PARMAK İZİ ARAŞTIRMALARI

TEMEL YAKLAŞIMLAR

Editör

Yakup GÜLEKÇİ

ISBN
978-625-375-870-7

Kitap Adı
Parmak İzi Araştırmaları: Temel Yaklaşımlar

Editör
Yakup GÜLEKÇİ
ORCID iD: 0000-0001-9643-6850

Yayın Koordinatörü
Yasin DİLMEN

Sayfa ve Kapak Tasarımı
Akademisyen Dizgi Ünitesi

Yayıncı Sertifika No
47518

Baskı ve Cilt
Vadi Matbaacılık

Bisac Code
LAW041000

DOI
10.37609/akya.3986

Kütüphane Kimlik Kartı
Parmak İzi Araştırmaları: Temel Yaklaşımlar / ed. Yakup Gülekçi.
Ankara : Akademisyen Yayınevi Kitabevi, 2025.
188 s. : tablo, şekil. ; 160x235 mm.
Kaynakça var.
ISBN 9786253758707

GENEL DAĞITIM
Akademisyen YAYINEVİ A.Ş.

Halk Sokak 5 / A Yenişehir / Ankara
Tel: 0312 431 16 33
siparis@akademisyen.com

www.akademisyen.com

ÖNSÖZ

Parmak izleri hukuksal tanımlama veya cezai yaptırım süreçlerinde kişi kimliklendirmesi amacıyla uzun yıllardır kullanılan güvenilir biyometrik delillerden biridir. Yaşam boyu değişmeyen yapısı ve her bireye özgü iz modelleri sayesinde, suçun aydınlatılması ve adaletin sağlanmasında güçlü bir referans noktası olarak kabul edilmektedir. Pratik uygulama kolaylığı ve diğer biyometrik özelliklere göre daha erişilebilir olması, parmak izini kriminal incelemelerin temel unsurlarından biri haline getirmiştir. Gelişen teknolojiyle beraber günümüzde yapılan incelemeler parmak izlerinin kişi kimliklendirmesinden çok daha ötesinde işlevleri olduğunu göstermektedir. Kişinin çevresiyle bulunduğu etkileşim, temas ettiği veya tükettiği maddelerden kaynaklanan metabolit izleri hakkında da bilgi sağlayabildiği ortaya konmaktadır. Bir başka güncel işlevi ise ait olduğu kişinin genetik mirası ile ilgili bilgiler açığa çıkarmasıdır. Antik dönemden günümüze uzanan parmak izi araştırmaları disiplinler arası yaklaşımlarla her geçen gün genişlemekte ve adli bilimlere dair yeni veriler sunmaya devam etmektedir. Bu eser, parmak izlerinin delil değerini; klasik yaklaşımlardan modern analitik tekniklere kadar uzanan kapsamlı bir çerçevede ele alarak, adli bilimlerdeki çok yönlü kullanımını bütüncül bir bakışla değerlendirmeyi amaçlamaktadır.

Parmak izi araştırmaları kitabı ile hem parmak izi inceleme uzmanlarının nasıl çalıştıklarına hem de parmak izlerinin güncel analitik tekniklerle nasıl ele alındığına odaklandık. Özellikle adli bilimler eğitimine başlayanlar ile hakimler, savcılar ve adli kolluğun (polis ve jandarma) kriminal birimlerinde çalışan uzmanları hedef kitleye alan bu kitap ile açık, anlaşılır ve görsellerle desteklenen temel bir kaynak oluşturmaya özen gösterdik.

Teşekkürlerimi, mesleki serüvenim boyunca desteklerini esirgemeyen aileme ve katkı sunan bölüm yazarlarına sunarım. Emeği geçen her bir meslektaşımın birikimi, bu kitabın eğitimde açıklık ve uygulamada doğruluk ilkelerini taşımasına imkân verdi. Kitabın, parmak izi araştırmalarında yeni çalışmalar için kıvılcım oluşturması ve adli bilimler ekosisteminde yetkinlik ve kalite kültürünü güçlendirmesi dileğiyle…

İÇİNDEKİLER

YAZARLAR

Dr. Öğr. Üyesi Harun ŞENER
Kütahya Sağlık Bilimleri Üniversitesi, Adli Bilimler Bölümü

Arş. Gör. Eda Nur AY
Kütahya Sağlık Bilimleri Üniversitesi, Adli Bilimler Bölümü

Dr. Öğr. Üyesi Yakup GÜLEKÇİ
Kütahya Sağlık Bilimleri Üniversitesi, Adli Bilimler Bölümü

Uzm. Dr. İnci SAĞLAM
Manisa Ruh Sağlığı ve Hastalıkları Hastanesi- Merkez Laboratuvarı, Adli ve Klinik Toksikoloji Birimi

Prof. Dr. Nebile DAĞLIOĞLU
Ankara Üniversitesi-Adli Bilimler Enstitüsü, Adli Kimya ve Adli Toksikoloji AD.

Öğr. Gör. Fatma Ebru BEKİROĞLU
Kütahya Sağlık Bilimleri Üniversitesi, Adli Bilimler Bölümü

Dr. Öğr. Üyesi Rukiye ASLAN
Ege Üniversitesi, Madde Bağımlılığı Toksikoloji ve İlaç Bilimleri Enstitüsü

Prof. Dr. Hasan ERTAŞ
Ege Üniversitesi, Fen Fakültesi, Kimya Bölümü

Dr. Öğr. Üyesi Fatma ÇAVUŞ YONAR
İstanbul Üniversitesi-Cerrahpaşa, Adli Tıp ve Adli Bilimler Enstitüsü, Fen Bilimleri AD.

Sena Nur KADEM
Yüksek Lisans Öğrencisi, İstanbul Üniversitesi-Cerrahpaşa, Adli Tıp ve Adli Bilimler Enstitüsü, Fen Bilimleri AD.

Cengizhan YOLDAŞ
Parmak İzi Uzmanı, Samsun İl Jandarma Komutanlığı, Kriminal Şube Müdürlüğü

BÖLÜM 1

ANTİK DÖNEMDEN DİJİTAL ÇAĞA PARMAK İZİNİN EVRİMİ

Harun ŞENER [1]
Eda Nur AY [2]

GİRİŞ

İnsanlık tarihi boyunca suç, toplumsal yaşamın kaçınılmaz bir gerçeği olarak varlığını sürdürmüştür. Suçun ortaya çıkarılması ve faillerin süratle yakalanması, toplum güvenliğinin sağlanması açısından kritik bir öneme sahiptir. Bu nedenle tarih boyunca bireylerin kimliklendirilmesi ve suçluların teşhisine yönelik çeşitli yöntemler geliştirilmiştir.

Olay yerinde bırakılan izler, yalnızca bir temasın izi olmanın ötesinde, faili adalete ulaştırabilecek değerli ipuçları barındırır. Bu izler arasında, benzersiz morfolojik özellikleri ve yaşam boyu değişmezliği sayesinde öne çıkan parmak izleri, yüzyıllardır kimlik tespitinde en güvenilir araçlardan biri olmuştur.

Parmak izlerinin eşsiz yapısına duyulan ilgi, antik medeniyetlerden itibaren belgelenmiş; tarihsel süreç içerisinde farklı coğrafyalarda bu izlerin kimlik doğrulamada kullanılabileceğine dair önemli kayıtlar bırakılmıştır. Modern kriminal laboratuvarlarda bilimsel yöntemlerle sistematik biçimde analiz edilen parmak izlerinin kökenleri, kadim uygarlıkların adalet arayışına kadar uzanmaktadır.

Dolayısıyla parmak izinin tarihsel evrimini incelemek, yalnızca adli bilimlerin gelişimini anlamaya katkı sağlamakla kalmaz; aynı zamanda insanlığın suçla mücadele konusundaki çabalarının kültürel, bilimsel ve teknolojik yansımalarını da ortaya koyar. Bu bağlamda, antik dönemlerden dijital çağa uzanan serüveniyle parmak izi biliminin gelişimi, hem disiplinler arası bir perspektif sunmakta hem de adaletin hizmetindeki evrensel bir bilimsel araç olarak önemini korumaktadır.

---

[1] Dr. Öğr. Üyesi, Kütahya Sağlık Bilimleri Üniversitesi, Adli Bilimler Bölümü, harun.sener@ksbu.edu.tr
ORCID iD: 0000-0003-3521-0684

[2] Arş. Gör., Kütahya Sağlık Bilimleri Üniversitesi, Adli Bilimler Bölümü, edanur.ay@ksbu.edu.tr
ORCID iD: 0000-0001-9070-253X

değil, aynı zamanda hukuki ve etik perspektiflerin de belirleyici bir rol oynaması beklenmektedir.

KAYNAKLAR

1. Xiang-Xin Z, Chun-Ge L. The historical application of hand prints in Chinese litigation. *Journal of Forensic Identification*, 1988;38(6):277-284.
2. Barnes JG. History. Holder EH, Robinson LO, Laub JH (ed.) The Fingerprint Sourcebook *içinde*. Washington: U.S. Dept. of Justice Office of Justice Programs. 2011
3. Hawthorne M. *Fingerprints- Analysis and understanding*. (1st ed.). Boca Raton: CRC Press; 2009. https://doi.org/10.1201/9781420068658
4. Sodhi GS, Kaur J. Indian civilization and the science of fingerprinting. *Indian J. of Traditional Knowledge*. 2003;2(2),126–136.
5. Cummins H, Midlo C. *Finger prints, palms and soles: an ıntroduction to dermatoglyphics*. (2nd ed.). New York: Dover Publications; 1961.
6. Karakuş O. *Kriminalistik,* (2. Baskı) Ankara: Adalet Yayınevi; 2013.
7. Cummins H, Midlo C. *Finger prints, palms and soles: an ıntroduction to dermatoglyphics*. (1st ed.). New York: Dover Publications; 1943.
8. Galton F. *Finger prints* (No. 57490-57492). (1st ed.). London:Cosimo Classics, Macmillan; 1892.
9. Wilder HH, Wentworth B. *Personal Identification*. (1st ed.) Boston:The Gorham Press; 1918.
10. Herschel WJ. *The origin of finger-printing*. (1st ed.) London:Oxford University Press; 1916.
11. Faulds H. *On the skin-furrows of the hand*. Nature;1880;22(574), 605-605.
12. Lambourne G. *The fingerprint story*. (1st ed.) London: Harrap;1984.
13. Saferstein R. *Criminalistics: An introduction to forensic science* (12th ed.). Vancouver Island, British Columbia; Pearson Education,2018.
14. Beavan C. *Fingerprints: the origins of crime detection and the murder case that launched forensic science*. (1st ed.). New York: Hyperion;2001.
15. Cole SA. *Suspect identities: A history of fingerprinting and criminal ıdentification* (1st ed.). Cambridge, MA: Harvard University Press;2001.
16. Henry ER. *Classification and uses of fingerprints*, (7th ed). London;H.M. Stationery Office;1934.
17. de Forest HP. *The first fingerprint file in the United States*. Finger Print and Ident. Mag. 1938;19,16–20.
18. Chapel CE. *Fingerprinting: A manual of identification*. New York: Coward McCann; 1941.
19. Nickell J. *The two Will Wests—A new verdict.* Journal of Police Science and Administration:1980,8(4),406–413.
20. Locard E. *La Preuve Judiciaire par les Empreintes Digitales (The Legal Evidence by the Fingerprints).* De Médecine Légale et de Psychologie Normale et Pathologique (of Forensic Medicine and of Normal and Pathological Psychology):1914,29,321.
21. Ashbaugh DR. *Quantitative-qualitative friction ridge analysis: an ıntroduction to basic and advanced ridgeology*. (1st. ed.). Boca Raton, FL:CRC Press;1999.
22. Myers HJ. II. Supplemental history of identification in the United States. *Fingerprint and Identification Magazine*:1942, 25 (6), 3–28.
23. McCann PD. Report of the standardization mmittee of the international ass'n for identification. *Identification News*:1973.
24. National Research Council. *Strengthening Forensic Science in the United States: A Path Forward*. Washington, DC: National Academies Press;2009.
25. Komarinski P.*Automated Fingerprint Identification Systems (AFIS),* Elsevier Academic

Press;2005.
26. Baldi P, Chauvin Y. *Neural networks for fingerprint recognition*. *Neural Computation*, 1993:*5*(3), 402-418.
27. Cao K, Nguyen DL, Tymoszek C, Jain AK. End-to-end latent fingerprint search. *IEEE Transactions on Information Forensics and Security*, 2019:15, 880-894.
28. Awad AI. Machine learning techniques for fingerprint identification: A short review. In Proceedings of CCIS.2012;322, 524–531.
29. Win KN, Li K, Chen J, Viger PF, Li K. *Fingerprint classification and identification algorithms for criminal investigation: A survey*. Future Generation Computer Systems, 2020:110, 758-771.
30. El Naqa I, Murphy MJ. What are machine and deep learning? El Naqa I, Murphy MJ (ed.) *Machine and Deep Learning in Oncology, Medical Physics and Radiology* içinde Cham:Springer,2022. https://doi.org/10.1007/978-3-030-83047-2_1
31. Winters D. *Fingerprint recognition using deep learning - A review.* Journal of Artificial Intelligence and Metaheuristics. 2023:5. 08-15. 10.54216/JAIM.050101.
32. Wagner L. Beyond the Surface: Examining How Artificial Intelligence Enhances Fingerprint Analysis and Identity Verification. 2025. http://dx.doi.org/10.2139/ssrn.5334143
33. Cole SA. *Grand illusion: The uncertain science of fingerprint evidence.* Cambridge, MA: MIT Press:2004.
34. Fiodorova A. *Information exchange and EU law enforcement. Oxon, UK and New York*, NY: Routledge:2018.
35. Amelung N, Granja R, Machado H. A brief history of the evolution of biometrics and biometric database systems crossing borders in EU law enforcement. Modes of Bio-Bordering içinde. Palgrave Pivot, Singapore: 2021. https://doi.org/10.1007/978-981-15-8183-0_2
36. Paripurna A, Indriani M, Widiati EP. Implementation of Resolution No. 4/2016 of the ICPO-INTERPOL concerning biometric data sharing: between countermeasures against Terrorist Foreign Fighters (FTFS) and protection of the privacy of Indonesian citizens. Brawijaya University. 2018;5(1);117-142. https://doi.org/10.21776/ub.blj.2018.005.01.08
37. European Commission. *What is SIS and how does it work?* Migration and Home Affairs. 2020. https://home-affairs.ec.europa.eu/policies/schengen/schengen-information-system/what-sis-and-how-does-it-work_en
38. European Commission. *Alerts and data in SIS*. Migration and Home Affairs. 2020. https://home-affairs.ec.europa.eu/policies/schengen/schengen-information-system/alerts-and-data-sis_en
39. Broeders D, Dijstelbloem H. The datafication of mobility and migration management: The mediating state. In: Van der Ploeg I, Pridmore, J (eds.), *Digitizing identities: Doing identity in a networked world.* New York: Routledge.2016. p. 242–260. 10.4324/9781315756400-13
40. Mayer-Schönberger V, Cukier K. *Big Data: die Revolution, die unser Leben verändern wird.* München:Redline Wirtschaft; 2013.
41. Liberatore A. Balancing security and democracy, and the role of expertise: Biometrics politics in the European Union. *European Journal on Criminal Policy and Research.* 2007; 13(1–2): 109–137. https://doi.org/10.1007/s10610-006-9016-1
42. Stojičić S, Petrović N, Srećković M, et al. The digital forensic method used in interoperability framework for information systems used on EU level in area of migration and border management. In *Thematic conference proceedings of international significance [Elektronski izvor]/ International Scientific Conference" Archibald Reiss Days", Belgrade, 9-10 November 2021* (pp. 547-566). Belgrade: University of Criminal Investigation and Police Studies.
43. Toom V, Granja R, Ludwig A. The Prüm decisions as an aspirational regime: Reviewing a decade of cross-border exchange and comparison of forensic DNA data. *Forensic Science International: Genetics*, 2019; 41: 50-57.
44. EUR-Lex .*Stepping up cross-border cooperation – the Prüm decision*. Available from htt-

