Medical Science

25(114), August, 2021

Incidence of primary palmar creases variants and their correlation to academic performance in KFU College of medicine-2020: A cross-sectional descriptive study

Mohamed Bahgat Ali[1], **Ahmed Waleed Alrashed**[2]✉, **Abdulaziz Emad Alateeq**[2], **Ahmed Mamdouh Alkhawfi**[2]

To Cite:
Ali MB, Alrashed AW, Alateeq AE, Alkhawfi AM. Incidence of primary palmar creases variants and their correlation to academic performance in Kfu College of medicine-2020: A cross-sectional descriptive study. Medical Science, 2021, 25(114), 1803-1811

Author Affiliation:
[1]Department of Biomedical sciences, anatomy division, Faculty of Medicine, King Faisal University, AlAhsa, Saudi Arabia
[2]Medical Interns, Faculty of medicine, King Faisal University, AlAhsa, Saudi Arabia

Contact Information

Ahmed Waleed Alrashed:	ahmedalrashid996@gmail.com
Mohamed Bahgat Ali:	drbahgat960@gmail.com
Abdulaziz Emad Alateeq:	mr.abdulaziz-2013@hotmail.com
Ahmed Mamdouh Alkhawfi:	pro_1415@outlook.com

✉**Corresponding author**
Medical Interns, Faculty of medicine, King Faisal University, AlAhsa, Saudi Arabia
Email: ahmedalrashid996@gmail.com

Peer-Review History
Received: 02 June 2021
Reviewed & Revised: 03/June/2021 to 14/July/2021
Accepted: 15 July 2021
Published: August 2021

Peer-review Method
External peer-review was done through double-blind method.

ABSTRACT

Background: Most human palms present have primary creases, but some present only 1-2 creases. PIC model described 21 variants. Previous studies showed great variation in different variants'incidence in different countries and ethnic groups. Correlation between PIC variants and students' academic performance is proposed. This study aimed to describe different PIC variants incidence in KFU College of medicine Saudi male students and assessing relationship between variants' types and academic performance. *Methodology:* A cross-sectional study conducted on 175 KFU College of medicine male students, years 1-4. Each student signed data collection form and recorded his data. PIC patterns of both hands were recorded and photograph of both palms was picked. Data were statistically analyzed using IBM SPSS 24th version. *Results:* Out of previously described 21 PIC variants, only 10 variants found in students' palms (310, 300, 311a, 311b, 312, 321c, 321d, 200, 201, 211). Our study revealed new variants (PIC 320, 400, 410,510). There was high incidence of bilateral symmetrical variants. Commonest variant was PIC 310 and 300.Academic performance was higher in students having bilateral symmetrical variants, PIC (300–300) than (310–310). Within PIC 310-310, higher performance was present in students having symmetrical meeting points. Academic performance was highest in bilateral two-creases (4.75±0.35) than in unilateral two-crease (3.67±0.52) variants. *Conclusions*: Similarity of variants in both palms was associated with higher academic performance (more prominent in those with similarity in points of meeting). Presence of new variants raises importance of performing further studies to find other new variants.

Keywords: Palmar creases, PIC, Academic performance, incidence, Saudi male students

1. INTRODUCTION

There are 3 primary palmar creases in most human hands; radial longitudinal crease (RLC), proximal transverse crease (PTC), and distal transverse crease (DTC). However, some primary creases may not be present in some individuals. Depending on numbers of Primary creases (P: 1-3), Intersections of primary creases (I: 0 – 2) and Complete transverse Creases (C: 0 – 2), Van Mensvoort (2009) described 21 different variants of primary palmar creases (PIC model), each formed of 3 digits. Palmar transverse creases may be incomplete or complete. Offei et al., (2014) used PIC model to study incidence of palmar creases variants and their relation to academic performance in Ghanaian secondary school students.

The primary palmar creases develop in embryos between 3rd and 5th months (same period of brain development, where genetic makeup plays the major role before environmental factors affect brain development) (Hirsch & Schweighel, 1973; Cannon et al., 1994). This explains high incidence of complete transverse palmar crease (CTC) variants together with intellectual disability in trisomy syndromes (Bagga, 1991; Than et al., 1998; Nazarabadi et al., 2007). The pattern of primary creases is genetically determined (Kong et al., 2006; Gutierez et al., 2012). Previous studies revealed variations in incidence of complete palmar creases in different populations and between different ethnic groups in same population (Dar et al., 1977; Malla et al., 2010; Sharma & Sharma, 2011).

