

Key words: dermatoglyphics, diabetes prevention, diabetes screening, fingerprints

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INTRODUCTION

Diabetes mellitus (DM) is a multisystem metabolic disorder characterized by hyperglycaemia resulting from defects in insulin secretion, action, or both (1, 2). Chronic hyperglycaemic conditions result from resistance to insulin actions on peripheral tissues as well as inadequate secretion of insulin and impaired suppression of glucagon secretion in response to ingested glucose (3, 4). Type 1 DM (T1DM) with the absolute deficiency of insulin secretion is caused by a lack of insulin secretion by beta cells of the pancreas (insulin-dependent diabetes mellitus IDDM). Type 2 DM (T2DM) with a combination of resistance to insulin action and inadequate compensatory insulin secretory response is caused by decreased sensitivity of target tissues to insulin (non-insulin-dependent diabetes mellitus NIDDM) (1, 4). T2DM was first described in 1988 as a component of the metabolic syndrome (2). T2DM is more common and is also genetically influenced (5) with a greater genetic association than T1DM (4). T2DM is a heterogenous disorder that occurs more in adults than in children and results from the interaction between the genetic, environmental and behavioural risk factors (e.g., stress, obesity and overeating, lack of exercise, sedentary lifestyle, excessive energy intake, lack of varied and quality diet) (6). Visceral obesity is observed in most patients with T2DM and it is related to insulin resistance. In addition, hypertension and dyslipidaemia are often present (2). T2DM is the predominant form of diabetes (90% of all DM cases) (4).

It is recognized that diabetes is increasing in occurrence as a global disease. Especially T2DM represents a major threat to the public health worldwide. The prevalence of DM for all age groups worldwide was estimated at 4.4% and the total number of adults with DM will reach 370 million by 2030 (4, 5, 7). DM will be the 7th leading cause of death and T2DM will make up about 80% to 90% of these cases (2, 5). Globally, the number of DM patients has more than doubled over the past three decades. T2DM especially is increasingly observed among children and adolescents (8). There is also a fast-increasing trend in the prevalence of this disease in Slovakia (6).

It will reach the top of the mortality and morbidity causes along with cardiovascular diseases and cancer (approx. 3.2 million deaths yearly) (7). The prevalence of T2DM, specific complications, and the presence of accompanying diseases make diabetes one of the main public health problems in the world today. Diabetes is also a costly disease for world economies (3, 4). This has intensified scientific understanding of its aetiology and pathogenesis. The aim is to improve its management to reduce the disease incidence and its impacts on lives and economies. Studies are continuously being done with a multidisciplinary approach to identify the potential early biomarkers of diabetes (4, 5). New predicting methods and better-shaped prevention programmes are needed to reduce diabetes onset (5, 8).

Dermatoglyphics and Fingerprint Patterns

Papillary lines (flow-like ridges) are the elevated areas of skin presented on the epidermis surface of the palmar and plantar side of the human hand and sole, including the fingers and toes. They are not created on the skin surface of other parts of the body. Papillary lines have a height of 0.1 to 0.4 mm and a width of 0.2 to 0.7 mm (9). Their formation depends on the initial conditions of the embryonic development and they are unique to each person (10). A fingerprint is a trace, print, or scan of the skin friction ridges that serve as a unique personal, natural, visible identification marker. It is used considerably to establish human identity because even monozygotic twins do not have the same fingerprints (11, 12).

Fingerprint patterns result from the processes during the first trimester stage of the human embryo. The patterns originate during gestational weeks 11 to 24 (7). Dermatoglyphic traits are formed under genetic control early in development but may be affected by environmental factors (5). The interaction of the foetus and its environment causes pressure differences on friction ridge skin, which ultimately form unique fingerprints for each individual (13). The maternal environment, gene deviants, and chromosomal aberrations can affect ridge formation during intrauterine development (7). The resulting fingerprints remain fixed permanently and do not change throughout life, except for the dimensions related to the growth of the human body (14). Once the configuration of dermal ridges is formed it won't be affected by age and environmental changes during the postnatal life period. It has predicting potential regarding various genetic and acquired disorders with a genetic influence (15). The configuration of ridges and furrows has applied value in various diseases and syndromes. Therefore, they could be used as a reliable indicator to indicate gene or chromosomal abnormalities and genetic damage (14, 16).