ps://eur-lex.europa.eu/EN/legal-content/summary/stepping-up-cross-border-cooperation-the-pr-m-decision.html. (Accessed 26th July 2025).
45. Kyriakou K, Apostolaras A, Velentzas P, et al. A secure and trustworthy biometric data ecosystem for cross-border suspect identification. In: *2024 IEEE International Conference on Big Data (BigData)*, 15-18 December, Washington DC, (pp. 2762-2771).
46. Topfer E. Network with errors: Europe's emerging web of DNA databases. *Statewatch Journal.* 2011;21(1) Available from http://www.statewatch.org/analyses/no-134-dna-databases.pdf (Accessed 09th February 2017).
47. House of Commons European Scrutiny Committee. Cross-border law enforcement cooperation - UK participation in Prüm. Available from https://publications.parliament.uk/pa/cm201516/cmselect/cmeuleg/342-xii/34203.htm (Accessed 28th July 2025).
48. Benos G, Koutsoukos K, Symvoulidis C. et al. Enhancing International Security: A Secure Biometric Data Sharing Framework for Effective Cross-Border Crime and Terrorism Prevention. In: *2024 IEEE International Conference on Big Data (BigData)*, 15-18 December, Washington DC, (pp. 2690-2696).
49. Sallavaci O. Strengthening cross-border law enforcement cooperation in the EU: the Prüm network of data exchange. *European Journal on Criminal Policy and Research*, 2018; 24: 219-235. https://doi.org/10.1007/s10610-017-9355-0
50. McCartney C. Forensic data exchange: ensuring integrity. *Australian Journal of Forensic Sciences,* 2014; 47(1): 36-48. https://doi.org/10.1080/00450618.2014.906654
51. Committee on Identifying the Needs of the Forensic Sciences Community, National Research Council. *Strengthening Forensic Science in the United States: A Path Forward*. Document No. 228091. 2009. National Academy of Sciences. Washington, DC: United States Department of Justice.
52. Daluz HM. *Fundamentals of fingerprint analysis*. 2nd ed. Boca Raton, FL: CRC Press; 2018.
53. Swofford HJ. The emerging paradigm shift in the epistemology of fingerprint conclusions. *Journal of Forensic Identification*, 2015; 65(3): 201.
54. Gnanasivam P, Muttan DS. Estimation of age through fingerprints using wavelet transform and singular value decomposition. *International Journal of Biometrics and Bioinformatics (IJBB),* 2012; 6(2): 58-67.
55. Prabhu RR, Ravikumar CN. A novel extended biometric approach for human character recognition using fingerprints. *International Journal of Computer Applications*, 2013; 77(1).
56. Singh M, Majumdar O. Dermatoglyphics: blueprints of human cognition on fingerprints. *Computational Science and Electronic Journal*, 2015; 6: 124-146.
57. Kralik M, Novotny V. Epidermal ridge breadth: an indicator of age and sex in paleodermatoglyphics. *Variability and Evolution*, 2003; 11: 5-30.
58. Acree MA. Is there a gender difference in fingerprint ridge density? *Forensic Science International,* 1999; 102: 35-44.
59. Gutierrez-Redomero E, Alonso C, Romero E, Galera V. Variability of fingerprint ridge density in a sample of Spanish Caucasians and its application to sex determination. *Forensic Science International*, 2008; 180: 17-22.
60. Ceyhan EB, Sağiroğlu Ş, Tatoğlu S, et al. Age estimation from fingerprints: Examination of the population in Turkey. 2014 *13th International Conference on Machine Learning and Applications*, 2014; 478-481.
61. Song HON, Tang WT, Zhang LHA, et al. Quantitative analysis of the correlation between fingerprint and age. *Acta Anthropologica Sinica*, 2022; 41(06): 1047.
62. Jamwal P. Review paper on application of dermatoglyphics in health, career, academic, and forensic setup. *Indian Journal of Social Studies and Humanities*, 2021.
63. Majumdar O. Dermatoglyphics: Blueprints of human cognition on fingerprints. *Computational Science and Electronic Journal*, 2015; 6(2): 124-146.

64. Atasu M, Kuru B, Firatli E, et al. Dermatoglyphic findings in periodontal diseases. *International Journal of Anthropology*, 2005; 20(1): 63-75.
65. Jindal G, Pandey RK, Gupta S, et al. A comparative evaluation of dermatoglyphics in different classes of malocclusion. *The Saudi Dental Journal*, 2015; 27(2): 88-92.
66. Singh S, Khurana AK, Harode HA, et al. Study of fingerprint patterns to evaluate the role of dermatoglyphics in early detection of bronchial asthma. *Journal of Natural Science, Biology, and Medicine*, 2016; 7(1): 43.
67. Vaidya P, Mahale S, Badade P, et al. Dermatoglyphics in periodontics: An assessment of the relationship between fingerprints and periodontal status-A cross-sectional observation study. *Indian Journal of Dental Research*, 2017; 28(6): 637-641.
68. Vasan MD, Thakar BR. Predictive digital forensic model to track antisocial behavior based on dermatoglyphics. In: Peng SL, Dey N, Bundele M, eds. *Computing and Network Sustainability*. Lecture Notes in Networks and Systems, vol 75. Singapore: Springer; 2019. https://doi.org/10.1007/978-981-13-7150-9_37
69. Janiani P, Subramanian EM. Assessment and correlation between dactyloscopy and behavior of children undergoing dental treatment: A cross-sectional study. *International Journal of Clinical Pediatric Dentistry*, 2023; 16(3): 444-447. https://doi.org/10.5005/jp-journals-10005-2600
70. Agarwal M, Alex A, Konde S. Relationship between dermatoglyphics, cheiloscopy, rugoscopy, and dental caries: a cross-sectional study in Bengaluru, Karnataka. *Contemporary Clinical Dentistry*, 2018; 9(4): 577-581. https://doi.org/10.4103/ccd.ccd_611_18
71. Jones KZ. *The Everything Palmistry Book: Discover what the future holds–Life, Love, and Wealth–All in the Palm of Your Hand*. 1st ed. Avon, MA: Adams Media; 2010.
72. van Oorschot R, Jones M. DNA fingerprints from fingerprints. *Nature*, 1997; 387: 767.
73. Kaygısız M. Kriminalistikte parmak izi incelemesi [Yüksek lisans tezi]. İstanbul: İstanbul Üniversitesi, Adli Tıp Enstitüsü; 1995. p. 1-4.
74. Akbabaöz O. Eşkâle dayalı kimliklendirmeden kriminal kimliklendirmeye: Osmanlı iç güvenliğinde biyometrik unsurlar. *Atatürk Üniversitesi Türkiyat Araştırmaları Enstitüsü Dergisi*, 2022; (74): 409-416.
75. Şahin E. *1907'den 2000'e Polis Okulları.* (1. Baskı). Ankara: Emniyet Genel Müdürlüğü Basımevi; 2001.
76. Şahin E. Osmanlı›dan Cumhuriyete Türk Polisinin Eğitimi. *Çağın Polisi Dergisi*, 2010; 9(98): 19-22.
77. Tongur H. *Türkiye'de genel kolluk teşkil ve görevlerinin gelişimi* (1. Baskı). Ankara: Polis Akademisi Yayınları; 2016.
78. Jandarma Meslek Okulunda Jandarma erbaşlarına okutulan derslerin müfredat programı. Ankara: Jandarma Genel Komutanlığı; 1937.
79. Baykal T. İz ve emare. *Jandarma Mecmuası*, 1938; (51): 63-77.
80. Esen S. Jandarma Subay Tatbikat ve Astsubay Okulunun 1962-1963 eğitim ve öğretim yılı. *Jandarma Dergisi*, 1963; (25/26): 12-17.
81. Sarıyıldız G. Osmanlı bürokrasisinde fotoğraflı belge kullanımı ve parmak izi uygulaması. *İstanbul Üniversitesi Tarih Dergisi*, 2009; 47: 185-187.
82. Bingöl S. Osmanlı Devleti'nde Tanzimat'tan sonra kriminal kimlik tespit yöntemlerine dair notlar ve belgeler (dokuz belge ile birlikte). *Belleten*, 2011; 274(C LXXV): 851.
83. European Commission. Study on the feasibility of improving information exchange under the Prüm Decisions. Deloitte Consulting & Advisory CVBA; 2020. https://www.statewatch.org/media/1386/eu-com-prum-expansion-technical-study-final-report-5-20.pdf

BÖLÜM 2

PARMAK İZİNİN DOĞASI

Eda Nur AY [1]
Yakup GÜLEKÇİ [2]

GİRİŞ

Parmak izleri adli incelemelerde kullanılan vazgeçilmez bir kimliklendirme aracıdır. Kişiye özgü izler olmanın ötesinde, derinin yapısından papil hatlarının düzenine kadar uzanan karmaşık bir biyolojik sistemin yansımasıdır. Bu nedenle birincil kimliklendirme aracı olarak tercih edilmesinin gerekçelerini kavramak için öncelikle parmak izinin doğasının keşfedilmesi gerekir.

Parmak izlerinin eşsizliği örüntünün oluşmasına katkı sağlayan farklı deri katmanları, katmanların oluşturduğu çıkıntılar ve terin yüzeye taşınmasını sağlayan porlardan kaynaklanır. Sahip olduğu benzersiz motifler uzmanların delili bireyselleştirme çabalarını destekler. Rastgele şekillenen izler başka bir insanda tekrarı görülmeyecek ölçüde özeldir. Her ne kadar benzersiz olsalar da, sınıflandırma ve kimliklendirme adımlarını kolaylaştıracak ortak desenlere sahiptirler. Papil hattı örüntüsü bazal tabaka düzeyinde belirlendiği için, çoğu darbe sonrası asıl şeklini kaybetmeden yeniden oluşurlar. Kişi öldükten sonra dahi delil değerini kaybetmez.

Bu bölümde anne karnında başlayan parmak izi oluşum sürecinden ölüm sonrası parmak izi gelişim aşamalarına kadar geniş bir perspektif sunulmaktadır.

1. PARMAK İZİ NEDİR?

Parmakların birinci boğumundan (falanksından) tırnak ucuna kadar olan alanda benzersiz motifler oluşturan papiller bulunur. Girintili çıkıntılı bir yapıya sahip olan papiller, ter bezlerinin epidermise açılan kanalları olan porları taşır. Porlar aracılığıyla ter sıvısı papil-

[1] Arş. Gör., Kütahya Sağlık Bilimleri Üniversitesi, Adli Bilimler Bölümü, edanur.ay@ksbu.edu.tr, ORCID iD: 0000-0001-9070-253X

[2] Dr. Öğr. Üyesi, Kütahya Sağlık Bilimleri Üniversitesi, Adli Bilimler Bölümü, yakup.gulekci@ksbu.edu.tr ORCID iD: 0000-0001-9643-6850

Kişilerin fizyolojik özellikleri yüzeye aktaracakları parmak izi kalıntılarında değişkenlik oluşturur. Yaş, cinsiyet, kullanılan ilaçlar, mevcut sağlık durumu gibi faktörler bu varyasyonu belirginleştirir. Ayrıca, yüzey üzerindeki parmak izleri de zamanla birçok faktörden etkilenir. Bu etkileşim, parmak izinin üç boyutlu yapısında ve kimyasal bileşiminde değişkenliğe sebep olur. Sonuç olarak parmak izinin gelişimi donör, yüzey ve çevre etmenlerinin karmaşık etkileşimiyle şekillenir. Parmak izlerinin biçimsel düzenini oluşturan por ve papiller kadar yüzeye aktarılmasını sağlayan ter sıvısı da adli yorum açısından değerli bilgiler barındırır. Çeşitli ter bezi salgılarının içeriği iç ve dış faktörler sebebiyle değişikliğe uğrar. Dış faktörlere maruz kalmak salgılarda zamanla farklılık oluşturur. Bu dinamik doğa, tek bileşene dayalı okumalardan ziyade çoklu gösterge ve tamamlayıcı fiziksel ölçümlerle parmak izi yaş tayini çalışmalarını teşvik etmektedir.

Parmak izleri dışında avuç izleri de olay yerlerinde sık karşılaşılan ve kimliklendirme sağlayan yapılardır. Papillerin oluşturduğu tasniflemeye yarar desenler avuç izlerinde de bulunur. Oluşumu ve analiz yöntemleri parmak izlerine büyük ölçüde benzerdir.

Parmak izleri yalnızca yüzeydeki bir iz kümesi değildir. Oluşumu ve bireyselleşmesinde görev alan biyolojik ve çevresel etmenlerin bütüncül etkisi, parmak izlerini güvenilir ve tekrarlanabilir bir kimlik tespit aracı haline getirir.

KAYNAKLAR

1. Figini A da L. *Datiloscopia e revelação de impressões digitais*. Campinas Millennium Editora. 2012.
2. Houck M. *Forensic fingerprints*. 1st ed. Amsterdam:Elsevier; 2016
3. Tortora GJ, Grabowski SR. *Principles of anatomy and physiology*. 7th ed. New York: Wiley; 1993.
4. Wertheim K, Maceo A. The critical stage of friction ridge pattern formation. *J Forensic Identif*. 2002;52(1):37.
5. Maceo AV. Anatomy and physiology of adult friction ridge skin. In: *The fingerprint sourcebook*. Washington; 2011. p. 2–4.
6. Cooper S. *The biology of the skin.* Freinkel RK, Woodman DA, editors. New York: Parthenon Publishing; 2001. P 71.
7. Yamashita B, French M. Latent print development. In: *The fingerprint sourcebook*. Washington; 2011. p. 3–67.
8. Bleay SM, de Puit M. Formation of fingermarks. In: *Fingerprint Development Techniques: Theory and Application*. John Wiley & Sons Ltd; 2018. p. 11–35.
9. Vincent P. Skin:A brief look under the surface. *Fingerprint Whorld*. 1985;11(41):8–12.
10. Scheibert J, Leurent S, Prevost A, et al., The Role of Fingerprints in the Coding of Tactile Information Probed with a Biomimetic Sensor. *Science* (1979). 2009 Mar 13;323(5920):1503–6.
11. Yum SM, Baek IK, Hong D, et al. Fingerprint ridges allow primates to regulate grip. *Proceedings of the National Academy of Sciences*. 2020 Dec 15;117(50):31665–73.
12. Hale A. Morphogenesis of volar skin in the human fetus. *American Journal of Anatomy*. 1952;91(1):147–81.
13. Biswas G. Review of Forensic Medicine and Toxicology : including clinical & pathological aspects. *Jaypee Brothers Medical* P; 2018.
14. Galton F. *Fingerprints*. Cosimo Classics. 1892.