PIC variants without CTC (310 and 300) are the most common variants (Wu et al., 2004; van Mensvoort, 2009; Offei et al., 2014). CTC variants are frequently present in chromosomal abnormalities e.g. Down syndrome (Purvis-Smith, 1972; Rignell, 1987; Nazarabadi et al., 2007). However, presence of CTC has been also reported in normal individuals and many exceptionally intelligent people (Lde Lestrange, 1969; Hernandez, 1985; Moore et al., 2018). Palmar creases are helpful in revealing the anthropologic characteristics of populations of different ethnic origins. For example, frequencies of normal, Simian, and Sydney creases are different between Caucasians and Negroes (Dar et al., 1977). Although general incidence of complete palmar creases in normal Nepalese children was 14.6%, Malla et al., (2010) found great variation in incidence of these Creases in different Nepalese ethnic groups ranging from 2.4 % in Tamang to 71.2 % in Lama. Adetona et al., (2012) reported very low incidence of complete palmar creases in Nigerians.

Palmprints unusual variants can be used as diagnostic indicator to some genetic or medical disorders (Lopuszanska & Jankowska, 2001). Some variants are more frequent in some genetic disorders as Down's, Edward's, Patau's syndromes, mental and psychiatric disorders, Turner and Klinefelter syndromes, fetal alcoholic syndrome and are useful in anthropologic studies (Bagga, 1991; Schaumann & Kimura, 1991; Stevenson et al., 1997; Than et al., 1998; Kava et al., 2004; Jones et al., 2006; Nazarabadi et al., 2007; Park, 2010). CTC variants were associated with delayed development, learning difficulties and/or behavioral disorders (Johnson & Opitz, 1971). Offei et al., (2014) used the PIC model to study incidence of palmar creases' variants in Ghana secondary school students. They correlated different variants with academic achievement of secondary school students.

To our knowledge, no research is done on palmar creases in Saudi Arabia. Identification of most frequent and rare variants of palmar creases will add new information to anthropological characteristics of Saudi community. This study is planned to 1. Describe incidence of different PIC variants in KFU College of medicine Saudi male students. 2. Assess relationship between different variants and students' academic achievement (GPA)

2. SUBJECTS AND METHODS

Research design

Our research is a cross-sectional descriptive study conducted on KFU College of medicine male students in years 1-4, during the period from 27 November 2020 to 27 March 2021.

Research population

Male students of KFU College of medicine were invited to share in our research. 175 male students agreed to share. Their age ranges from 19 to 23 years.

- Inclusion criteria: male KFU medical students at First to fourth years.
- Exclusion criteria: Presence of disfiguring hand lesions.

Procedure

Each student was asked to sign the data collection form and record his name, academic number, GPA. Then, photograph of his palmswas picked and pattern of palmar creases in right and left hands was recorded according to the PIC system (van Mensvoort, 20091). According to PIC model, the pattern of palm creases was described as 3 digits (the first represents the number of the

primary creases (1 – 3), the middle represents number of intersection between the primary creases (0 – 2), the last represents the number of complete transverse creases (0 – 2).

Presence of complete transverse crease was described according to the criteria of CTC as Simian (single transverse crease), Sydney (complete PTC + normal DTC) or Suwon (normal PTC + complete DTC). Also we classified the point of meeting between the radial crease and proximal transverse crease from 1 to 4, according to its level in relation to fingers (point 1 at the level of lateral margin of index finger, point 2 at level of midline of index finger, point 3 at level of the cleft between index and middle fingers, point 4 at level of the midline of middle finger).

Statistical analyses

The data were entered and statistically analyzed using IBM SPSS 24th version.

Ethical consideration

Our research was accepted and permitted by the ethical committee of KFU College of medicine. Participants were properly informed about required data and study objectives and assured about confidentiality of their data. Written consent was obtained from each participant.

3. RESULTS

PIC variants in KFU College of medicine male students

Out of the previously described 21 variants, we found only 10 variants {310, 300, 311a (Sydney crease), 311b (Suwon crease), 312, 321c, 321d, 200, 201, 211} (table 1 and Fig 1-2).

Table 1 PIC variants in the hands of KFU College of medicine students.