Dermatoglyphics has numerous utilities in human biology, genetics, anthropology, morphology, and anatomy, and also in the diagnostics of genetic based diseases and health disorders (17). There is an important connection between the types of dermatoglyphic patterns on the fingerprints and some health disorders and diseases (7). These patterns are used as a diagnostic tool in several diseases with a strong hereditary background and become an identification biomarker for diabetes. They can be used as additional support for the diagnosis of various hereditary disorders including T2DM (1, 14, 15).

Diabetes is a disease with a strong genetic basis that has a hereditary background. An offspring of two diabetic parents has an 80% risk of having diabetes (7, 14). Genetic factors are very significant, T2DM develops slowly and occurs most often in overweight patients (15). There is a well-known connection between dermatoglyphics and T2DM, which has a rich genetic charge. It is illustrated by a high index of disease concordance in monozygotic twins (about 100%) and a higher risk (20–40%) of the appearance of disease in relatives of the affected people versus a 2–6% risk in the normal population (18).

Dermatoglyphic investigation is cost-effective; it can help in predicting the phenotype of a possible future illness (14) and can be used as a way of measuring gene expression determined by the early prenatal environment (15). The relevance of dermatoglyphics is in the prognosis and also in the identification of people with a genetic predisposition to develop certain diseases. It can be useful in screening populations at disease risk; so a watch can be kept for the early onset of the symptoms (19). Dermatoglyphics are genetically determined and used as a diagnostic tool. If a significant correlation exists between fingerprint patterns and T2DM, it will be possible to identify the high risks of developing T2DM patients (5). Therefore, the present study intends to evaluate the relationship between dermatoglyphic patterns and T2DM.

MATERIALS AND METHODS

In our research we qualitatively analysed 630 fingerprints of 63 patients with T2DM (38 men and 25 women aged between 40 and 70); and 630 fingerprints of 63 healthy individuals (control group of 19 men and 44 women aged between 35 and 55). Both groups were from the same population and geographical area of the Eastern part of Slovakia (Prešov Region). Fingerprints of T2DM patients were acquired at a Diabetic Clinic in Sabinov only on an optional basis of cooperation; as well as in the case of the control group. Fingerprints were acquired using an optical contact sensor DactyScan 26i (Green Bit S.p.A., Italy). The qualitative analysis was performed manually (Fig. 1) according to previous studies (modified) (20).

Frequencies of patterns were compared between T2DM and the control group mutually and also between the fingers to each other in both groups. Fingers were marked as follows: left thumb (L1), left index finger (L2), left middle finger (L3), left ring finger (L4), left little finger (L5), and similarly on the right hand (R1,

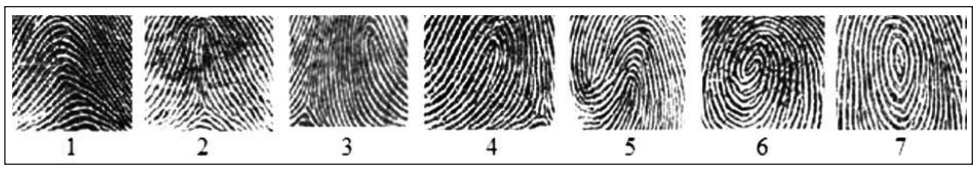

Fig. 1. *Basic dermatoglyphic patterns.*

1 – plain arch (Ap), 2 – tented arch (At), 3 – ulnar loop (Lu) (in the right hand), 4 – radial loop (Lr) (in the right hand), 5 – double loop (Ld), 6 – spiral whorl (W), 7 – plain whorl (concentric) (Wp)

R2, R3, R4, R5). We have detected the frequency of patterns: plain arch (Ap) and tented arch (At), radial loop (Lr), ulnar loop (Lu), double loop (Ld), spiral whorl (W), and plain whorl (concentric) (Wp) (Fig. 1). We searched significant association between the fingerprint pattern frequencies of T2DM and control group and also the difference in the frequency of occurrence of each pattern of fingerprints.