15. Babler WJ. Embryologic development of epidermal ridges and their configurations. *Birth Defects Orig Artic Ser*. 1991;27(2):95–112.
16. Kaur J, Dhall M. Reproducibility of fingerprint microfeatures. *Egypt J Forensic Sci* [Internet]. 2022 Dec 1 [cited 2023 Oct 28];12(1):1–9. Available from: https://ejfs.springeropen.com/articles/10.1186/s41935-022-00266-6
17. Ashbaugh D. Quantitative-qualitative friction ridge analysis. Boca Raton,FL: CRC Press; 1999.
18. Preethi DS, Nithin MD, Manjunatha B. Et al., Study of Poroscopy Among South Indian Population*. *J Forensic Sci*. 2012 Mar 15;57(2):449–52.
19. Oklevski S. Poroscopy: Qualitative and Quantitative Analysis of the 2nd and 3rd Level Detail and their Relation. *Fingerprint Whorld*. 2011;37(145):170–81.
20. Ramotowski RS. Composition of Latent Print Residue CRC Press,. In: Lee HC, Gaensslen RE, editors. Advances in Fingerprint Technology. 2nd ed. Boca Raton, FL; 2001.
21. Saga K. Structure and function of human sweat glands studied with histochemistry and cytochemistry. *Prog Histochem Cytochem*. 2002 Jan;37(4):323–86.
22. Quinton PM. Sweating and its Disorders. *Annu Rev Med*. 1983 Feb;34(1):429–52.
23. Goldsmith L. Biochemistry and Physiology of the Skin. *New York: Oxford University Press;* 1983. p. 596–641.
24. Junqueira LCU, Carneiro J. *Journal of basic histology*. 10th ed. New York: Lange Medical Books; 2003. p. 369–380.
25. Olsen RD, Scatt WR. Scott's fingerprint mechanics. Charles Thomas Publisher; 1978.
26. Anderson K, Anderson L, Glanze W. Mosby's medical, nursing and allied health dictionary. 5th ed. Mosby, Incorporated; 1998. p. 1561.
27. Downing DT, Strauss JS. Synthesis and composition of surface lipids of human skin. *Journal of Investigative Dermatology*. 1974 Mar;62(3):228–44.
28. Akamatsu Hirohiko, Zouboulis CC, Orfanos CE. Control of Human Sebocyte Proliferation In Vitro by Testosterone and 5-Alpha-Dihydrotestosterone Is Dependent on the Localization of the Sebaceous Glands. *Journal of Investigative Dermatology*. 1992 Oct;99(4):509–11.
29. Croxton RS, Bleay SM, de Puit M. Composition and properties of fingermark. In: Bleay SM, Croxton RS, de Puit M, editors. *Fingerprint Development Techniques: Theory and Application*. Wiley; 2018. p. 35–68.
30. Bojar RA, Holland KT. Review: the human cutaneous microflora and factors controlling colonisation. *World J Microbiol Biotechnol*. 2002 Dec;18(9):889–903.
31. Croxton RS, Baron MG, Butler D, et al., Variation in amino acid and lipid composition of latent fingerprints. *Forensic Sci Int*. 2010 Jun;199(1–3):93–102.
32. Xu L, Zhang C, He Y, et al., Advances in the development and component recognition of latent fingerprints. *Sci China Chem*. 2015 Jul 3;58(7):1090–6.
33. Shelley WB. Apocrine sweat. *Journal of investigative dermatology*. 1951;17(255):255.
34. Cadd S, Islam M, Manson P, et al., Fingerprint composition and aging: A literature review. *Science & Justice*. 2015 Jul;55(4):219–38.
35. VanPutte C, Regan J, Russo A, et al., *Seeley's anatomy & physiology*. 10th ed. McGraw-Hill; 2011. p. 692–694.
36. Noble WC. *Microbiology of Human Skin*. Moscow: Medicine; 1981.
37. Harper DR, Clare CM, Heaps CD, Brennan J, Hussain J. A bacteriological technique for the development of latent fingerprints. *Forensic Sci Int*. 1987 Mar;33(3):209–14.
38. Fierer N, Hamady M, Lauber CL, Knight R. The influence of sex, handedness, and washing on the diversity of hand surface bacteria. *Proceedings of the National Academy of Sciences*. 2008 Nov 18;105(46):17994–9.
39. Dorakumbura BN, Becker T, Lewis SW. Nanomechanical mapping of latent fingermarks: A preliminary investigation into the changes in surface interactions and topography over time. *Forensic Sci Int*. 2016 Oct;267:16–24.
40. Scruton B, Blott BH. Surface Potential of Finger Prints on Paper and Fabrics. University of

Southampton. Physics Department: Report for PSDB; 1973.
41. Chizmadzhev YA, Indenbom A V., Kuzmin PI, et al., Electrical Properties of Skin at Moderate Voltages. *Biophys J.* 1998 Feb;74(2):843–56.
42. Hazarika P, Russell DA. Advances in Fingerprint Analysis. Angewandte Chemie International Edition. 2012 Apr 10;51(15):3524–31.
43. Maltoni D, Mario D, Jain AK, Prabhakar S. Introduction. In: *Handbook of fingerprint recognition*. 2nd ed. Springer; 2009. p. 1–56.
44. Barnes JG. History. In: The Fingerprint Sourcebook [Internet]. U.S. Dept. of Justice; 2011. Available from: www.nij.gov
45. Yount L. Forensic science: from fibers to fingerprints. New York: Chelsea House Publishers; 2007.
46. Lin C, Liu J, Osterburg J, et al., Fingerprint Comparison. I: Similarity of Fingerprints. *J Forensic Sci*. 1982 Apr 1;27(2):290–304.
47. Awad AI. Machine Learning Techniques for Fingerprint Identification: A Short Review. In 2012. p. 524–31.
48. Nagesh KR, Bathwal S, Ashoka B. A preliminary study of pores on epidermal ridges: Are there any sex differences and age related changes? *J Forensic Leg Med*. 2011 Oct;18(7):302–5.
49. Champod C, Lennard C, Margot P. *Fingerprints and other ridge skin impressions*. 2nd ed. New York: CRC Press; 2016.
50. Sears VG, Bleay SM, Bandey HL. et al., A methodology for finger mark research. *Science & Justice*. 2012 Sep;52(3):145–60.
51. Kumar R, Singh JP, Srivastava G. Altered Fingerprint Identification and Classification Using SP Detection and Fuzzy Classification. In: 2nd International Conference on Soft Computing for Problem Solving SocProS. 2012. p. 1343–9.
52. Girod A, Ramotowski R, Weyermann C. Composition of fingermark residue: A qualitative and quantitative review. *Forensic Sci Int*. 2012 Nov;223(1–3):10–24.
53. Ramasastry P, Downing DT, Pochi PE, et al., Chemical composition of human skin surface lipids from birth to puberty. *Journal of Investigative Dermatology*. 1970 Feb;54(2):139–44.
54. Ramotowski RS. Composition of Latent Print Residue CRC Press. In: Lee HC, Gaensslen RE, editors. *Advances in Fingerprint Technology.* 2nd ed. Boca Raton, FL; 2001.
55. Antoine KM, Mortazavi S, Miller AD, et al., Chemical Differences Are Observed in Children's Versus Adults' Latent Fingerprints as a Function of Time*. *J Forensic Sci*. 2010 Mar;55(2):513–8.
56. Stewart ME, Downing DT. Unusual Cholesterol Esters in the Sebum of Young Children. *Journal of Investigative Dermatology*. 1990 Nov;95(5):603–6.
57. Ichinose-Kuwahara T, Inoue Y, Iseki Y, et al., Experimental Physiology – Research Paper: Sex differences in the effects of physical training on sweat gland responses during a graded exercise. *Exp Physiol*. 2010 Oct 2;95(10):1026–32.
58. Charkoudian N, Stachenfeld N. Sex hormone effects on autonomic mechanisms of thermoregulation in humans. *Autonomic Neuroscience*. 2016 Apr;196:75–80.
59. Firooz A, Sadr B, Babakoohi S, et al. Variation of Biophysical Parameters of the Skin with Age, Gender, and Body Region. *The Scientific World Journal.* 2012;2012:1–5.
60. Huynh C, Brunelle E, Halámková L, et al., Halámek J. Forensic Identification of Gender from Fingerprints. *Anal Chem*. 2015 Nov 17;87(22):11531–6.
61. Kapoor N, Badiye A. Sex differences in the thumbprint ridge density in a central Indian population. *Egypt J Forensic Sci*. 2015 Mar;5(1):23–9.
62. Kralik M, Novotny V. Epidermal ridge breadth: an indicator of age and sex in paleodermatoglyphics. *Variability and Evolution*. 2003;11:5–30.
63. Krishan K, Ghosh A, Kanchan T, et al., Sex differences in fingerprint ridge density – Causes and further observations. *J Forensic Leg Med*. 2010 Apr;17(3):172–3.
64. Ganceviciene R, Zouboulis CC. Isotretinoin: state of the art treatment for acne vulgaris. JDDG:

Journal der Deutschen Dermatologischen Gesellschaft. 2010 Mar 16;8:47–59.
65. Shi VY, Leo M, Hassoun L, et al., Role of sebaceous glands in inflammatory dermatoses. *J Am Acad Dermatol*. 2015 Nov;73(5):856–63.
66. Strauss JS, Stranieri AM. Changes in long-term sebum production from isotretinoin therapy. *J Am Acad Dermatol*. 1982 Apr;6(4):751–5.
67. Cheshire WP, Fealey RD. Drug-induced hyperhidrosis and hypohidrosis. *Drug Saf*. 2008;31(2):109–26.
68. Al-Ahwal MS. Chemotherapy and Fingerprint Loss: Beyond Cosmetic. *Oncologist.* 2012 Feb 1;17(2):291–3.
69. Upshaw BY. Hereditary anhidrotic ectodermal dysplasia. *Arch Derm Syphilol.* 1949 Dec 1;60(6):1170.
70. Drahansky M, Dolezel M, Urbanek J. et al., Influence of Skin Diseases on Fingerprint Recognition. *J Biomed Biotechnol*. 2012;2012:1–14.
71. Azadeh P, Dashti-Khavidaki S, Joybari AY, et al. Fingerprint changes among cancer patients treated with paclitaxel. *J Cancer Res Clin Oncol*. 2017 Apr 17;143(4):693–701.
72. Sarfraz N. Adermatoglyphia: Barriers to Biometric Identification and the Need for a Standardized Alternative. *Cureus*. 2019 Feb 8.
73. James WD, Elston D, Berger T. Andrew's diseases of the skin: clinical dermatology. *Elsevier Health Sciences*; 2011.
74. Habif TP. Clinical dermatology . Elsevier Health Sciences. 2015.
75. David TJ. Congenital malformations of human dermatoglyphs. *Arch Dis Child*. 1973 Mar 1;48(3):191–8.
76. Ramaswami U, Whybra C, Parini R, et al., Sunder-Plassmann G, et al. Clinical manifestations of Fabry disease in children: Data from the Fabry Outcome Survey. *Acta Paediatr*. 2006 Jan 1;95(1):86–92.
77. Lee CK, Chang CC, Johar A, et al., Fingerprint Changes and Verification Failure Among Patients With Hand Dermatitis. *JAMA Dermatol*. 2013 Mar 1;149(3):294.
78. Batool A, Shehzad F, Gul I. Identification and comparison of fingerprint damages among different occupations in Punjab, Pakistan for forensic casework. *International Journal of Natural Medicine and Health Sciences*. 2023;2(2):21–6.
79. Sharma R, Mukhopdhyay R, Tarunam A, et al., Personal identification from occupational marks present on the palm prints: A study of the urban region of New Delhi. *Indian J Phys Anthropol Hum Genet*. 2024;43(1):45–58.
80. Dhall JK, Kapoor AK. Development of latent prints exposed to destructive crime scene conditions using wet powder suspensions. *Egypt J Forensic Sci*. 2016 Dec;6(4):396–404.
81. Bleay SM, de Puit M. Ageing of fingermarks. In: *Fingerprint Development Techniques: Theory and Application*. 2018. p. 69–98.
82. Richmond-Aylor A, Bell S, Callery P, et al., Thermal degradation analysis of amino acids in fingerprint residue by pyrolysis GC–MS to develop new latent fingerprint developing reagents. *J Forensic Sci*. 2007 Mar 16;52(2):380–2.
83. Gülekçi Y. Effects of environmental factors on fingerprint development. *Avrupa Bilim ve Teknoloji Dergisi*. 2021;32:463–70.
84. Wargacki SP, Lewis LA, Dadmun MD. Enhancing the Quality of Aged Latent Fingerprints Developed by Superglue Fuming: Loss and Replenishment of Initiator. *J Forensic Sci*. 2008 Sep 28;53(5):1138–44.
85. G. Ferreira R, B. A. Paula R, A. Okuma A, M. Costa L. Fingerprint development techniques: A review. *Revista Virtual de Química*. 2021;13(6):1278–302.
86. Champod C, Lennard C, Margot P, et al., Fingermark Detection and Enhancement. In: Fingerprints and Other Ridge Skin Impressions. 2nd ed. CRC Press; 2016.
87. Archer NE, Charles Y, Elliott JA, et al., Changes in the lipid composition of latent fingerprint residue with time after deposition on a surface. *Forensic Sci Int*. 2005 Nov;154(2–3):224–39.