PIC variants	Left hand		Right hand		Both hands		Total	
	No	%	No	%	No	%	No	%
310	8	4.57	5	2.86	128	73.14	141	80.57
300	5	2.86	10	5.71	22	12.57	37	21.14
311a (Sydney)	3	1.71	1	0.57	0	0.00	4	2.29
311b (Suwon)	0	0.00	1	0.57	0	0.00	1	0.57
312	0	0.00	2	1.14	0	0.00	2	1.14
321c	0	0.00	1	0.57	0	0.00	1	0.57
321d	1	0.57	0	0.00	0	0.00	1	0.57
200	1	0.57	2	1.14	1	0.57	4	2.29
201	2	1.14	1	0.57	0	0.00	3	1.71
211	1	0.57	1	0.57	1	0.57	3	1.71
New variants								
320	1	0.57	0	0.00	0	0.00	1	0.57
400	0	0.00	1	0.57	0	0.00	1	0.57
410	1	0.57	0	0.00	0	0.00	1	0.57
510	0	0.00	1	0.57	0	0.00	1	0.57

Most frequent variant was 310 (total 141 (80.57%)), mostly symmetrical (both hands of 128-students (73.14%)). Second commonest variant was 300 (total 37 (21.14%)), mostly symmetrical (both hands of 22-students (12.57%)) (Table 1, Fig. 1). Other less frequent variants are shown in Fig. 2, 3 and Table 1. Complete transverse creases (CTC) are shown in Fig. 1d, 2d and Table 1. We observed new variants (not described in PIC system), namely PIC 320, 400, 410, 510 (Fig. 3a, b, c) and a new 310 variant with intersection between PTC and DTC (Fig. 3d).

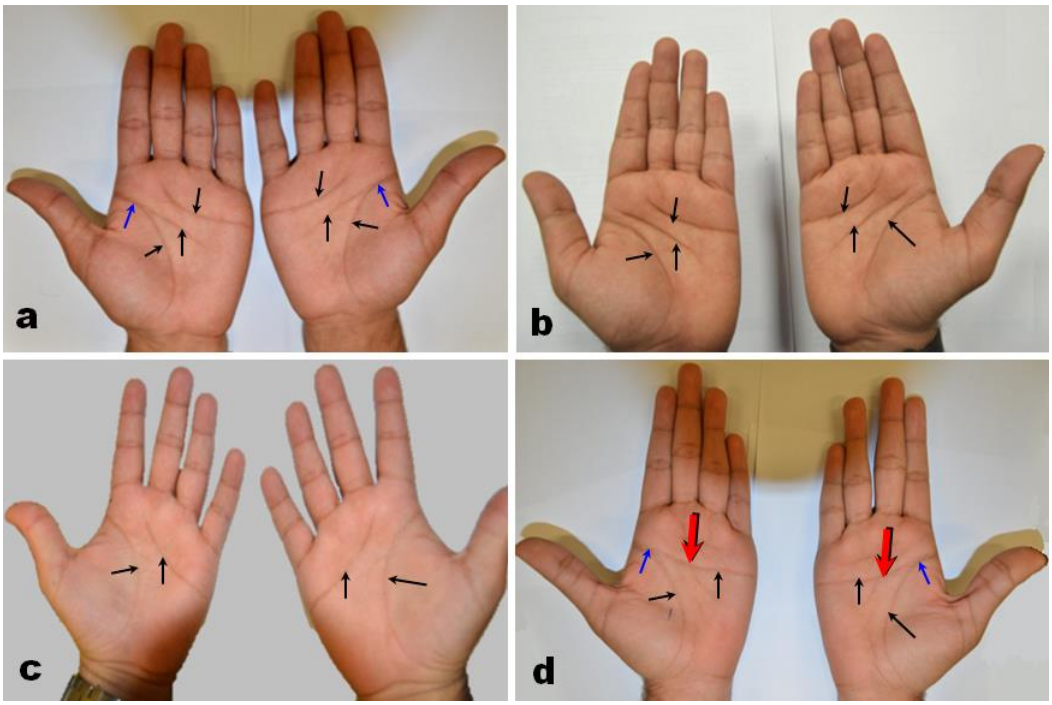

Figure 1 Symmetrical PIC patterns among KFU medical students (Lt. Hand – Rt. Hand): a. 310 -310, b. 300 – 300, c. 200 -200, d. 211 – 211. (Black arrows = number of creases, blue arrows mark points of meeting and red arrows mark complete transverse creases)