Fingerprint pattern frequency values were recorded and statistically evaluated by Pearson's chi-square in Statistica ver. 12. The p-value < 0.05 was considered a statistically significant result.

RESULTS

In our study, we aimed to evaluate dermatoglyphic analysis of fingerprint patterns in T2DM patients, in healthy controls and their mutual comparison. Table 1 shows the frequency and distribution of fingerprint patterns in the left and right hand in both groups. The radial loop pattern was presented with the highest frequency (56.19%) on the left hand in the T2DM group. The ulnar loop pattern was presented in 55.23% on the right hand in both groups with the second highest frequency. The lowest incidence of the plain whorl was recorded on the left hand in the control group (0.63%).

If there were significant correlations between the fingerprint patterns of T2DM patients and controls and the difference in the frequency of fingerprint patterns, it would be a possible way to identify patients with a high risk of developing T2DM. The results could be used in an earlier diagnosis and treatment. Table 2 shows the results of statistical analysis with a significant difference ($p < 0.05$) in the frequency (%) of radial loop (Lr), double loop (Ld), and spiral whorl (W) patterns between the T2DM and control group compared mutually on the left thumbs (L1). Incidence of the radial loop (52.38%) and spiral whorl (26.98%) was found significantly higher in the T2DM subjects (compared to 44.44% and 14.29%, respectively, in healthy controls) while the frequency of double loop (30.16%) was higher in the control group compared to 11.11% in T2DM subjects (on the finger L1 – left thumb).

The incidence of a tented arch (At) was found significantly higher ($p<0.05$) in the control group (19.05%) compared to the T2DM group (3.17%) in the left middle finger (L3). The radial loop (Lr) frequency was significantly higher ($p<0.05$) in the T2DM group (66.67%) compared to the control group (52.38%).

Tented arch (At) incidence in the control group (9.52%) was found significantly higher ($p<0.05$) compared to the T2DM group (0.00%) in which we did not find this type of pattern in the right ring fingers (R4). Spiral whorl (W) and plain whorl (concentric) (Wp) frequencies (42.86% and 11.11%) were significantly higher in T2DM subjects compared to the incidence in controls (34.92% and 3.17%, respectively) in the right ring fingers (R4).

In the statistical comparison of fingerprints of the right little fingers (R5), we have found significant differences ($p<0.05$) in the tented arch (At) and spiral whorl (W) frequency. Tented arch (At) was more frequent in the control subjects (7.94%) compared to the T2DM group in which we did not find this type of pattern (0.00%). Spiral whorl (W) was found with higher frequency in the T2DM subjects (20.63%) compared to healthy controls (11.11%).

There were no significant differences found in the other statistical mutual comparisons of L2, L4, L5, R1, R2, and R3 fingers between the T2DM and control group in the frequencies of all analysed fingerprint patterns ($p>0.05$).

Table 1. *Frequency and distribution of fingerprint patterns*

Pattern	Left hand		Right hand	
	T2DM (%)	C (%)	T2DM (%)	C (%)
Ap	5.08	2.86	3.18	2.54
At	4.13	14.92	2.86	11.43
Lu	2.54	2.54	55.23	55.23
Lr	56.19	49.21	1.58	1.90
Ld	4.13	11.75	4.13	5.09
W	26.35	18.09	29.84	21.91
Wp	1.58	0.63	3.18	1.90

T2DM – patients' group; C – control group; Ap – plain arch; At – tented arch; Lu – ulnar loop; Lr – radial loop; Ld – double loop; W – spiral whorl; Wp – plain whorl (concentric)

DISCUSSION

We have found a radial loop on the left hand in the T2DM group as a pattern with the highest frequency (56.19%) in our study. Statistically significant differences ($p<0.05$) in the percentage of patterns between the T2DM and control group were found in the cases of L1, L3, R4, and R5 fingers in their mutual comparison. The most common pattern on fingerprints was the ulnar loop, followed by a whorl, according to a scientific study that evaluated the frequency of dermatoglyphic patterns among

Table 2. *Statistically significant differences in fingerprint patterns variability*