88. Wertheim K. Fingerprint age determination: is there any hope? *Journal of Forensic Identification*. 2003;53(1):42–9.
89. Reed H, Stanton A, Wheat J, et al. The Reed-Stanton press rig for the generation of reproducible fingermarks: Towards a standardised methodology for fingermark research. *Science & Justice*. 2016 Jan;56(1):9–17.
90. Daluz HM. The Nature of Latent Prints. In: Fundamentals of Fingerprint Analysis. 2nd ed. *Taylor & Francis*; 2019. p. 83–93.
91. Czech A, Gryszczyk N, Szabelak A, et al., Changes in Fingerprints and the Quantity of Material Forming the Print Depending on Hand Cleanliness, Gender, and Ambient Conditions. *J Forensic Sci*. 2020 Jan 27;65(1):84–9.
92. Aseri V, Nagar V, Godara VR, et al. A comparative study on scanned fingerprint after applying lubricants and without scanned fingerprint on porous surface; (white paper). *Mater Today Proc*. 2022;69:1515–31.
93. Bleay SM. Evaluation and comparison of fingermark enhancement processes. In: Bleay SM, Croxton RS, de Puit M, editors. *Fingerprint development techniques: Theory and application*. 1st ed. Sandridge: wiley; 2018. p. 421–42.
94. Kaur T, Chitara N, Guleria A, et al. Development, detection and decipherment of obfuscated fingerprints in humans: Implications for forensic casework. *The Science of Nature.* 2023 Dec 4;110(6):55.
95. Suman A. Classification of arch test fingerprint verification result template features acquisition and preprocessing features extraction comparison knowledge base. *Int J Math Comput Sci*. 2012;17:289–307.
96. Harrison J, Beasley B, Baraniuk C, et al., Classification of images. *OpenStax-CNX*. 2004.
97. Cole SA. More than zero: Accounting for error in latent fingerprint identification. *The Journal of Criminal Low and Criminology*. 2004;95(3):985.
98. Sodhi GS, Kaur J. The forgotten Indian pioneers of fingerprint science. *Curr Sci*. 2005;88(1):185–91.
99. Singh RK, Sharma M, Tarannum A, A Case of Three Deltas in a Fingerprint. *J Forensic Res*. 2018;9(2).
100. Forensic Science Regulator. Fingerprint Examination - Terminology, Definitions and Acronyms. *Crown Copyright*. 2013.
101. Daluz HM. The Nature of Latent Prints. In: *Fundamentals of Fingerprint Analysis*. 2nd ed. CRC Press; 2018. p. 83–93.
102. Lennard C. Fingerprint detection: current capabilities. Australian *Journal of Forensic Sciences*. 2007 Dec;39(2):55–71.
103. Peixoto AS, Ramos AS. Filmes finos & Revelação de ımpressões digitais latentes. *Tecnologia dos Materiais* . 2010;22(29).
104. Daluz HM. Palm Print Comparisons. In: *Fundamentals of Fingerprint Analysis*. 2nd ed. 2019.
105. Dar H, Carney FE, Winter ST. Dermatoglyphics and The Sımıan Crease ın Infants of Low Birth Weight. *Acta Paediatr*. 1971 Jul 21;60(4):479–81.
106. Maceo A, Carter M, Stromback B. Palm Prints. In: *Encyclopedia of Forensic Sciences*. Elsevier; 2013. p. 29–36.
107. Alter M. Variation in Palmar Creases. Arch Pediatr Adolesc Med. 1970 Nov 1;120(5):424.
108. Afework M. Prevalence of the Different Types of Palmar Creases Among Medical and Dental Students in Addis Ababa, Ethiopia. *Ethiop J Health Sci*. 2019 Jan 1;29(3):391–400.
109. Johnson BT, Riemen JAJM. Digital capture of fingerprints in a disaster victim identification setting: a review and case study. *Forensic Sci Res.* 2019 Oct 2;4(4):293–302.
110. Daluz HM. Known Fingerprints. In: *Fundamentals of Fingerprint Analysis.* 2nd ed. CRC Press; 2019. p. 76–9.
111. DiMaio V, DiMaio D. Forensic Pathology. 2nd ed. Boca Raton, FL: Taylor & Francis; 2001.
112. Chen C, Yang C, Chen C, et al., Comparison of Rehydration Techniques for Fingerprinting the

Deceased after Mummification. *J Forensic Sci*. 2017 Jan 10;62(1):205–8.
113. INTERPOL. https://www.interpol.int/How-we-work/Forensics/Disaster-Victim-Identification-DVI. 2021. Diseaster Victim Identification (DVI).
114. Cutro B. Recording living and postmortem friction ridge exemplars. In: The Fingerprint Sourcebook. Washington, DC: National Institute of Justice, U.S. Department of Justice, Office of Justice Programs; 2011.
115. Ünlütürk O, Afşin H. Ölüm Olgularında Kimlik Tespiti. *Turkiye Klinikleri Forensic Medicine-Special Topics.* 2016;2(1):24–34.
116. FBI (Federal Bureau of Investigation USD of J. The Science of Fingerprints. US Government Printing Office. 1979.
117. Cattaneo C, De Angalis D, Porta D, et al., Personal identification of cadavers and human remains. In: Schmitt A, Cunha E, Pinheiro J, editors. Forensic Anthropology and Medicine: Complementary Sciences from Recovery to Cause of Death. 1st ed. Totowa, NJ: Humana Press Inc; 2006. p. 359–79.
118. Boudreault A, Beaudoin A. Pseudo-Operational Study on the Efficiency of Various Fingermark Development Techniques During the Aging Process. *J Forensic Identif*. 2017;67(1).
119. Boseley RE, Vongsvivut J, Appadoo D, et al., Monitoring the chemical changes in fingermark residue over time using synchrotron infrared spectroscopy. *Analyst*. 2022;147(5):799–810.
120. Yang JH, Yoh JJ. Reconstruction of chemical fingerprints from an individual's time-delayed, overlapped fingerprints via laser-induced breakdown spectrometry (LIBS) and Raman spectroscopy. *Microchemical Journal*. 2018 Jun;139:386–93.
121. Pleik S, Spengler B, Schäfer T, et al., Fatty Acid Structure and Degradation Analysis in Fingerprint Residues. *J Am Soc Mass Spectrom*. 2016 Sep 1;27(9):1565–74.
122. Johnston A, Rogers K. A study of the intermolecular interactions of lipid components from analogue fingerprint residues. *Science & Justice*. 2018 Mar;58(2):121–7.
123. Popov KT, Sears VG, Jones BJ. Migration of latent fingermarks on non-porous surfaces: Observation technique and nanoscale variations. *Forensic Sci Int*. 2017 Jun;275:44–56.
124. De Alcaraz-Fossoul J, Einfalt MR, Dean ER, et al., Chavez A, Roberts KA. Repeatability and reproducibility of the color contrast technique for fingermark age estimation applications. *J Forensic Sci*. 2021 May 22;66(3):1075–84.
125. Chen H, Shi M, Ma R, et al., Advances in fingermark age determination techniques. *Analyst*. 2021;146(1):33–47.
126. van Dam A, Schwarz JC V., de Vos J, et al., Oxidation Monitoring by Fluorescence Spectroscopy Reveals the Age of Fingermarks. *Angewandte Chemie International Edition*. 2014 Jun 10;53(24):6272–5.
127. Merkel R, Gruhn S, Dittmann J, et al., On non-invasive 2D and 3D Chromatic White Light image sensors for age determination of latent fingerprints. *Forensic Sci Int*. 2012 Oct;222(1–3):52–70.
128. Hinners P, Thomas M, Lee YJ. Determining Fingerprint Age with Mass Spectrometry Imaging via Ozonolysis of Triacylglycerols. *Anal Chem*. 2020 Feb 18;92(4):3125–32.
129. Girod A, Spyratou A, Holmes D, et al., Aging of target lipid parameters in fingermark residue using GC/MS: Effects of influence factors and perspectives for dating purposes. *Science & Justice*. 2016 May;56(3):165–80.

BÖLÜM 3

PSİKOAKTİF MADDELERİN PARMAK İZİNDEN TAYİNİ

İnci SAĞLAM [1]
Nebile DAĞLIOĞLU [2]

GİRİŞ

Parmak izi, adli bilimlerin en köklü kimliklendirme araçlarından biri olarak uzun yıllardır kullanılmaktadır. Ancak güncel adli toksikoloji perspektifi, parmak izini yalnızca bir biyometrik desen olmaktan çıkarıp, kişinin fizyolojik özelliklerine, temas ettiği maddelere ve yasadışı veya terapötik bileşenlere maruz kalım geçmişine dair kimyasal bilgi taşıyan bir biyolojik numune olarak yeniden konumlandırmaktadır. Bu dönüşüm, gelişmiş analitik cihazların kazandırdığı yüksek duyarlılık sayesinde mümkün olmuş; böylece parmak izi hem kimlik hem de kimyasal profil bilgisi içeren çok boyutlu bir delil türüne evrilmiştir (1).

Parmak izi kalıntısı; ter, sebum, organik bileşikler, inorganik iyonlar ve epidermal hücre parçalarının karmaşık bir birleşimidir. Bu biyolojik karışım, kişinin metabolizmasının ürünü olan endojen maddelerin yanı sıra, çevreden veya dokunulan yüzeylerden taşınan çok çeşitli kimyasalları da içerebilir. Kozmetik ürünler, gıdalar, ilaç bileşenleri ve yasadışı maddeler bu kimyasal çeşitliliğin başlıca örnekleridir (2). Yasadışı bir maddenin vücuda alınmasıyla oluşan metabolitler terle atılabildiğinden, parmak izi kalıntısında hem ana madde hem de metabolit düzeyinde sistemik maruz kalımın izleri bulunabilir. Bu yönüyle parmak izi, kullanım ile yüzey temasından kaynaklanan bulaşın ayırt edilebilmesi açısından önemli bir potansiyele sahiptir (3).

Parmak izleri adli süreçlerde iki temel bağlamda değerlendirilir: suç mahallinde bırakılan latent izler ve kontrollü koşullarda donörden alınan izler. Kontrollü alınan örneklerde temas süresi, yüzey türü ve basınç gibi değişkenlerin standardize edilebilmesi analitik

[1] Uzm. Dr. Manisa Ruh Sağlığı ve Hastalıkları Hastanesi- Merkez Laboratuvarı, Adli ve Klinik Toksikoloji Birimi, drinciyilmaz@gmail.com, ORCID iD: 0000-0003-2076-9602

[2] Prof. Dr. Ankara Üniversitesi-Adli Bilimler Enstitüsü, Adli Kimya ve Adli Toksikoloji AD., ndaglioglu@ankara.edu.tr, ORCID iD: 0000-0003-3415-8159

KAYNAKLAR

1. Adamowicz P, Bigosińska J, Gil D, et al. Drugs detection in fingerprints. *Journal of Pharmaceutical and Biomedical Analysis*, 2024;*238:115835*. doi:10.1016/j.jpba.2023.115835
2. Girod A, Ramotowski R, Weyermann C. Composition of fingermark residue: A qualitative and quantitative review. *Forensic Science International*. 2012;223(1–3):10–24. doi:10.1016/j.forsciint.2012.05.018.
3. Bailey MJ, Bradshaw R, Francese S, et al. Rapid detection of cocaine, benzoylecgonine and methylecgonine in fingerprints using surface mass spectrometry. *Analyst*, 2015;140(18), 6254–6259. doi:10.1039/c5an00112a
4. Costa C, Ismail M, Stevenson D, et al. Distinguishing between contact and administration of heroin from a single fingerprint using high resolution mass spectrometry. *Journal of Analytical Toxicology*, 2020;44(3), 218–225. doi:10.1093/jat/bkz088
5. Ameline A, Gheddar L, Arbouche N, et al. Fingerprints: A new specimen for innovative applications for the detection of xenobiotics. *Journal of Analytical Toxicology*, 2022;46(9), e243–e247. doi:10.1093/jat/bkac091
6. Czekanski P, Fasola M, Allison J. A mechanistic model for the superglue fuming of latent fingerprints. *Journal of Forensic Sciences*, 2006;51(6), 1323–1328. doi:10.1111/j.1556-4029.2006.00258.x
7. Mong GM, Petersen CE, Clauss TRW. Advanced fingerprint analysis project fingerprint constituents (No. PNNL-13019). Pacific Northwest National Laboratory. 1999;1-40. doi:10.2172/14172 1999
8. Wolstenholme R, Bradshaw R, Clench MR, et al. Study of latent fingermarks by matrix-assisted laser desorption/ionisation mass spectrometry imaging of endogenous lipids. *Rapid Communications in Mass Spectrometry*, 2009;23(19), 3031–3039. doi:10.1002/rcm.4218
9. de Almeida CM, dos Santos NA, Lacerda V, et al. Applications of MALDI mass spectrometry in forensic science. *Analytical and Bioanalytical Chemistry,* 2024;416,5255–5280. doi:10.1007/s00216-024-05470-y
10. Day JS, Edwards HGM, Dobrowski SA, et al. The detection of drugs of abuse in fingerprints using Raman spectroscopy II: Cyanoacrylate-fumed fingerprints. *Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy*, 2004;60(8–9),1725–1730. doi:10.1016/j.saa.2003.09.013
11. Brown HM, McDaniel TJ, Fedick PW, et al. The current role of mass spectrometry in forensics and future prospects. *Analytical Methods.* 2020;12(32),3974–3997. doi:10.1039/d0ay01113d
12. Jang M, Costa C, Bunch J, et al. On the relevance of cocaine detection in a fingerprint. Scientific Reports. 2020;6,10(1):1974. doi: 10.1038/s41598-020-58856-0.
13. Jacob S, Jickells S, Wolff K, et al. Drug testing by chemical analysis of fingerprint deposits from metha-done-maintained opioid dependent patients using UPLC-MS/MS. *Drug Metabolism Letters*. 2008 2(4):245-7. doi: 10.2174/187231208786734094
14. Zhang T, Chen X, Yang R, et al. Detection of methamphetamine and its main metabolite in fingermarks by liquid chromatography-mass spectrometry. *Forensic Science International*, 2015;248, 10–14. doi:10.1016/j.forsciint.2014.12.013
15. Ismail M, Costa C, Longman K, et al. Potential to use fingerprints for monitoring therapeutic levels of ısoniazid and treatment adherence. *ACS Omega*, 2022;*7*(17), 15167–15173. doi:10.1021/acsomega.2c01257
16. Kuwayama K, Tsujikawa K, Miyaguchi H, et al. Time-course measurements of caffeine and its metabolites extracted from fingertips after coffee intake: A preliminary study for the detection of drugs from fingerprints. *Analytical and Bioanalytical Chemistry*, 2013;405(12), 3945–3952. doi:10.1007/s00216-012-6569-3
17. Talaat R, Darwish S, Adel M, et al. Detection of some drugs of abuse from fingerprınts using

liquid chromatography-Mass spectrometry. *Egyptian Journal of Forensic Sciences and Applied Toxicology*. 2017;17,2,73-91. doi: 10.21608/ejfsat.2017.46122
18. González M, Gorziza RP, de Cássia Mariotti K, et al. Methodologies applied to fingerprint analysis. *Journal of Forensic Sciences.* 2020;65(4): 1040–1048. doi:10.1111/1556-4029.14313
19. Takáts Z, Wiseman JM, Gologan B, et al. Mass spectrometry sampling under ambient conditions with desorption electrospray ıonization. *Science.* 2004;15;306(5695):471-473. doi: 10.1126/science.1104404
20. Costa C, Jang M, De Jesus J. et al. Imaging mass spectrometry: A new way to distinguish dermal contact from administration of cocaine, using a single fingerprint. *Analyst*, 2021;146(12), 4010–4021. doi:10.1039/d1an00232e
21. Ismail M, Stevenson D, Costa C, et al. Noninvasive detection of cocaine and heroin use with single fingerprints: Determination of an environmental cutoff. *Clinical Chemistry*, 2018;*64*(6), 909–917. doi:10.1373/clinchem.2017.281469
22. McDonnell LA, Heeren RMA. Imaging mass spectrometry. *Mass Spectrometry Reviews* 2007;26(4):606–643. Doi:10.1002/mas.20124
23. Bradshaw R, Rao W, Wolstenholme R, et al, Separation of overlapping fingermarks by Matrix Assisted Laser Desorption Ionisation Mass Spectrometry Imaging. *Forensic Science International*. 2012;*222*(1–3), 318–326. doi:10.1016/j.forsciint.2012.07.009
24. Ferguson L, Bradshaw R, Wolstenholme R, et al. Two-step matrix application for the enhancement and imaging of latent fingermarks. *Analytical Chemistry*, 2011;*83*(14), 5585–5591. Doi:10.1021/ac200619f
25. Groeneveld G, De Puit M, B leay S, et al. Detection and mapping of illicit drugs and their metabolites in fingermarks by MALDI MS and compatibility with forensic techniques. *Scientific Reports*, 2015;*5*. Doi:10.1038/srep11716
26. Salomé PMP, Rodriguez-Alvarez H, Sadewasser S. Incorporation of alkali metals in chalcogenide solar cells. *Solar Energy Materials and Solar Cells*. 2015;143:9–20.V. doi:10.1016/j.solmat.2015.06.011
27. Bailey MJ, Ismail M, Bleay S, et al. Enhanced imaging of developed fingerprints using mass spectrometry imaging. *Analyst*, 2013;138(21), 6246–6250. doi:10.1039/c3an01204b
28. Szynkowska MI, Czerski K, Rogowski J, et al. ToF-SIMS application in the visualization and analysis of fingerprints after contact with amphetamine drugs. *Forensic Science International*, 2009;*184*(1–3). doi:10.1016/j.forsciint.2008.11.003
29. Ionoptica Ltd. *Cocaine metabolite imaging in fingerprints with water ckuster SIMS*. 2012. Available from:https://ionoptika.com/news/cocaine-metabolite-imaging-in-fingerprints-with-water-cluster-sims/ (Accessed 29 November 2025).
30. Mogk DW. *Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS)* 2018. Available from:https://serc.carleton.edu/research_education/geochemsheets/techniques/ToFSIMS.html. Accessed:29 November 2025.
31. Cody RB, Laramée JA, Durst HD. Versatile new ion source for the analysis of materials in open air under ambient conditions. *Analytical Chemistry*, 2005; 77(8), 2297–2302. doi:10.1021/ac050162j
32. Lesiak AD, Shepard JRE. Recent advances in forensic drug analysis by DART-MS. Bioanalysis, 2014;6(6), 819–842. doi:10.4155/bio.14.31
33. Costa C, Webb R, Palitsin V, et al. Rapid, secure drug testing using fingerprint development and paper spray mass spectrometry. *Clinical Chemistry*, 2017; *63*(11), 1745–1752. doi:10.1373/clinchem.2017.27557.8
34. Chiang S, Zhang W, Ouyang Z. Paper spray ionization mass spectrometry: recent advances and clinical applications. *Expert Review of Proteomics*, 2018;*15*(10), 781–789. doi:10.1080/14789450.2018.1525295
35. Bumbrah GS, Sharma RM. Raman spectroscopy – Basic principle, instrumentation and selec-

ted applications for the characterization of drugs of abuse. *Egyptian Journal of Forensic Sciences* 2016;6(3);209–215. doi:10.1016/j.ejfs.2015.06.001