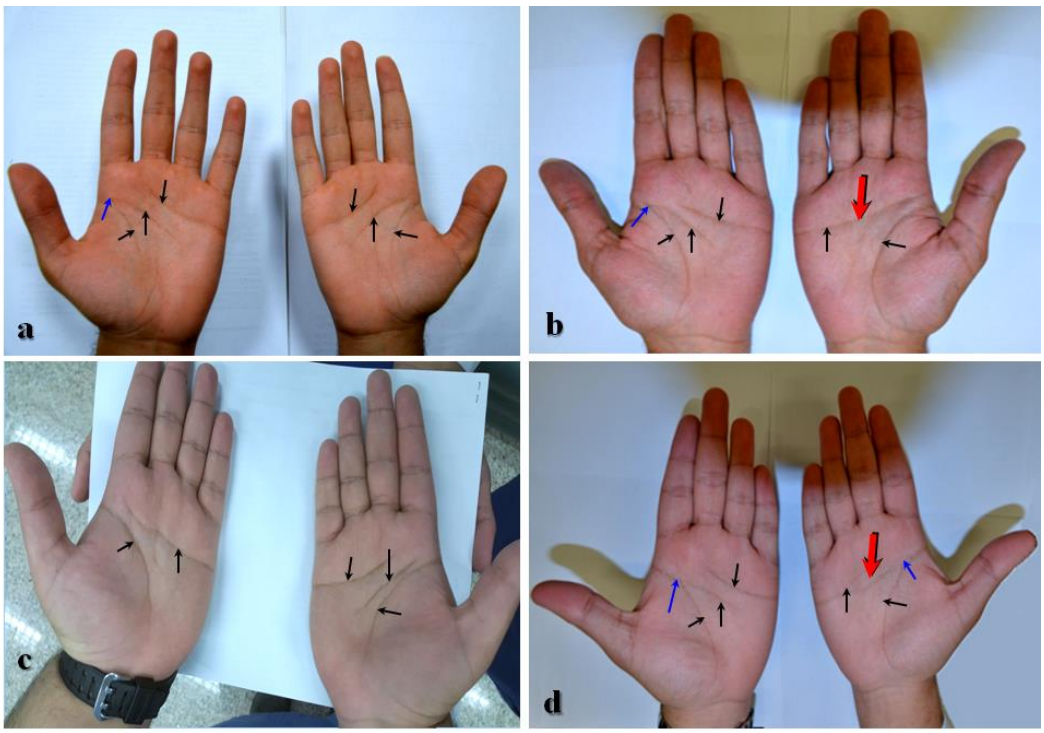

Figure 2 Asymmetrical PIC patterns among KFU medical students (Lt. Hand – Rt. Hand): a. 310 -300, b. 310 – 201, c. 200 -300, d. 310– 211. (Black arrows = number of creases, blue arrows mark points of meeting and red arrows mark complete transverse creases)