Pattern	Finger L1		p-value	Pattern	Finger R4		p-value
	T2DM (%)	C (%)			T2DM (%)	C (%)	
Lr	52.38	44.44	0.037	At	0.00	9.52	0.023
Ld	11.11	30.16		W	42.86	34.92	
W	26.98	14.29		Wp	11.11	3.17	
Pattern	**Finger L3**		**p-value**	**Pattern**	**Finger R5**		**p-value**
	T2DM (%)	**C (%)**			**T2DM (%)**	**C (%)**	
At	3.17	19.05	0.025	At	0.00	7.94	0.018
Lr	66.67	52.38		W	20.63	11.11	

T2DM – patients' group; C – control group; At – tented arch; Lr – radial loop; Ld – double loop; W – spiral whorl; Wp – plain whorl (concentric)

the inhabitants of eastern Slovakia (20). This is in concordance with our findings. Another dermatoglyphic study reported and also confirmed the ulnar loop as the most common type of pattern (59.72%), followed by the whorl (35.53%). According to the mentioned study, the occurrence of dermatoglyphic patterns does not depend on ethnic origin (21).

There is a conformity between our findings for individual fingerprint patterns and the results of another study in a higher percentage of whorls on the left thumbs of diabetic patients (20%) compared to the left thumb patterns in controls (5%). The authors also suggested that dermatoglyphics might reflect disorders during foetal development (22). The whorl (53%) was found as the most frequent fingerprint pattern and then the loop pattern with a frequency of 45%, they did not find any arch pattern in the group of diabetic patients (7). That contrasted with our results because we found the highest percentage in loops and then in whorls. Significant differences were observed in male and female groups of diabetic patients and controls in another study. In the study, it was also noted that whorls were significantly increased whereas loops and arches were decreased in T2DM groups compared to healthy controls (1), which also matches our present study.

The comparison of fingerprint patterns between the healthy subjects and diabetic patients did not confirm any association ($p > 0.05$). The authors reported a higher percentage of loop and whorl patterns in healthy subjects and a higher percentage of arch patterns in diabetic patients. Compared to our presented study there is a higher incidence of loop and whorl patterns in the T2DM patients' group and the incidence of arch patterns is higher in the control subjects. In the study, they also compared fingerprint variability between male diabetic patients and healthy subjects. They found a significant association only on the right hand ($p < 0.05$) probably due to differences between loop and arch patterns between the male diabetic patients and control healthy subjects. Likewise, they found no association between the fingerprint pattern and diabetes in both hands in comparing normal subjects and female diabetic patients. The study suggests that there is a higher possibility of developing diabetes in males with an arch pattern in the right hand (11). According to another research, a higher incidence in the occurrence of ulnar loops, simple and tented arches were reported in diabetic patients, but simple and spiral whorls were found more frequent in healthy controls (14). These results do not agree completely with our study where we found an equal incidence of ulnar loops in comparing both groups and tented arches were found higher in the control group. Only plain arches were highly present in diabetic patients compared to controls. In addition, even whorls were more frequently found in diabetic patients than in controls (14).

The fingerprint patterns showed no significant differences in ulnar loops, radial loops, and tented arches while plane arches of male T2DM patients increased significantly ($p < 0.05$) and whorls of male T2DM patients decreased significantly ($p < 0.05$) compared with the group of healthy male controls (15). The reported research also compared the distribution of fingerprint patterns in female T2DM patients and healthy female controls and found a higher frequency of ulnar loops, radial loops, and plane arches in female diabetic patients while the whorls decreased significantly ($p < 0.05$). This is in concordance with our study where we found a higher frequency of plain arches (8.26%) in T2DM patients compared to healthy controls (5.40%). On the other hand, we found a lower frequency of whorl patterns in healthy controls (42.53%) compared to T2DM patients (59.95%). The study of dermatoglyphics is useful in the identification and investigation of various diseases based on variations in fingerprint patterns (15).