36. Holze RE. *Modern Raman spectroscopy—a practical approach*, 1st ed. Chichester:Wiley;2005.
37. Weyermann C, Mimoune Y, Anglada F, Applications of a transportable Raman spectrometer for the in situ detection of controlled substances at border controls. *Forensic Science International*, 2011;*209*(1–3), 21–28. doi:10.1016/j.forsciint.2010.11.027
38. West MJ, Went MJ. Detection of drugs of abuse by Raman spectroscopy. *Drug Testing and Analysis.* 2011;3(9):532–538. doi:10.1002/dta.217
39. Huynh C, Halámek J. Trends in fingerprint analysis. *TrAC - Trends in Analytical Chemistry* 2016;82,328–336. doi:10.1016/j.trac.2016.06.003
40. Bailey MJ, De Puit M, Romolo FS. Surface analysis techniques in forensic science: successes, challenges, and opportunities for operational deployment. *Annual Review of Analytical Chemistry*, 2022; *15*(1), 173-196.

BÖLÜM 4

LATENT PARMAK İZLERİNDEN ADLİ DNA PROFİLLEME: MOLEKÜLER İZLER ÜZERİNE ENTEGRE YAKLAŞIMLAR

Fatma Ebru BEKİROĞLU [1]
Eda Nur AY [2]

GİRİŞ

1997 yılında van Oorschot ve Jones, bir kişinin yüzeye temasıyla aktardığı hücresel materyalin kimliklendirme açısından kullanılabileceğini ortaya koymuştur. Bu materyal "dokunma DNA'sı" (touch/trace DNA) olarak adlandırılır. Dokunma DNA'sı, bireyler ve koşullar arasında önemli farklılıklar göstermektedir. Temas sırasındaki fizyolojik etmenler (cilt kuruluğu/terleme, basınç, süre) ve temas sonrası çevresel koşullar (sıcaklık, nem, UV maruziyeti) bırakılan DNA miktarını etkiler. Ayrıca, dokunma sırasında sadece DNA değil aynı zamanda latent parmak izi de yüzeye aktarılmaktadır. Dolayısıyla, analistler parmak izi tespit edilen bir delilin biyolojik incelemeye de elverişli olabileceğini unutmamalıdır. Bu noktada kritik olan, parmak izi geliştirme yöntemlerinin DNA bütünlüğüne mümkün olduğunca az zarar verecek biçimde seçilmesi ve uygulanmasıdır.

Deliller arası çapraz bulaş da analizlerin doğru yorumlanmasını güçleştirir. Tozlama yönteminde kullanılan fırça ve tozlar ya da parmak izini yüzeyden kaldırmada kullanılan transfer bantları DNA aktarımına neden olabilir. Dokunma ile elde edilen bu biyolojik materyal genellikle düşük miktarda DNA içerir. Çeşitli dış etmenler ve delil işleme basamaklarındaki kayıplar nedeniyle eser düzeyde kalabilmektedir. Bu nedenle, örnekleme ve işlem sırasını optimize eden stratejilerin geliştirilmesi, DNA verimini artırarak dokunma DNA'sının adli bağlamda daha güvenilir kullanılmasını sağlayacaktır.

[1] Öğr. Gör., Kütahya Sağlık Bilimleri Üniversitesi, Adli Bilimler Bölümü, fatmaebru.yuksek@ksbu.edu.tr, ORCID iD: 0000-0002-1666-5416
[2] Arş. Gör., Kütahya Sağlık Bilimleri Üniversitesi, Adli Bilimler Bölümü, edanur.ay@ksbu.edu.tr, ORCID iD: 0000-0001-9070-253X

çok faktörden etkilenmektedir. Aynı yüzeyde parmak izi ve DNA'nın birlikte değerlendirilmesi delil değerini artırsa da, seçilecek yöntemlerin kontaminasyona yol açma veya DNA'ya zarar verme riski dikkatle yönetilmelidir. Bu nedenle, tek kullanımlık DNA-free malzeme kullanımı, uygun ıslatma/toplama stratejileri, yüzeye uygun izolasyon kimyası ve miniSTR/PCR gibi kanıta duyarlı protokollerle profil kalitesi ve bütünlüğünün artırılması hedeflenmelidir. Kısacası, birkaç saniyelik bir temasla bile kimliğe ulaşılabilmesi mümkünken, standardizasyon güçlükleri ve transfer/ kontaminasyon riskleri, alanın hâlen çözüm gerektiren eşzamanlı fırsat ve sınırlılıklarını ortaya koymaktadır.

KAYNAKLAR

1. Ahyayauch H, Bennouna M, Alonso A, et al. Detergent effects on membranes at subsolubilizing concentrations: Transmembrane lipid motion, bilayer permeabilization, and vesicle lysis/reassembly are independent phenomena. *Langmuir*, 2010; 26(10), 7307–7313.
2. Alaeddini R, Walsh SJ, Abbas A. Forensic implications of genetic analyses from degraded DNA—A review. *Forensic Science International: Genetics*, 2010; 4(3), 148–157.
3. Alessandrini F, Cecati M, Pesaresi, M. et al. Fingerprints as evidence for a genetic profile: Morphological study on fingerprints and analysis of exogenous and individual factors affecting DNA typing. *Journal of Forensic Sciences*, 2003; 48(3).
4. Alketbi SK. The affecting factors of touch DNA. *Journal of Forensic Research*, 2018; 9(3).
5. Alketbi SK. Analysis of Touch DNA. [Doctoral Dissertation]. University of Central Lancashire; 2022.
6. Alketbi SK, Goodwin, W. The effect of surface type, collection and extraction methods on touch DNA. *Forensic Science International: Genetics Supplement Series*, 2019a; 7(1), 704–706.
7. Alketbi SK, Goodwin, W. The effect of time and environmental conditions on Touch DNA. *Forensic Science International: Genetics Supplement Series,* 2019b; 7(1), 701–703.
8. Alketbi SK, Goodwin, W. H. Validating Touch DNA Collection Techniques Using Cotton Swabs. *Journal of Forensic Research*, 2019c; 10(3).
9. Aloraer DB. Evaluation of collection protocols for the recovery of biological samples from crime scenes. [Master's Thesis]. University of Central Lancashire; 2017.
10. Aloraer D, Hassan NH, Albarzinji B. et al. Improving recovery and stability of touch DNA. *Forensic Science International: Genetics Supplement Series*, 2017; 6, e390–e392.
11. Ambers A, Wiley R, Novroski N, et al. Direct PCR amplification of DNA from human bloodstains, saliva, and touch samples collected with microFLOQ® swabs. Forensic Science International: Genetics, 2018; 32, 80–87.
12. Anastassopoulou J. Metal–DNA interactions. *Journal of Molecular Structure*, 2003; 651–653, 19–26.https://doi.org/10.1016/S0022-2860(02)00625-7
13. Andersen J, Bramble S. The effects of fingermark enhancement light sources on subsequent PCR-STR DNA analysis of fresh bloodstains. *Journal of Forensic Sciences*, 1997; 42(2), 303–306.
14. Applied Biosystem. *GlobalFiler™ and GlobalFiler™ IQC PCR Amplification Kits.* 2019.
15. Balogh MK, Burger J, Bender K, et al. STR genotyping and mtDNA sequencing of latent fingerprint on paper. *Forensic Science International,* 2003; 137(2–3), 188–195.
16. Bathrick AS, Norsworthy S, Plaza DT, et al. DNA recovery after sequential processing of latent fingerprints on copy paper. *Journal of Forensic Sciences*, 2022; 67(1), 149–160.
17. Benschop CCG, Wiebosch DC, Kloosterman AD, et al. Post-coital vaginal sampling with nylon flocked swabs improves DNA typing. *Forensic Science International: Genetics*, 2010; 4(2),

115–121.
18. Bhoelai B, de Jong BJ, de Puit M, et al. Effect of common fingerprint detection techniques on subsequent STR profiling. *Forensic Science International: Genetics Supplement Series*, 2011; 3(1), e429–e430.
19. Bini C, Giorgetti A, Fazio G, et al. Impact on touch DNA of an alcohol-based hand sanitizer used in COVID-19 prevention. *International Journal of Legal Medicine*, 2023; 137(3), 645–653.
20. Bogas V, Carvalho M, Anjos MJ, et al. Genetic identification of degraded DNA samples buried in different types of soil. *Forensic Science International: Genetics Supplement Series*, 2009; 2(1), 169–171. https://doi.org/10.1016/j.fsigss.2009.08.031
21. Bonnet J, Colotte M, Coudy D, et al. Chain and conformation stability of solid-state DNA: implications for room temperature storage. *Nucleic Acids Research*, 2010; 38(5), 1531–1546.https://doi.org/10.1093/nar/gkp1060
22. Bonsu DOM, Higgins D, Austin JJ. Forensic touch DNA recovery from metal surfaces – A review. *Science & Justice*, 2020; 60(3), 206–215.https://doi.org/10.1016/j.scijus.2020.01.002
23. Bowman ZE, Mosse KSA, Sungaila AM, et al. Detection of offender DNA following skin-to-skin contact with a victim. *Forensic Science International: Genetics*, 2018; 37, 252–259.https://doi.org/10.1016/j.fsigen.2018.09.005
24. Breathnach M, Williams L, McKenna L, et al. Probability of detection of DNA deposited by habitual wearer and/or the second individual who touched the garment. *Forensic Science International: Genetics*, 2016; 20, 53–60. https://doi.org/10.1016/j.fsigen.2015.10.001
25. Bright JA, Petricevic SF. Recovery of trace DNA and its application to DNA profiling of shoe insoles. *Forensic Science International*, 2004; 145(1), 7–12. https://doi.org/10.1016/j.forsciint.2004.03.016
26. Bruijns B. What are the limitations and challenges of swab-based DNA sampling? *Forensic Sciences*, 2024; 4(1), 76–95. https://doi.org/10.3390/forensicsci4010006
27. Burrill J, Daniel B, Frascione N. A review of trace "Touch DNA" deposits: Variability factors and an exploration of cellular composition. *Forensic Science International: Genetics*, 2019; 39, 8–18. https://doi.org/10.1016/j.fsigen.2018.11.019
28. Butler J. *Fundamentals of forensic DNA typing.* Academic Press; 2009.
29. Cale CM. Forensic DNA evidence is not infallible. *Nature*, 2015; 526(7575), 611. https://doi.org/10.1038/526611a
30. Cale CM, Earll ME, Latham KE, et al. Could Secondary DNA Transfer Falsely Place Someone at the Scene of a Crime? *Journal of Forensic Sciences*, 2016; 61(1), 196–203. https://doi.org/10.1111/1556-4029.12894
31. Carlin M, Nickel R, Halstead K, et al. Quantifying DNA loss in laboratory-created latent prints due to fingerprint processing. *Forensic Science International*, 2023; 344, 111595. https://doi.org/10.1016/j.forsciint.2023.111595
32. Carrara L, Hicks T, Samie L, et al. DNA transfer when using gloves in burglary simulations. *Forensic Science International: Genetics*, 2023; 63, 102823. https://doi.org/10.1016/j.fsigen.2022.102823
33. Corradini B, Alù M, Magnanini E, et al. The importance of forensic storage support: DNA quality from 11-year-old saliva on FTA cards. *International Journal of Legal Medicine*, 2019; 133(6), 1743–1750. https://doi.org/10.1007/s00414-019-02146-6
34. Coutlée F, Voyer H. Effect of Nonionic Detergents on Amplification of Human Papillomavirus DNA with Consensus Primers MY09 and MY11. *Journal of Clinical Microbiology*, 1998; 36(4), 1164–1164.
35. Cowell RG, Lauritzen SL, Mortera J. Probabilistic expert systems for handling artifacts in complex DNA mixtures. *Forensic Science International: Genetics*, 2011; 5(3), 202–209. https://doi.org/10.1016/j.fsigen.2010.03.008
36. Dąbrowska AK, Spano F, Derler S, et al. The relationship between skin function, barrier proper-