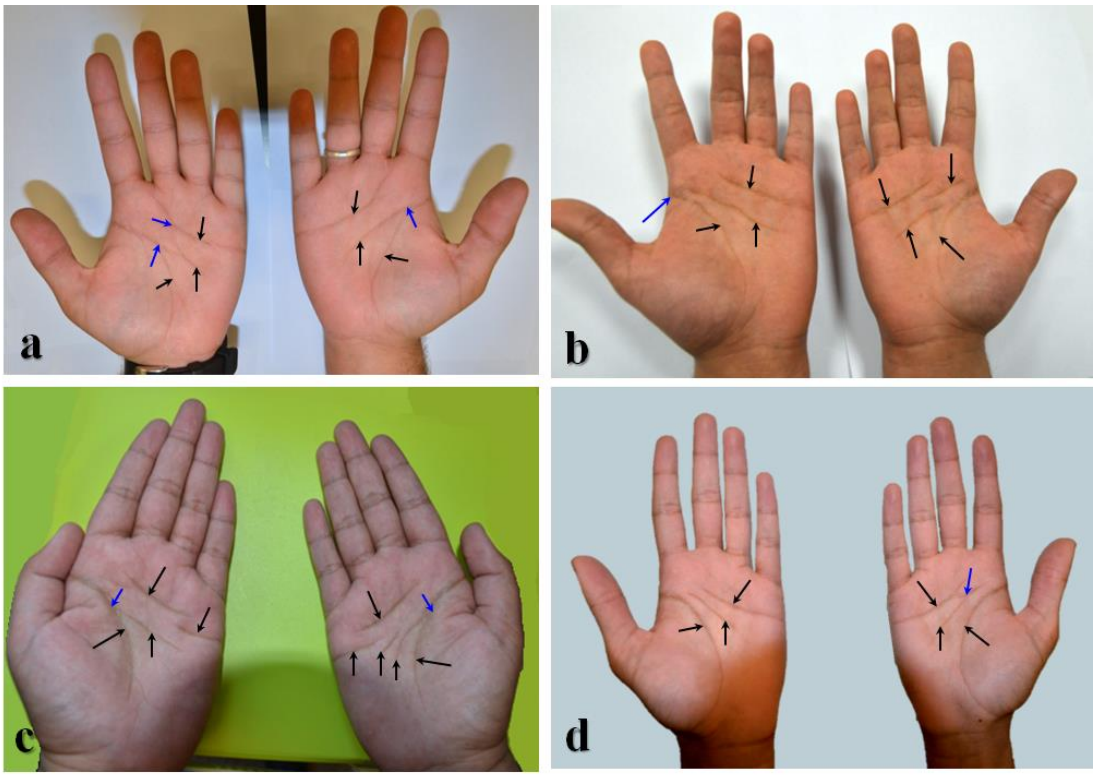

Figure 3 New PIC patterns among KFU medical students (in Lt and Rt. Hands): a. 320 – 310 (320: 2 meeting points in left hand with no complete crease, 310: usual meeting between PTC and RLC). b. 310 - 400, c. 410 – 510, d. 300 – 310N (meeting between PTC and DTC). (Black arrows = number of creases, blue arrows mark points of meeting)

Symmetry of PIC variants in both hands

Symmetrical variants (same pattern in both hands) were present in 152 (86.86%) students (Table 1, Fig. 1). Asymmetrical variants (different patterns in both hands) were present in 23 (13.14%) students (Table 1, Fig.2).

Meeting between radial crease, PTC and DTC

Meeting between radial crease and PTC was found in most students either in both hands (88-50.29%), or in left (34-19.43%) or right hand (30-17.14%). Points of meeting showed variation ranging from point 1 (level of lateral side of index finger) to point 4 (level of midline of middle finger). Both hands may have same point or different points of meeting of these 2 lines (table 2). We found meeting between PTC and DCT in one right hand (Fig. 3d) and 3 Lt Hands.

Table 2 Meeting between radial longitudinal crease and proximal transverse crease in the hands of KFU College of medicine students.

Meeting points	Left hand		Right hand		Both hands		No. of students (175)		Total hands (350)	
	No	%	No	%	No	%	No	%	No	%
Absent	30	17.14	34	19.43	23	13.14	87	49.71	110	31.43
Present	34	19.43	30	17.14	88	50.29	152	86.86	240	68.57
Point 1	1	0.57	2	1.14	2	1.14	5	2.86	7	2.00
Point 2	8	4.57	6	3.43	16	9.14	30	17.14	46	13.14
Point 3	14	8.00	16	9.14	55	31.43	85	48.57	140	40.00
Point 4	11	6.29	6	3.43	15	8.57	32	18.29	47	13.43

Level of point of meeting between radial crease and PTC

Table 2 shows presence or absence of meeting between primary creases in one or both hands. Presence of meeting points was more frequent than their absence. Bilateral meeting points were more frequent than unilateral meeting points. Out of 1-4 levels of meeting

points, commonest meeting is point 3 (at level of cleft between index and middle fingers) followed by point 2 (at level of midline of index finger) (Table 2).

Correlation between PIC variants and students' academic performance

Our results revealed higher academic performance among students with symmetrical PIC variants than those with asymmetrical variants, though not statistically significant (p-value = 0.5). Highest performance was found in symmetrical followed by asymmetrical bilateral 2 creases variants. Although symmetrical PIC 300 students have higher academic performance than symmetrical 310 students, symmetrical 310 students with symmetrical meeting point 1 or 2 had a higher performance. The least academic performance was found in students having CTC and unilateral 2 creases variants (Table 3).

Table 3 KFU College of medicine students' academic performance according to different PIC variants

PIC variants	Number	(%)	GPA – Range	GPA (Mean ± SD)
All symmetrical	152	86.86	2 – 5	4±0.68
Symmetrical 310 (All)	128	73.14	2 – 5	3.99 ±0.69
Symmetrical 310 +Symmetrical point of meeting				
Point 1	2	1.14	4-5	4.38±0.53
Point 2	21	12.00	3-5	4.13±0.63
Point 3	59	33.71	3-5	3.90±0.63
Point 4	16	9.14	3-5	3.90±0.78
Symmetrical 300	22	12.57	3 – 5	4.01±0.69
Symmetrical 2 creases	2	1.14	4.5 - 5	4.75±0.35
All asymmetrical	23	13.14	3 – 4.75	3.74±0.63
Asymmetrical bilateral 3 creases	15	8.57	3 – 4.75	3.69±0.66
Asymmetrical bilateral 2 creases	2	1.14	4.5 – 4.75	4.63±1.77
Asymmetrical unilateral 2 creases	6	3.43	3 – 4.5	3.67±0.52
All 2 creases	10	5.71	3-5	4.08±0.67
CTC variants	10	5.71	2 – 5	3.22 ±1.52