Several other studies were focused on the issue of dermatoglyphic patterns in connection with a certain type of disease – especially congenital, genetically conditioned diseases. A certain correlation was demonstrated here not only in the fingerprints of dermatoglyphic patterns but also in the papillary patterns of the palm (23, 24). Statistically significant ($p < 0.05$) differences were shown in the high occurrence of whorls in a group of women with breast cancer (48.7%). It was also manifested in almost the same high percentage representation in a group of women with a high predisposition for breast cancer formation and development (47.4%). It contrasted with the control group (27.5%). Dermatoglyphics can therefore play an important role in identifying women at increased risk for developing breast cancer, which can lead to earlier measures or contribute to faster initiation of therapy (23). In cancer patients, whirls occurred at a significantly higher frequency (40.53%) compared to the control group, especially on the ring finger and little finger of the right hand ($p < 0.05$) (24).

Statistically significant differences were also found in frequencies of fingerprint patterns in relation to bronchial asthma ($p < 0.05$). In the group of patients with bronchial asthma was the incidence of ulnar loops higher (55.8%) compared to healthy controls (48.6%). On the contrary, the presence of arches was significantly lower in patients with bronchial asthma (5.4%) compared to the control group (12.0%). Similarly, when comparing the occurrence of arches (A) and ulnar loops (Lu) between the given groups, significant differences were found (25). Some studies also reported strong statistical significance of the dermatoglyphic patterns in pulmonary tuberculosis patients (26), but some did not record significant results (27). Another dermatoglyphic study also investigated associations of fingerprint patterns with cardiovascular disease (e.g., myocardial infarction, ischaemic heart disease) without significant statistical dependence (28).

CONCLUSIONS

Dermatoglyphic patterns may be used as an additional screening and prevention tool with the potential to predict the expectance of T2DM. It can serve as a helpful and budget mechanism to select individuals from a larger population for further investigation to confirm the possibility of T2DM onset. Fingerprint patterns show relative similarity among close relatives, suggesting genetic determination, which may be helpful also in diagnosing and predicting hereditary diseases. The presented findings could be used for the early diagnosis and treatment of this disease based on further research. Subsequently, we propose a gradual pilot screening in cooperation with paediatricians (e.g., in the Prešov and Košice Regions). The newly acquired results in larger sets of probands will help to confirm the presented pilot testing data. The cooperation with paediatricians will enable the implementation of these procedures, e.g., during preventive examinations of paediatric patients at the level of primary prevention. Early examination (even confirmation of the diagnosis) can reduce the prevalence of T2DM, and reduce its impact on the patient. Also, further studies should be carried out with larger samples of T2DM patients with

an emphasis on new findings regarding possible sex differences in association with fingerprint patterns and diabetes.