ties, and body- dependent factors. *Skin Research and Technology*, 2018; 24(2), 165–174.
37. Daly DJ, Murphy C, McDermott SD. The transfer of touch DNA from hands to glass, fabric and wood. *Forensic Science International: Genetics*, 2012; 6(1), 41–46.
38. Dong H, Wang J, Zhang T, et al. Comparison of preprocessing methods and storage times for touch DNA samples. *Croatian Medical Journal*, 2017; 58(1), 4–13. https://doi.org/10.1016/j.ejfs.2016.06.003
39. Dong, H., Wang, J., Zhang, T., Ge, J., Dong, Y., Sun, Q., Liu, C., & Li, C. (2017). Comparison of preprocessing methods and storage times for touch DNA samples. *Croatian Medical Journal*, *58*(1), 4-13. https://doi.org/10.3325/cmj.2017.58.4
40. Doran AE, Foran DR. Assessment and mitigation of DNA loss utilizing centrifugal filtration devices. *Forensic Science International: Genetics*, 2014; 13, 187–190. https://doi.org/10.1016/j.fsigen.2014.08.001
41. Farmen RK, Jaghø R, Cortez P, et al. Assessment of individual shedder status and implication for secondary DNA transfer. *Forensic Science International: Genetics Supplement Series*, 2008; 1(1), 415–417.https://doi.org/10.1016/j.fsigss.2007.08.015
42. Farrell RE. Resilient ribonucleases. In: *RNA Methodologies*, Elsevier; 2010, 155–172.https://doi.org/10.1016/B978-0-12-374727-3.00007-3
43. Ferrara M, Sessa F, Rendine M, et al. A multidisciplinary approach is mandatory to solve complex crimes: a case report. *Egyptian Journal of Forensic Sciences*, 2019; 9(1), 11.https://doi.org/10.1186/s41935-019-0116-8
44. Fieldhouse S, Oravcova E, Walton-Williams L. The effect of DNA recovery on the subsequent quality of latent fingermarks. *Forensic Science International*, 2016; 267, 78–88.
45. Fonneløp AE, Johannessen H, Gill P. Persistence and secondary transfer of DNA from previous users of equipment. *Forensic Science International: Genetics Supplement Series*, 2015; 5, e191–e192.
46. Frégeau C, Germain O, Fourney R. Fingerprint Enhancement Revisited and the Effects of Blood Enhancement Chemicals on Subsequent Profiler Plus™ Fluorescent Short Tandem Repeat DNA Analysis of Fresh and Aged Bloody Fingerprints. *Journal of Forensic Sciences*, 2000; 45(2), 354–380.
47. Frégeau CJ, Germain O, Miller KJ, et al. The effects of blood enhance. *Journal of Forensic Sciences*.
48. Frégeau CJ, Lett CM, Fourney RM. Validation of a DNA IQ™-based extraction method for TECAN robotic liquid handling workstations for processing casework. *Forensic Science International: Genetics*, 2010; 4(5), 292–304.
49. Gardiner J, Banasiak M, Krosch MN. Sequencing DNA sampling and fingerprint development using DNA-free consumables: fingermark obliteration versus DNA recovery is not a zero-sum game. *Australian Journal of Forensic Sciences*, 2025; 57(4), 404–417.
50. Gardner RM, Krouskup DR. *Practical crime scene processing and investigation.* CRC Press; 2018.
51. Garrett AD, Patlak DJ, Gunn LE, et al. Exploring the potential of a wet-vacuum collection system for DNA recovery. *Journal of Forensic Identification*, 2014; 64(5), 429.
52. Gill P, Whitaker J, Flaxman C, et al. An investigation of the rigor of interpretation rules for STRs derived from less than 100 pg of DNA. *Forensic Science International*, 2000; 112(1), 17–40.
53. Goodwin W, Linacre A, Hadi S. *An introduction to forensic genetics.* John Wiley & Sons Ltd; 2007.
54. Goray M, Fowler S, Szkuta B, et al. Shedder status—An analysis of self and non-self DNA in multiple handprints deposited by the same individuals over time. *Forensic Science International: Genetics*, 2016; 23, 190–196.https://doi.org/10.1016/j.fsigen.2016.05.005
55. Goray M, Mitchell RJ, van Oorschot RAH. Investigation of secondary DNA transfer of skin cells under controlled test conditions. Legal Medicine, 2010; 12(3), 117–120.
56. Goray M, van Oorschot RAH. Shedder status: Exploring means of determination. Science &

Justice, 2021; 61(4), 391–400.
57. Hallmaier-Wacker LK, Lueert S, Roos C, et al. The impact of storage buffer, DNA extraction method, and polymerase on microbial analysis. Scientific Reports, 2018; 8(1), 6292.
58. Hammer U, Bulnheim U, Karstädt G, et al. Zur DNA-Typisierung übertragener Hautzellen nach körperlicher Gewalt. Rechtsmedizin, 1997; 7(6), 180–183.
59. Hegenbart S. The sequential analysis of DNA interpretation and fingerprint ridge patterns on porous paper evidence [Master thesis]. University of California; 2023.
60. Holland MM, Bonds RM, Holland CA, et al. Recovery of mtDNA from unfired metallic ammunition components with an assessment of sequence profile quality and DNA damage through MPS analysis. Forensic Science International: Genetics, 2019; 39, 86–96.
61. Holohan C, Feely N, Li P, et al. Role of detergents and nuclease inhibitors in the extraction of RNA from eukaryotic cells in complex matrices. Nanoscale, 2022; 14(33), 12153–12161.
62. Hytinen ME, Solomon AD, Miller MT, et al. Methods for Obtaining High-Quality Touch DNA from a Nonporous Surface after Latent Fingerprint Collection. Journal of Forensic Identification, 2017; 67(1).
63. Ip SCY, Lin S, Lai K. An evaluation of the performance of five extraction methods: Chelex® 100, QIAamp® DNA Blood Mini Kit, QIAamp® DNA Investigator Kit, QIAsymphony® DNA Investigator® Kit and DNA IQ™. Science & Justice, 2015; 55(3), 200–208.
64. Jansson L, Swensson M, Gifvars E, et al. Individual shedder status and the origin of touch DNA. Forensic Science International: Genetics, 2022; 56, 102626. https://doi.org/10.1016/j.fsigen.2021.102626
65. Kaesler T, Kirkbride KP, Linacre A. DNA deposited in whole thumbprints: A reproducibility study. *Forensic Science International: Genetics*, 2022; 58, 102683. https://doi.org/10.1016/j.fsigen.2022.102683
66. Kamphausen T, Schadendorf D, von Wurmb-Schwark N, et al. Good shedder or bad shedder—the influence of skin diseases on forensic DNA analysis from epithelial abrasions. International Journal of Legal Medicine, 2012; 126(1), 179–183.
67. Kanokwongnuwut P, Kirkbride KP, Kobus H, et al. Enhancement of fingermarks and visualizing DNA. Forensic Science International, 2019; 300, 99–105.
68. Kanokwongnuwut P, Kirkbride P, Linacre A. Visualising latent DNA on swabs. Forensic Science International, 2018; 291, 115–123.
69. Kanokwongnuwut P, Kirkbride P, Linacre A. Speed of accumulation of DNA in a fingermark. Australian Journal of Forensic Sciences, 2020; 52(3), 293–302.
70. Kanokwongnuwut P, Martin B, Kirkbride KP, et al. Shedding light on shedders. Forensic Science International: Genetics, 2018; 36, 20–25.
71. Kawahata A. Sex differences in sweating. In: Essential Problems in Climatic Physiology, 1960; 169–184.
72. Khuu A, Chadwick S, Moret S, et al. Impact of one-step luminescent cyanoacrylate treatment on subsequent DNA analysis. Forensic Science International, 2018; 286, 1–7.
73. Khuu A, Spindler X, Roux C. Detection of latent fingermarks and cells on paper. Forensic Science International, 2020; 309, 110185.
74. Kirgiz IA, Calloway C. Increased recovery of touch DNA evidence using FTA paper compared to conventional collection methods. Journal of Forensic and Legal Medicine, 2017; 47, 9–15.
75. Korzik ML, De Alcaraz-Fossoul J, Adamowicz MS, et al. Preliminary Study: DNA Transfer and Persistence on Non-Porous Surfaces Submerged in Spring Water. Genes, 2023; 14(5), 1045.
76. Köchl, S., Niederstätter, H., & Parson, W. (2005). DNA extraction and quantitation of forensic samples using the phenol–chloroform method and real-time PCR. Içinde *Forensic DNA typing protocols* (ss. 13-30). Humana Press. https://doi.org/10.1385/1-59259-867-6:013
77. Köchl S, Niederstätter H, Parson W. DNA extraction and quantitation of forensic samples using the phenol–chloroform method and real-time PCR. In: Forensic DNA typing protocols, 13–30.

Humana Press; 2005.
78. Lee H, Yim J, Eom Y. Effects of fingerprint development reagents on subsequent DNA analysis. Electrophoresis, 2019; 40(14), 1824–1829.
79. Lee HC, Gaensslen RE. Advances in fingerprint technology (2nd ed.). CRC Press; 2001.
80. Lee LYC, Tan J, Lee YS, et al. Shedder status—An analysis over time and assessment of various contributing factors. Journal of Forensic Sciences, 2023; 68(4), 1292–1301.
81. Lehmann VJ, Mitchell RJ, Ballantyne KN, et al. Following the transfer of DNA: How far can it go? Forensic Science International: Genetics Supplement Series, 2013; 4(1), e53–e54.
82. Lennard C. The Detection and Enhancement of Latent Fingerprints. 13th Interpol Forensic Science Symposium; 2001; 16–19.
83. Lennard C. Fingermark detection and identification: Current research efforts. Australian Journal of Forensic Sciences, 2018; 1–21.
84. Levy-Booth DJ, Campbell RG, Gulden RH, et al. Cycling of extracellular DNA in the soil environment. Soil Biology and Biochemistry, 2007; 39(12), 2977–2991.
85. Li R. Forensic biology (2nd ed.). CRC Press; 2015.
86. Lin S, Ip SCY, Lam T, et al. Compatibility of DNA IQ™, QIAamp® DNA Investigator, and QIAsymphony® DNA Investigator® with various fingerprint treatments. International Journal of Legal Medicine, 2017; 131(2), 293–301.Linacre, A., Pekarek, V., Swaran, Y. C., & Tobe, S. S. (2010). Generation of DNA profiles from fabrics without DNA extraction. *Forensic Science International: Genetics*, *4*(2), 137-141. https://doi.org/10.1016/j.fsigen.2009.07.006
87. Linacre A, Templeton JEL. Forensic DNA profiling: state of the art. Research and Reports in Forensic Medical Science, 2014; 25. https://doi.org/10.2147/RRFMS.S60955
88. Lindahl T. Eminent Victorians and science at the grass roots. Nature, 1993; 362(6422), 700.
89. Lowe A, Murray C, Whitaker J, et al. The propensity of individuals to deposit DNA and secondary transfer of low level DNA from individuals to inert surfaces. Forensic Science International, 2002; 129(1), 25–34.
90. Lu X, Xu Z, Niu QS, Tu Z. Application of touch DNA in investigation practice. Fa Yi Xue Za Zhi, 2018; 34(3), 294–298.
91. Manohar Pandre G, W. Evaluation of Low Trace DNA Recovery Techniques from Ridged Surfaces. Journal of Forensic Research, 2013; 04(04).
92. Martin B, Blackie R, Taylor D, et al. DNA profiles generated from a range of touched sample types. Forensic Science International: Genetics, 2018; 36, 13–19.
93. Martin B, Taylor D, Linacre A. Comparison of six commercially available STR kits for their application to touch DNA using direct PCR. Forensic Science International: Reports, 2021; 4, 100243.
94. Martin NC, Pirie AA, Ford LV, et al. The use of phosphate buffered saline for the recovery of cells and spermatozoa from swabs. Science & Justice, 2006; 46(3), 179–184.
95. McCartney C. LCN DNA: proof beyond reasonable doubt? Nature Reviews Genetics, 2008; 9(5), 325.
96. McDonald C, Nolan M, Lepore L, et al. DNA alloys: The enduring story of touch DNA on metals. Forensic Science International: Genetics, 2025; 80, 103335.
97. Meakin G, Jamieson A. DNA transfer: Review and implications for casework. Forensic Science International: Genetics, 2013; 7(4), 434–443.Montpetit, S., & O'Donnell, P. (2015). An optimized procedure for obtaining DNA from fired and unfired ammunition. *Forensic science international: genetics*, *17*, 70-74. https://doi.org/10.1016/j.fsigen.2015.03.012
98. Nontiapirom K, Bunakkharasawat W, Sojikul P, et al. Assessment and prevention of forensic DNA contamination in DNA profiling from latent fingerprint. *Forensic Science International: Genetics Supplement Series*, 2019; 7(1), 546–548. https://doi.org/10.1016/j.fsigss.2019.10.085
99. Oleiwi AA, Morris MR, Schmerer WM, et al. The relative DNA-shedding propensity of the palm and finger surfaces. *Science & Justice*, 2015; 55(5), 329–334. https://doi.org/10.1016/j.sci-

jus.2015.04.003
100. Otten L, Banken S, Schürenkamp M, et al. Secondary DNA transfer by working gloves. Forensic Science International: Genetics, 2019; 43, 102126.
101. Pages BJ, Ang DL, Wright EP, et al. Metal complex interactions with DNA. Dalton Transactions, 2015; 44(8), 3505–3526.
102. Pesaresi M, Buscemi L, Alessandrini F, et al. Qualitative and quantitative analysis of DNA recovered from fingerprints. International Congress Series, 2003; 1239, 947–951.
103. Petcharoen P, Nolan M, Kirkbride KP, et al. Shedding more light on shedders. Forensic Science International: Genetics, 2024; 72, 103065.
104. Phillips K, McCallum N, Welch L. A comparison of methods for forensic DNA extraction: Chelex-100® and the QIAGEN DNA Investigator Kit (manual and automated). Forensic Science International: Genetics, 2012; 6(2), 282–285.
105. Phipps M, Petricevic S. The tendency of individuals to transfer DNA to handled items. Forensic Science International, 2007; 168(2–3), 162–168.
106. Plaza DT, Mealy JL, Lane JN, et al. ESDA®-Lite collection of DNA from latent fingerprints on documents. Forensic Science International: Genetics, 2015; 16, 8–12.
107. Plaza DT, Mealy JL, Lane JN, et al. Nondestructive Biological Evidence Collection with Alternative Swabs and Adhesive Lifters. Journal of Forensic Sciences, 2016; 61(2), 485–488.Poinar, H. N. (2003). The top 10 list: criteria of authenticity for DNA from ancient and forensic samples. *International Congress Series*, *1239*, 575-579. https://doi.org/10.1016/S0531-5131(02)00624-6
108. Prasad E, Atwood L, van Oorschot RA, et al. Trace DNA recovery rates from firearms and ammunition as revealed by casework data. Australian Journal of Forensic Sciences, 2023; 55(1), 73–88.https://doi.org/10.6084/m9.figshare.15032845.v1
109. Proff C, Schmitt C, Schneider PM, et al. Experiments on the DNA contamination risk via latent fingerprint brushes. International Congress Series, 2006; 1288, 601–603.https://doi.org/10.1016/j.ics.2005.10.053
110. Quinones I, Daniel B. Cell free DNA as a component of forensic evidence recovered from touched surfaces. Forensic Science International: Genetics, 2012; 6(1), 26–30.
111. Quinque D, Kittler R, Kayser M, et al. Evaluation of saliva as a source of human DNA for population and association studies. Analytical Biochemistry, 2006; 353(2), 272–277.
112. Raymond JJ, Du Pasquier E. The effect of common fingerprint detection techniques on the DNA typing of fingerprints deposited on different. J Forensic Identif, 2004; 23, 22.
113. Rinnerthaler M, Bischof J, Streubel M, et al. Oxidative stress in aging human skin. Biomolecules, 2015; 5(2), 545–589.
114. Schulte J, Rittiner N, Seiberle I, et al. Collecting touch DNA from glass surfaces using different sampling solutions and volumes: Immediate and storage effects on genetic STR analysis. Journal of Forensic Sciences, 2023; 68(4), 1133–1147.
115. Schwender M, Bamberg M, Dierig L, et al. The diversity of shedder tests and a novel factor that affects DNA transfer. International Journal of Legal Medicine, 2021; 135(4), 1267–1280.
116. Scruton B, Robins BW, Blott BH. The deposition of fingerprint films. Journal of Physics D: Applied Physics, 1975; 8(6), 714–723.
117. Semizoğlu İ. Biyolojik Delil. Içinde Adli DNA Analizleri (1. bs, ss. 53–70). Adalet Yayınevi, 2013.
118. Sessa F, Salerno M, Bertozzi G, et al. Touch DNA: impact of handling time on touch deposit and evaluation of different recovery techniques: An experimental study. Scientific Reports, 2019; 9(1), 9542.https://doi.org/10.1038/s41598-019-46051-9
119. Sewell J, Quinones I, Ames C, et al. Recovery of DNA and fingerprints from touched documents. Forensic Science International: Genetics, 2008; 2(4), 281–285. https://doi.org/10.1016/j.fsigen.2008.03.006.
120. Sinelnikov A, Reich K. Materials and methods that allow fingerprint analysis and DNA profi-

ling from the same latent evidence. *Forensic Science International: Genetics Supplement Series*, 2017; 6, e40–e42. https://doi.org/10.1016/j.fsigss.2017.09.010