4. DISCUSSION

PIC variants in KFU College of medicine male students

The PIC classification depends on 3 criteria: number of creases (1-3), intersection between creases (0-2) and presence of complete transverse crease (0-2) The PIC classification of primary palmar creases presented 21 variants (van Mensvoort, 2009; Offei et al., 2014). Out of these PIC variants, our results showed only 10 variants in hands of our students. However, we observed new variants (not described previously), namely PIC 320 (2 meeting points without complete transverse crease), 400, 410 and 510, each of them is seen only in one hand. Commonest variants observed in our results are also described as commonest variants by other researchers, but no one reported our new variants (Dar et al., 1977; Hernandez, 1985; Wu et al., 2004; van Mensvoort, 2009; Park, 2010; Adetona et al., 2012; Offei et al., 2014; Moore et al., 2018; Mekbeb, 2019; Ranjit et al., 2019).

Moreover, in 310 variants in PIC model, the intersection is between radial crease and PTC (van Mensvoort, 2009; Offei et al., 2014). This type of intersection is found in all 310 variants of our study except in one right hand (with intersection between PTC and DTC). This pattern is not described in PIC model and not reported by previous studies (Dar et al., 1977; Hernandez, 1985; Schaumann & Kimura, 1991; Wu et al., 2004; van Mensvoort, 2009; Park, 2010; Adetona et al., 2012; Offei et al., 2014; Moore et al., 2018). So according to our results, 310 variants should be classified into 2 variants (the original 310 variant as 310a-which is very common) and our new variant 310b (which is very rare – found only in one (0.29%) out of 350 hands).

Symmetrical PIC variants in both hands were the most frequent patterns in our study, found in 152 (86.85%) students. The commonest symmetrical pattern was PIC 310, followed by PIC 300. Our incidence of symmetrical patterns is higher than that reported by Offei et al., (2014) who reported symmetrical patterns in (76.2%) of their cases. Ranjit et al., (2019) reported higher

incidence (82.3%) of symmetrical variantsbut still less than our incidence. Ranjit et al., (2019) described 310 variants as 2 forms: closed palm crease and meeting palm crease. Their meeting palm crease corresponds to meeting point-1 and closed palm crease to meeting points-2, 3, 4 of our study. Incidence of complete transverse creases; Simian (3.42%), Sydney (2.29%) and Suwon (0.57%) creases was low in our study. In palms of medical and dental students, Mekbeb (2019) reported higher incidence of different complete transverse crease variants (Simian 6.3%, Sydney 3.5%and Suwon 4.1%). Other studies also reported variable but higher incidences of different complete creases (Oyinbo & Fawehinmi, 2008; Park, 2010; Sharma & Sharma, 2011; Alhaji et al., 2015; Ranjit et al., 2019).

Meeting between radial crease, PTC and DTC

Our results revealed high incidence of meeting between radial crease and PTC. Out of 350 hands, this meeting was observed in 240 hands (68.57%) of 152 students (86.86%). Moreover, meeting between PTC and DTC was very rare, observed only in one-right Hand and 3-left Hands associating second meeting between PTC and radial crease. This informationis not reported in previous studies (Dar et al., 1977; Hernandez, 1985; Schaumann & Kimura, 1991; Wu et al., 2004; van Mensvoort, 2009; Malla et al., 2010; Park, 2010; Sharma & Sharma, 2011; Adetona et al., 2012; Gutierez et al., 2012; Offei et al., 2014).

We further classified points of meeting between radial crease and PTC into different levels ranging from 1-4. According to meeting points, we classified meeting patterns as symmetrical (same point of meeting in both hands) or asymmetrical (meeting in only one hand or different levels of meeting in both hands). Symmetrical meeting points were more frequent (50.29%) than asymmetrical meeting points (36.57%) and bilateral absence of meeting points (13.14%).