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Conflicts of Interest

None declared

REFERENCES

1. Mehta AA, Mehta AA. Study of fingerprint patterns in type II. diabetes mellitus. Int J Anat Res. 2015;3(2):1046-8.
2. Baynest HW. Classification, pathophysiology, diagnosis and management of diabetes mellitus. J Diabetes Metab. 2015;6(5):1000541. doi: 10.4172/2155-6156.1000541.
3. Carrera Boada CA, Martínez-Moreno JM. Pathophysiology of diabetes mellitus type 2: beyond the duo "insulin resistance-secretion deficit". Nutr Hosp. 2013;28 Suppl 2:78-87.
4. Ozougwu JC, Obimba KC, Belonwu CD, Unakalamba CB. The pathogenesis and pathophysiology of type 1 and type 2 diabetes mellitus. J Physiol Pathophysiol. 2013;4(4):46-57.
5. Mohan S, Jaybhaye PL. Study of fingerprint pattern in patients with diabetes mellitus in a tertiary care centre. IOSR J Dent Med Sci. 2015;14(11):39-41.
6. Mokáň M, Martinka E, Galajda P. [Diabetes mellitus and selected metabolic diseases]. Martin: P+M; 2008. Slovak.
7. Ameer Y, Zafar R, Abbasi AMH, Rasheed MA, Habib H, Salahuddin T, et al. Finger prints pattern variation in diabetic patients. PJMHS. 2014;8(1):162-5.
8. Chen L, Magliano DJ, Zimmet PZ. The worldwide epidemiology of type 2 diabetes mellitus - present and future perspectives. Nat Rev Endocrinol. 2012;8(4):228-36.
9. Porada V. [Criminalistics: (introduction, technique, tactics)]. Plzeň: Vydavatelství a nakladatelství Aleš Čeněk; 2007. Czech.
10. Jain AK, Bolle RM, Pankanti S. Biometrics: personal identification in networked society. New York: Springer; 1996.
11. Umana UE, Bello R, Timbuak J, Ibegbu A, Musa SA, Ikyembe D, et al. Dermatoglyphic and cheiloscopic patterns among diabetic patients: a study in Ahmadu Bello University Teaching Hospital Zaria, Nigeria. J Biol Life Sci. 2013;4(2):206-14.
12. Taduran RJ, Tadeo AK, Escalona NA, Townsend GC. Sex determination from fingerprint ridge density and white line counts in Filipinos. Homo. 2016;67(2):163-71.
13. Gray T. Impact of time, weathering and surface type on fingerprinting. In: Proceedings of The National Conference On Undergraduate Research (NCUR) 2012. The National Conference on Undergraduate Research; 2012 Mar 29-31; Ogden, Utah. Ogden: Weber State University; 2012. p. 1588-96.
14. Padmini MP, Rao BN, Malleswari B. The study of dermatoglyphics in diabetes of North coastal Andhra pradest population. Indian J Fundam Appl Life Sci. 2011;1(2):75-80.
15. Karim J, Saleem A. Dermatoglyphics study of finger prints pattern‘s variations of a group of type II. diabetes mellitus patients in Erbil city. Zanco J Pure Appl Sci. 2014;26:11-6.
16. Igbigbi PS, Msamati BC, Ng'ambi TM. Plantar and digital dermatoglyphic patterns in Malawian patients with diabetes, hypertension and diabetes with hypertension. Int J Diabetes Metab. 2001;9(1-2):24-31.
17. Ahmed AA, Osman S. Topological variability and sex differences in fingerprint ridge density in a sample of the Sudanese population. J Forensic Leg Med. 2016;42:25-32.
18. Ţarcă A. Dermatoglyphics in diabetes mellitus of type 2 (T2DM) or non-insulindependent. J Prev Med 2006;14(1-2):60-70.
19. Fuller IC. Dermatoglyphics: a diagnostic aid? J Med Genet. 1973;10:165-9.
20. Mačurová Ľ. [Dermatoglyphic characteristics of eastern Slovakia]. Prešov: Faculty of Humanities and Natural Sciences, University of Prešov; 2000. Slovak.
21. Wijerathne BT, Rathnayake GK, Adikari SC, Amarasinghe S, Abhayarathna PL, Jayasena AS. Sexual dimorphism in digital dermatoglyphic traits among Sinhalese people in Sri Lanka. J Physiol Anthropol. 2013;32(1):27. doi: 10.1186/1880-6805-32-27.
22. Shield JP, Wadsworth EJ, Hobbs K, Baum JD. Dermatoglyphics, fetal growth, and insulin dependent diabetes in children under 5 years. Arch Dis Child. 1995 Feb;72(2):159-60.
23. Abbasi S, Einollahi N, Dashti N, Vaez-Zadeh F. Study of dermatoglyphic patterns of hands in woman with breast cancer. Pak J Med Sci. 2006;22(1):18-22.
24. Chintamani, Khandelwal R, Mittal A, Saijanani S, Tuteja A, Bansal A, et al. Qualitative and quantitative dermatoglyphic traits in patients with breast cancer: a prospective clinical study. BMC Cancer. 2007;7:44. doi: 10.1186/1471-2407-7-44.
25. Sahana BN, Bannur BM, Patil BG, Hadimani GA, Jose AR. Dermatoglyphic pattern in patients with bronchial asthma: a qualitative and quantitative study. Int J Healthc Biomed Res. 2013;2(1):38-42.
26. Khare ON, Babu SS, Powar BP. Palmar dermatoglyphics in pulmonary tuberculosis. J Anat Soc India. 2005;54(2):64-6.
27. Chaudhari J, Chaudhari JS, Sarvaiya BJ, Patel S, Rathod SP, Singel TC. A study of palmar dermatoglyphics of pulmonary tuberculosis patients in Bhavnagar District. NJIRM. 2011;2(2):50-2.
28. Imran S. Dermatoglyphics as diagnostic tool in myocardial infarction: a study in Gulbarga District. Anatomica Karnataka - Int J. 2012;6(1):7-11.

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