121. Smith PJ, Ballantyne J. Simplified Low-Copy-Number DNA Analysis by Post-PCR Purification. Journal of Forensic Sciences, 2007; 52(4), 820–829. https://doi.org/10.1111/j.1556-4029.2007.00470.x
122. Solomon AD, Hytinen ME, McClain AM, et al. An Optimized DNA Analysis Workflow for the Sampling, Extraction, and Concentration of DNA obtained from Archived Latent Fingerprints. Journal of Forensic Sciences, 2018; 63(1), 47–57. https://doi.org/10.1111/1556-4029.13504
123. Stamatas GN, Nikolovski J, Luedtke MA, et al. Infant Skin Microstructure Assessed In Vivo Differs from Adult Skin in Organization and at the Cellular Level. Pediatric Dermatology, 2010; 27(2), 125–131. https://doi.org/10.1111/j.1525-1470.2009.00973.x
124. Stanciu CE, Philpott MK, Kwon YJ, et al. Optical characterization of epidermal cells and their relationship to DNA recovery from touch samples. F1000Research, 2015; 4, 1360. https://doi.org/10.12688/f1000research.7385.1
125. Subhani Z, Daniel B, Frascione N, et al. DNA profiles from fingerprint lifts—Enhancing the evidential value of fingermarks through successful DNA typing. Journal of Forensic Sciences, 2019; 64(1), 201–206. https://doi.org/10.1111/1556-4029.13830
126. Sweet D, Lorente M, Lorente J, et al. An Improved Method to Recover Saliva from Human Skin: The Double Swab Technique. Journal of Forensic Sciences, 1997; 42(2), 320–322. https://doi.org/10.1520/JFS14120J
127. Szkuta B, Ballantyne KN, van Oorschot RAH, et al. Transfer and persistence of DNA on the hands and the influence of activities performed. Forensic Science International: Genetics, 2017; 28, 10–20. https://doi.org/10.1016/j.fsigen.2017.01.006
128. Szkuta B, van Oorschot RAH, Ballantyne KN, et al. DNA decontamination of fingerprint brushes. Forensic Science International, 2017; 277, 41–50. https://doi.org/10.1016/j.forsciint.2017.05.009Tan,
129. Tan J, Lee JY, Lee LYC, et al. Shedder status: Does it really exist? Forensic Science International: Genetics Supplement Series, 2019; 7(1), 360–362. https://doi.org/10.1016/j.fsigss.2019.10.012
130. Tan X, Ge L, Zhang T, et al. Preservation of DNA for data storage. Russian Chemical Reviews, 2021; 90(2), 280–291. https://doi.org/10.1070/RCR4994
131. Taylor D, Biedermann A, Samie L, et al. Helping to distinguish primary from secondary transfer events for trace DNA. Forensic Science International: Genetics, 2017; 28, 155–177. https://doi.org/10.1016/j.fsigen.2017.02.008
132. Templeton JEL, Taylor D, Handt O, et al. Direct PCR improves the recovery of DNA from various substrates. Journal of Forensic Sciences, 2015; 60(6), 1558–1562. https://doi.org/10.1111/1556-4029.12843
133. Thamnurak C, Bunakkharasawat W, Riengrojpitak S, et al. DNA typing from fluorescent powder dusted latent fingerprints. Forensic Science International: Genetics Supplement Series, 2011; 3(1), e524–e525. https://doi.org/10.1016/j.fsigss.2011.10.009
134. Thomasma SM, Foran DR. The influence of swabbing solutions on DNA recovery from touch samples. Journal of Forensic Sciences, 2013; 58(2), 465–469. https://doi.org/10.1111/1556-4029.12036
135. Tobias SHA, Jacques GS, Morgan RM, et al. The effect of pressure on DNA deposition by touch. Forensic Science International: Genetics Supplement Series, 2017; 6, e12–e14. https://doi.org/10.1016/j.fsigss.2017.09.020
136. Tozzo P, Giuliodori A, Rodriguez D, et al. Effect of dactyloscopic powders on DNA profiling from enhanced fingerprints. American Journal of Forensic Medicine & Pathology, 2014; 35(1), 68–72. https://doi.org/10.1097/PAF.0000000000000081
137. Tozzo P, Mazzobel E, Marcante B, et al. Touch DNA sampling methods: Efficacy evaluation and systematic review. International Journal of Molecular Sciences, 2022; 23(24), 15541. https://doi.

org/10.3390/ijms232415541

138. Tsai L, Lee C, Chen C, et al. The influence of selected fingerprint enhancement techniques on forensic DNA typing of epithelial cells deposited on porous surfaces. Journal of Forensic Sciences, 2016; 61(S1).https://doi.org/10.1111/1556-4029.12893
139. van den Berge M, Ozcanhan G, Zijlstra S, et al. Prevalence of human cell material: DNA and RNA profiling of public and private objects and after activity scenarios. Forensic Science International: Genetics, 2016; 21:81-89. https://doi.org/10.1016/j.fsigen.2015.12.012
140. Van Nieuwerburgh F, Van Hoofstat D, Van Neste C, et al. Retrospective study of the impact of miniSTRs on forensic DNA profiling of touch DNA samples. Science & Justice, 2014; 54(5):369-372. https://doi.org/10.1016/j.scijus.2014.05.009
141. van Oorschot RA, Ballantyne KN, Mitchell RJ, et al. Forensic trace DNA: a review. Investigative Genetics, 2010; 1(1):14. https://doi.org/10.1186/2041-2223-1-14
142. van Oorschot RAH, Jones MK, DNA fingerprints from fingerprints. Nature, 1997; 387(6635):767. https://doi.org/10.1038/42838
143. van Oorschot RAH, Phelan DG, Furlong S, et al. Are you collecting all the available DNA from touched objects? International Congress Series, 2003; 1239:803-807. https://doi.org/10.1016/S0531-5131(02)00498-3
144. Vela-Romera A, Carriel V, Martín-Piedra MA, et al. Characterization of the human ridged and non-ridged skin: a comprehensive histological, histochemical and immunohistochemical analysis. Histochemistry and Cell Biology, 2019; 151(1):57-73. https://doi.org/10.1007/s00418-018-1701-x
145. Verdon TJ, Mitchell RJ, van Oorschot RAH, et al. Evaluation of tapelifting as a collection method for touch DNA. Forensic Science International: Genetics, 2014; 8(1):179-186. https://doi.org/10.1016/j.fsigen.2013.09.005
146. von Wurmb N, Meissner D, Wegener R, et al. Influence of cyanoacrylate on the efficiency of forensic PCRs. Forensic Science International, 2001; 124(1):11-16. https://doi.org/10.1016/S0379-0738(01)00515-1Walsh, P. S.,
147. Metzger DA, Higuchi R, et al. Chelex 100 as a Medium for Simple Extraction of DNA for PCR-Based Typing from Forensic Material. BioTechniques, 2013; 54(3):134-139. https://doi.org/10.2144/000114018
148. Wang C, Stanciu CE, Ehrhardt CJ, et al. Nanoscale characterization of forensically relevant epithelial cells and surface associated extracellular DNA. Forensic Science International, 2017; 277:252-258. https://doi.org/10.1016/j.forsciint.2017.06.019
149. Warshauer DH, Marshall P, Kelley S, et al. An evaluation of the transfer of saliva-derived DNA. *International Journal of Legal Medicine*, 2012;126(6), 851-861. https://doi.org/10.1007/s00414-012-0743-1
150. Wickenheiser R. Trace DNA: A review, discussion of theory, and application of the transfer of trace quantities of DNA through skin contact. *Journal of Forensic Sciences*, 2002;47(3). https://doi.org/10.1520/JFS15284J
151. Wood I, Park S, Tooke J, et al. Efficiencies of recovery and extraction of trace DNA from non-porous surfaces. *Forensic Science International: Genetics Supplement Series*, 2017;*6*, e153-e155. https://doi.org/10.1016/j.fsigss.2017.09.022
152. Zaghloul NM, Samir T, Megahed HM. Recovery of DNA from Fingerprints on Enhanced Different Paper Types. *J Forensic Sci Criminol* , 2019:7(2), 202.
153. Zoppis S, Muciaccia B, D'Alessio A, DNA fingerprinting secondary transfer from different skin areas: Morphological and genetic studies. *Forensic science international: Genetics*, 2014:11, 137-143. https://doi.org/10.1016/j.fsigen.2014.03.005
154. Zupanič Pajnič I, Marrubini G, Pogorelc BG. On the long term storage of forensic DNA in water. *Forensic Science International*, 2019: 305, 110031. https://doi.org/10.1016/j.forsciint.2019.110031

BÖLÜM 5

PARMAK İZİ ANALİZLERİNDE KEMOMETRİK YAKLAŞIMLAR

Rukiye ASLAN [1]
Hasan ERTAŞ [2]

GİRİŞ

Adli bilimler, karmaşık delillerin incelendiği ve bu incelemelerin kritik uygulama alanına sahip olduğu bir disiplindir. Adli soruşturmalardaki temel amaç, bir suçu çevreleyen olayları yeniden yapılandırmak için insanlar, mekânlar veya nesneler arasındaki bağlantıları kurmaktır. Bu, fiziksel ve biyolojik delillerin toplanması, analiz edilmesi ve yorumlanması yoluyla gerçekleştirilmektedir. Örneklerin doğru bir şekilde tanımlanması ve ardından sınıf özelliklerine göre sınıflandırılması büyük önem taşır; bu sayede her bir delilin doğru şekilde tanımlanması ve sınıflandırılması, adli yargılama süreçlerinin tarafsız kararlara ulaşılmasını sağlar. Parmak izi analizleri, suçun aydınlatılmasında adli bilimler açısından önemli araştırma konularından biridir. Bu izler, parmak uçlarında bulunan ve her bireyde benzersiz bir desen oluşturan papil hatlarının (friction ridges) teması sonucu bıraktığı fiziksel kalıntılardır. Suç mahallinden elde edilen latent (gizli) veya görünür parmak izleri, olay yeri ile burada bulunmuş bir şüphelinin ilişkilendirilmesinde kilit bir delil teşkil etmektedir (1). Ayrıca parmak izi materyali olarak elde edilen ter ve sebum gibi biyolojik örnekler de analiz için önemli materyallerdir.

Fiziksel bir delil başarıyla ele geçirilip analiz edilse dahi, elde edilen verilerin yorumlanması önemli zorluklar barındırmaktadır. Çünkü pek çok adli bilim dalı, karmaşık görüntülerin görsel karşılaştırmalarına veya spektrumlar, kromatogramlar ya da diğer analitik çıktılardan oluşan çok değişkenli kimyasal verilere dayanmaktadır (2). Bu karşılaştırmalar, incelemeyi yapan uzmanın önemli miktarda zaman ve uzmanlık harcamasını gerektirmektedir.

[1] Dr. Öğr. Üyesi, Ege Üniversitesi, Madde Bağımlılığı Toksikoloji ve İlaç Bilimleri Enstitüsü, rukiye.doger@gmail.com, rukiye.aslan@ege.edu.tr, ORCID iD: 0000-0002-4012-3684

[2] Prof. Dr., Ege Üniversitesi, Fen Fakültesi, Kimya Bölümü, hasan.ertas@ege.edu.tr, ORCID iD: 0000-0002-5539-3732

olarak, Büyük Veri ve Bulut Bilişimi (Big Data and Cloud Computing), laboratuvarlar arası karşılaştırmaları ve iş birliğini güçlendirecek paylaşımlı veri tabanları ile standardize edilmiş kemometrik protokollerin geliştirilmesinin önünü açarak, adli analizin nesnelliğini ve güvenilirliğini bir üst seviyeye taşıyabilir.

KAYNAKLAR

1. Adamowicz P, Bigosińska J, Gil D, Suchan M, Tokarczyk B. Drugs detection in fingerprints. J Pharm Biomed Anal [Internet]. 2024 Jan 20;238:115835. Available from: https://www.sciencedirect.com/science/article/pii/S0731708523006040
2. Jackson ARW, Jackson JM. Forensic Science. 3rd ed. England: Pearson Education; 2011. 1–14 p.
3. Morgan SL, Bartick E. New Methods for Trace Evidence Analysis. In: Blackledge RD, editor. Forensic Analysis on the Cutting Edge [Internet]. John Wiley and Sons; 2007. p. 333–74. Available from: https://onlinelibrary.wiley.com/doi/book/10.1002/9780470166932
4. Wold S. Chemometrics; what do we mean with it, and what do we want from it? Chemom Intell Lab Syst [Internet]. 1995 Nov 1;30(1):109–15. Available from: https://www.sciencedirect.com/science/article/pii/0169743995000429
5. Cadd S, Islam M, Manson P, Bleay S. Fingerprint composition and aging: A literature review. Sci Justice [Internet]. 2015 Jul 1;55(4):219–38. Available from: https://www.sciencedirect.com/science/article/pii/S1355030615000131
6. Costa C, Ismail M, Stevenson D, Gibson B, Webb R, Bailey M. Distinguishing between Contact and Administration of Heroin from a Single Fingerprint using High Resolution Mass Spectrometry. J Anal Toxicol [Internet]. 2019 Apr 30;44(3):218. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC7299524/
7. Gulekci Y, Cavus Yonar F, Ozseker PE, Gören İE, Daglioglu N. The other side of the paper as the evidence: impacts of fingermark development reagents on fingermark development and cocaine amount in cocaine-impregnated paper. Forensic Sci Med Pathol [Internet]. 2024 Oct 17;21(2):555–64. Available from: https://link.springer.com/article/10.1007/s12024-024-00897-2
8. Gemperline P. Practical Guide to Chemometrics [Internet]. Practical Guide to Chemometrics. CRC Press; 2006. 1–542 p. Available from: https://www.taylorfrancis.com/books/mono/10.1201/9781420018301/practical-guide-chemometrics-paul-gemperline
9. Singh S, Shakeel H, Sharma R. Overview of chemometrics in forensic toxicology. Egypt J Forensic Sci [Internet]. 2023 Dec 13;13(1):53. Available from: https://ejfs.springeropen.com/articles/10.1186/s41935-023-00371-0
10. Brereton RG. Pattern recognition in chemometrics. Chemom Intell Lab Syst [Internet]. 2015 Dec 15;149:90–6. Available from: https://www.sciencedirect.com/science/article/pii/S0169743915001604
11. Hazarika P, Russell DA. Advances in fingerprint analysis. Angew Chem Int Ed Engl [Internet]. 2012 Apr 10;51(15):3524–31. Available from: https://pubmed.ncbi.nlm.nih.gov/22461202/
12. Kindell J, Bridge C. Error rate and similarity determination of latent fingerprint chemistry via 1D GC and GC × GC–MS. Forensic Chem [Internet]. 2023 Sep 1;35:100521. Available from: https://www.sciencedirect.com/science/article/pii/S2468170923000577?ssrnid=4400849&dgcid=SSRN_redirect_SD
13. Brunelle E, Eldridge M, Halámek J. Determination of Time since Deposition of Fingerprints via Colorimetric Assays. ACS Omega [Internet]. 2021 May 18;6(19):12898–903. Available from: /doi/pdf/10.1021/acsomega.1c01344?ref=article_openPDF