Correlation between academic performance and PIC variants

Academic performance of students was higher in all symmetrical groups (4±0.68) than asymmetrical groups (3.74±0.63). Our results support results of Offei et al., (2014). Highest performance was found in bilateral 2 creases variants (symmetrical then asymmetrical). Although symmetrical PIC 300 students had higher academic performance than symmetrical 310 students, symmetrical 310 students with symmetrical meeting points 1 or 2 had a higher performance than symmetrical 300 students (mean GPA was highest in symmetrical meeting point 2). The least academic performance was found in students having CTC and asymmetrical unilateral 2 creases variants.

This information is not reported in previous studies and can be helpful as one of the criteria for admission to medical Colleges (requiring high academic performance).

5. CONCLUSIONS

Saudi students showed only 10 PIC variants out of previously described 21 variants. New variants were seen in Saudi students. Commonest patterns are symmetrical patterns. Meeting points were studied and classified into 1-4. Single meeting points between radial crease and PTC was observed in most students (86.86%). Our results revealed correlation between GPA and PIC variants. It can be a criterion for admission to medical Colleges.

Recommendations

We recommend the following:

1. Conducting further studies in other groups of Saudi population (as other Colleges) to determine anthropological characteristics of Saudi community.
2. Examination of hands to confirm full symmetry of major and minor details of palmar creases may be considered as one of criteria for higher academic performance and can be added to criteria used for admission to different medical Colleges.

Abbreviations

CTC: Complete Transverse Crease
DTC: Distal Transverse Crease
KFU: King Faisal University
PIC: P= number of primary lines, I= number of intersections, C= number of complete lines
PTC: Proximal Transverse Crease

Authors' Contributions

1. Mohamed Bahgat Ali (Principal Investigator) - Role: Concept and design, Literature search, Data acquisition, Data analysis and interpretation, Drafting of manuscript, Critical revising and Final approval.
2. Ahmed Waleed Alrashed, MBBS (Co-Investigator) - Role: Literature search, Data acquisition, Data analysis and interpretation, Drafting of manuscript, Critical revising and Final approval.
3. Abdulaziz Emad Alateeq, MBBS (Co-Author) - Role: Literature search, Data acquisition, Data analysis and interpretation, Drafting of manuscript, Critical revising and Final approval.
4. Ahmed Mamdouh Alkhawfi, MBBS (Co-Author) - Role: Concept and design, Literature search, Data acquisition, Data analysis and interpretation, Critical revising and Final approval

Ethical approval

The study was approved by the Medical Ethics Committee of College of Medicine, King Faisal University (ethical approval code: 2020-12-38; Date: 27/12/2020).

Consent to participate

Participants were asked to join the study in their times of convenience. Each volunteer signed written consent before participating.

Competing interests

Authors declare that they have no competing interests.

Funding

This study has not received any external funding.

Declaration of conflicting interests

The authors declare that there are no conflicts of interests.

Acknowledgements

We thank all patients who were participated in and contributed to help us in study, and we thank Dr. Sayed Ibrahim for help in statistical analysis, and we would like to thanks all leaders who participate in our research by helping as to reaches maximum number of students.

Data and materials availability

All data associated with this study are present in the paper.

REFERENCES AND NOTES

1. Adetona MO, Oladapo OO, Akinyemi JO. Palmar Flexion Creases Variants among Nigerians. Afr J Biomed Res 2012; 15:93-96.
2. Alhaji M, Timbuak J, Umana U, Tanko M: Palmar creases and handedness in hausas of northern nigeria: a cross-sectional study. Asian J Biol Med Sci 2015; 1(2), 6-13.
3. Bagga A. Dermatoglyphics of Schizophrenic Criminals. In: New Horizons in Human Biology: Proceedings of the UGC National Seminar Organized by Human Biology Department, Punjabi University, Patiala, on Nov. 9-10, 1989: Today & Tomorrow Printers & Publishers 1991; pp.135.
4. Cannon M, Byrne M, Cotter D, Sham P, Larkin C, O'Callaghan E. Further evidence for anomalies in the hand-prints of patients with schizophrenia: a study of secondary creases. Schizophr Res 1994; 13:179-184.
5. Dar H, Schmidt R, Nitowsky HM. Palmar crease variants and their clinical significance: a study of newborns at risk. Pediatr Res 1977; 11(2):103-8.
6. Gutierez SB, Lucenario JLS, Yebes MJT. Dermatoglyphic studies among the Dumagat-Remontado tribal population of the Philippines. J Anthropol 2012; ID812128, 6 pages. https://doi.org/10.1155/2012/812128
7. Hernandez M. Palmar creases in Spaniards. Anthropol Anz 1985; 43:187-90.
8. Hirsch W, Schweighel J. Morphological evidence concerning the problem of skin ridge formation. J Intellect Disabil Res 1973; 17:58-72.
9. Johnson CF, Opitz E. Clinical Review: The Single Palmar Crease and its Clinical Significance in a Child Development

Clinic Observations and Correlations. Clin pediatr 1971; 10:392-403.
10. Jones KL, Robinson, LK, Bakhireva LN. Accuracy of the diagnosis of physical features of fetal alcohol syndrome by pediatricians after specialized training. Pediatric 2006; 118:1734-1738.
11. Kava MP, Tullu MS, Muranjan MN, Girisha KM. Down syndrome: Clinical profile from India. Arch Med Res 2004; 35(1):31–35.
12. Kong A, Zhang D, Lu G. A study of identical twins palmprint for personal verification. Pattern Recognit 2006; 39(11):2149-2156.
13. Lde Lestrange, MT. The transverse crease in Europe: Index and comparative study of different samples cited in the literature. Am J Phys Anthropol 1969; 30(2):173-82.
14. Lopuszanska M, Jankowska EA. Dermatoglyphic morphology in some diseases. Pol Merkur Lekarski 2001; 11:282-6.
15. Malla T, Malla KK, Gauchan E, Brijesh S, Sharma R. Incidence of Simian Crease in Normal Nepalese Children. Kathmandu Univ Med J 2010; 9(32):410-4.
16. Mekbeb A. Prevalence of the Different Types of Palmar Creases among Medical and Dental Students in Addis Ababa, Ethiopia. Ethiop J Health Sci 2019; 29(3):391.
17. Moore KL, Dalley AF, Agur AMR. Surface anatomy of the hand: Clinically Oriented Anatomy 8th edition, Wolters Kluwer; 2018; pp. 636-7.
18. Nazarabadi M, Raoofian R, Abutorabi1 R, Hosseini HB. Dermatoglyphic Assessment in Down and Klinefelter Syndromes. Iran J Med Sci 2007; 32:105-9.
19. Offei EB, Abledu JK, Osabutey CK, Kesse DK. Relationship between Palmar Dermatoglyphic Pattern and Academic Performance of Students in a Ghanaian Secondary School. J Med Biomed Sci 2014; 3(2):24-31.
20. Oyinbo C, Fawehinmi H. Prevalence of simian and Sydney creases in the Ijaws of South- South Nigeria. Internet J Biol Anthrop 2008; 3(2):1-5.
21. Park JS. Improved analysis of palm creases. Anat Cell Biol 2010; 43(2):169-177.
22. Purvis-Smith SG. The Sydney line: a significant sign in Down's syndrome. Aust. Pediatric J 1972; 8(4):198-200.
23. Ranjit N, Adhikari B, Shrestha R, Shrestha A, Bhandari R, Dhungel D. Palm Creases analysis in students and staff of a teaching hospital in Kathmandu. MJSBH 2019; 18(1):51-8.
24. Rignell A. Simian crease incidence and the correlation with thenar and hypothenar pattern types in Swedish patients with trisomy 21 (Down's syndrome). Am J Phys Anthropol 1987; 72:277-86.
25. Schaumann BA, Kimura S. Palmar, planter and digital flexion creases: Morphological and clinical considerations. Birth Defects 1991; 27(2):229-52.
26. Sharma DK, Sharma V. Prevalence of Simian, Sydney and Suwon creases and their association with each other, body sides, handedness, sex and anomalies/diseases/syndromes in a population of Central India. Int J Morphol 2011; 29(3):1069-1075.
27. Stevenson RE, Häne B, ArenaJ F, May M, Lawrence L, Lubs HA. Arch fingerprints, hypotonia and flexia associated with X linked mental retardation. Am J Med Genet 1997; 34(6):465-469.
28. Than M, Myat KA, Khadijah S, Jamaludin N, Isa MN. Dermatoglyphics of Down's syndrome patients in Malaysia, a comparative study. Anthropol Anz 1998; 56(4), 351-365.
29. Van Mensvoort M. Handprints: the hands of Al-bert Einstein! What do the hands of Albert Einstein reveal about his independent personality, his suspected autism & his presumed left-handedness? (2009) www.handresearch.com.
30. Wu X, Zhang D, Wang K, Huang B. Palmprint classification using principal lines. Pattern recognit 2004; 37:1987-1998.