14. de Souza MA, Santos AS, da Silva SW, Braga JWB, Sousa MH. Diffuse Reflectance FTIR of Latent Fingerprints and Discriminant Analysis for Sex Identification in Humans. J Braz Chem Soc [Internet]. 2023 Jan 1;34(6):819–25. Available from: https://www.scienceopen.com/document?vid=4050a019-7c6e-4e8d-a850-7e9295b47f75
15. Fikiet MA, Khandasammy SR, Mistek E, Ahmed Y, Halámková L, Bueno J, et al. Surface enhanced Raman spectroscopy: A review of recent applications in forensic science. Spectrochim Acta Part A Mol Biomol Spectrosc [Internet]. 2018 May 15;197:255–60. Available from: https://www.sciencedirect.com/science/article/pii/S138614251830163X
16. Skoog DA., West DM., Holler FJ, Crouch SR. Fundamentals of analytical chemistry. 9th ed. Brooks/Cole, Cengage Learning; 2014.
17. Sauzier G, Van Bronswijk W, Lewis SW. Chemometrics in forensic science: approaches and applications. Analyst [Internet]. 2021 Apr 26;146(8):2415–48. Available from: https://pubs.rsc.org/en/content/articlehtml/2021/an/d1an00082a
18. Bevilacqua M, Nescatelli R, Bucci R, Magrì AD, Magrì AL, Marini F. Chemometric classification techniques as a tool for solving problems in analytical chemistry. J AOAC Int [Internet]. 2014 Jan [cited 2025 Nov 14];97(1):19–28. Available from: https://pubmed.ncbi.nlm.nih.gov/24672856/
19. Singh I, Juneja P, Kaur B, Kumar P, Haji Shabani M, Klodzinska E, et al. Pharmaceutical Applications of Chemometric Techniques. Int Sch Res Not [Internet]. 2013 Jan 1;2013(1):795178. Available from: /doi/pdf/10.1155/2013/795178
20. Brereton RG, Jansen J, Lopes J, Marini F, Pomerantsev A, Rodionova O, et al. Chemometrics in analytical chemistry-part II: modeling, validation, and applications. Anal Bioanal Chem [Internet]. 2018 Oct 1;410(26):6691–704. Available from: https://pubmed.ncbi.nlm.nih.gov/30073517/
21. Chauchard F, Cogdill R, Roussel S, Roger JM, Bellon-Maurel V. Application of LS-SVM to non-linear phenomena in NIR spectroscopy: development of a robust and portable sensor for acidity prediction in grapes. Chemom Intell Lab Syst [Internet]. 2004 May 28 [cited 2025 Nov 14];71(2):141–50. Available from: https://www.sciencedirect.com/science/article/pii/S0169743904000073
22. da Silva IN, Spatti DH, Flauzino RA, Liboni LHB, dos Reis Alves SF. Artificial neural networks: A practical course. Artificial Neural Networks: A Practical Course. Springer International Publishing; 2016. 1–307 p.
23. Otto M. Chemometrics [Internet]. Wiley; 2016. Available from: https://onlinelibrary.wiley.com/doi/book/10.1002/9783527699377
24. Taylor BJ. Methods and procedures for the verification and validation of artificial neural networks. 1st ed. Taylor BJ, editor. Springer US; 2006. 1–277 p.
25. Marini F, Bucci R, Magrì AL, Magrì AD. Artificial neural networks in chemometrics: History, examples and perspectives. Microchem J. 2008 Apr;88(2):178–85.
26. Tistaert C, Dejaegher B, Heyden Y Vander. Chromatographic separation techniques and data handling methods for herbal fingerprints: A review. Anal Chim Acta [Internet]. 2011 Apr 1;690(2):148–61. Available from: https://www.sciencedirect.com/science/article/pii/S0003267011002200
27. Goodarzi M, Russell PJ, Vander Heyden Y. Similarity analyses of chromatographic herbal fingerprints: A review. Anal Chim Acta [Internet]. 2013 Dec 4;804:16–28. Available from: https://www.sciencedirect.com/science/article/pii/S0003267013011884
28. Daszykowski M, Walczak B. Methods for the exploratory analysis of two-dimensional chromatographic signals. Talanta [Internet]. 2011 Jan 30;83(4):1088–97. Available from: https://www.sciencedirect.com/science/article/pii/S0039914010006715
29. Custers D, Courselle P, Apers S, Deconinck E. Chemometrical analysis of fingerprints for the detection of counterfeit and falsified medicines. Rev Anal Chem [Internet]. 2016 Dec

1;35(4):145–68. Available from: https://www.degruyterbrill.com/document/doi/10.1515/revac-2016-0013/html?srsltid=AfmBOooUEgjcWEjetZEfjDkGKtqbMXnjDwTgATFv9uHHja-E67idEhd3v
30. Jollife IT, Cadima J. Principal component analysis: a review and recent developments. Philos Trans A Math Phys Eng Sci [Internet]. 2016 Apr 13;374(2065). Available from: https://pubmed.ncbi.nlm.nih.gov/26953178/
31. F.R.S. KP. LIII. On lines and planes of closest fit to systems of points in space. London, Edinburgh, Dublin Philos Mag J Sci [Internet]. 1901 Nov;2(11):559–72. Available from: https://www.tandfonline.com/doi/abs/10.1080/14786440109462720
32. Bro R, Smilde AK. Principal component analysis. Anal Methods [Internet]. 2014 Apr 10;6(9):2812–31. Available from: https://pubs.rsc.org/en/content/articlehtml/2014/ay/c3ay41907j
33. Greenacre M, Groenen PJF, Hastie T, D'Enza AI, Markos A, Tuzhilina E. Principal component analysis. Nat Rev Methods Prim 2022 21 [Internet]. 2022 Dec 22 [cited 2025 Nov 14];2(1):100-. Available from: https://www.nature.com/articles/s43586-022-00184-w
34. Wehrens R. Chemometrics with R [Internet]. Berlin, Heidelberg: Springer Berlin Heidelberg; 2020. (Use R!). Available from: http://link.springer.com/10.1007/978-3-662-62027-4
35. Coon AM, Beyramysoltan S, Musah RA. A chemometric strategy for forensic analysis of condom residues: Identification and marker profiling of condom brands from direct analysis in real time-high resolution mass spectrometric chemical signatures. Talanta [Internet]. 2019 Mar 1;194:563–75. Available from: https://www.sciencedirect.com/science/article/pii/S0039914018310191
36. Tharwat A, Gaber T, Ibrahim A, Hassanien AE. Linear discriminant analysis: A detailed tutorial. AI Commun [Internet]. 2017;30(2):169–90. Available from: https://scholar.google.com/scholar_url?url=https://journals.sagepub.com/doi/pdf/10.3233/AIC-170729&hl=tr&sa=T&oi=ucasa&ct=usl&ei=zyYXaYL9NZvJieoP1YSd0QY&scisig=ABGrvjLBabJcgIUUEU0WOumXfdME
37. Setser AL, Waddell Smith R. Comparison of variable selection methods prior to linear discriminant analysis classification of synthetic phenethylamines and tryptamines. Forensic Chem [Internet]. 2018 Dec 1;11:77–86. Available from: https://www.sciencedirect.com/science/article/pii/S2468170918300754
38. Bécue A, Champod C. Interpol review of fingermarks and other body impressions (2019 – 2022). Forensic Sci Int Synerg [Internet]. 2023 Jan 1;6:100304. Available from: https://www.sciencedirect.com/science/article/pii/S2589871X22000894
39. Bailey MJ, Ismail M, Bleay S, Bright N, Elad ML, Cohen Y, et al. Enhanced imaging of developed fingerprints using mass spectrometry imaging. Analyst [Internet]. 2013 Sep 30;138(21):6246–50. Available from: https://pubs.rsc.org/en/content/articlehtml/2013/an/c3an01204b
40. Patten DR, Paulson AE, Forsman TT, Lee YJ. Predicting Fingerprint Age Based on Ozonolysis Kinetics of Unsaturated Triacylglycerol Degradation. Anal Chem [Internet]. 2023 Aug 15;95(32):12047–53. Available from: https://pubmed.ncbi.nlm.nih.gov/37531602/
41. Rajs N, Harush-Brosh Y, Raisch R, Yakobi Arancibia R, Zoabi A, Golan GN, et al. Determining time since deposition of latent fingerprints on forensic adhesive tape using ultrafast DESI-MS and machine learning. Sci Reports 2025 151 [Internet]. 2025 May 26;15(1):18413-. Available from: https://www.nature.com/articles/s41598-025-02639-y
42. Hinners P, O'Neill KC, Lee YJ. Revealing Individual Lifestyles through Mass Spectrometry Imaging of Chemical Compounds in Fingerprints. Sci Reports 2018 81 [Internet]. 2018 Mar 26;8(1):5149-. Available from: https://www.nature.com/articles/s41598-018-23544-7
43. Souza MA, Santos AS, da Silva SW, Braga JWB, Sousa MH. Raman spectroscopy of fingerprints and chemometric analysis for forensic sex determination in humans. Forensic Chem [Internet]. 2022 Mar 1;27:100395. Available from: https://www.sciencedirect.com/science/article/pii/

S2468170921000916
44. Bradshaw R, Denison N, Francese S. Implementation of MALDI MS profiling and imaging methods for the analysis of real crime scene fingermarks. Analyst [Internet]. 2017 May 2;142(9):1581–90. Available from: https://pubs.rsc.org/en/content/articlehtml/2017/an/c7an00218a
45. Ismail M, Stevenson D, Costa C, Webb R, De Puit M, Bailey M. Noninvasive Detection of Cocaine and Heroin Use with Single Fingerprints: Determination of an Environmental Cutoff. Clin Chem [Internet]. 2018 Jun 1;64(6):909–17. Available from: https://pubmed.ncbi.nlm.nih.gov/29567660/
46. Guo S, Popp J, Bocklitz T. Chemometric analysis in Raman spectroscopy from experimental design to machine learning-based modeling. Nat Protoc [Internet]. 2021 Dec 1;16(12):5426–59. Available from: https://pubmed.ncbi.nlm.nih.gov/34741152/

BÖLÜM 6

PARMAK İZİ İNCELEMELERİNDE BİLİMSEL GEÇERLİLİK: METODOLOJİK STANDARTLAR, KALİTE GÜVENCESİ VE AKREDİTASYON GEREKLİLİKLERİ

Fatma ÇAVUŞ YONAR [1]
Sena Nur KADEM [2]

"Bir parmak izinin değeri, yalnızca onun benzersiz çizgilerinde değil; o çizgileri yorumlayan bilimin doğrulanmış güveninde yatar."

GİRİŞ

Adli bilimler, geçmişte meydana gelen olaylardan kalan izlerin sistematik bir biçimde tespiti, toplanması, incelenmesi ve yorumlanması yoluyla suçların aydınlatılmasına ve adaletin tesisine önemli katkılar sunmaktadır (1). Olay yeri incelemeden toksikolojiye, DNA analizinden dijital adli bilimlere kadar uzanan geniş uygulama alanı hem olay yerinde yürütülen işlemleri hem de laboratuvar temelli analizleri içeren çok yönlü bir yaklaşımı zorunlu kılmaktadır (2). Bu kapsamda bilimsel metodolojinin özenle uygulanması, elde edilen bulguların doğruluğunun yanı sıra güvenilirliğini ve tarafsızlığını da güvence altına almaktadır. Söz konusu güvence, uluslararası düzeyde kabul görmüş standartların benimsenmesiyle sağlanmaktadır. Ayrıca, adli bulguların yargı süreçlerinde kullanılabilirliği yalnızca verilerin doğruluğuna değil, bu verilerin elde edilme, değerlendirilme ve raporlanma biçimlerinin şeffaflığına da bağlıdır (3). Dolayısıyla, kalite yönetimi ve standardizasyon adli bilimlerin temel yapı taşlarındandır (1,4).

Bu bağlamda ISO/IEC 17020:2012 standardı, olay yeri incelemelerinde inceleme kuruluşlarının teknik yeterliliğini; ISO/IEC 17025:2017 standardı ise laboratuvar analizlerinin doğruluğunu ve uluslararası geçerliliğini desteklemektedir. Her iki standart, adli

[1] Dr. Öğr. Üyesi, İstanbul Üniversitesi-Cerrahpaşa, Adli Tıp ve Adli Bilimler Enstitüsü, Fen Bilimleri AD., fatma.cavus@iuc.edu.tr, ORCID iD: 0000 0001 5941 8434

[2] Yüksek Lisans Öğrencisi, İstanbul Üniversitesi-Cerrahpaşa, Adli Tıp ve Adli Bilimler Enstitüsü, Fen Bilimleri AD., senakaadem@gmail.com , ORCID iD: 0009 0001 7429 3307

nin entegre bir şekilde ele alınması gerektiğini ortaya koymaktadır. Bu eksenler, *bilimsel temel yöntemlerin* validasyonu, hata oranlarının belirlenmesi ve olasılıksal karar modellerinin geliştirilmesini; ISO/IEC 17025 ve 21043 standartlarının eksiksiz uygulanmasını ve yeterlilik testleri ile sürekli denetimler aracılığıyla *kalite güvencesinin* sağlanmasını; *etik ve dijital uyum kapsamında veri gizliliğinin* korunmasını, algoritmik şeffaflığın temin edilmesini ve insan gözetiminin sürdürülmesini kapsamaktadır. Bu bütünleşik yaklaşım, adli bilimleri "deneyimsel" olmaktan çıkarak "kanıta dayalı bilimsel" bir yapıya dönüşümünü desteklemektedir.

Bu bölümde ele alınan konular ve önerilen politikalar, adli bilimlerde sürdürülebilir kalite güvence sisteminin ulusal düzeyde güçlendirilmesini amaçlamaktadır. Bu doğrultuda, Türkiye'deki tüm adli laboratuvarların ISO/IEC 17025 uyum düzeylerini izleyip karşılaştıran bir *Ulusal Adli Bilimler Kalite Platformu* kurulmalı; parmak izi analizinde kullanılan yöntemlerin bilimsel geçerliliğini belgeleyen bir *Ulusal Parmak İzi Validasyon Kütüphanesi* oluşturulmalıdır. Uzman yeterliliğinin sürekli ölçülmesini sağlamak amacıyla, her personelin yılda en az bir ulusal veya uluslararası yeterlilik testine katıldığı bir *Sürekli Yeterlilik Döngüsü* uygulanmalı ve sonuçlar kurumsal performans göstergeleri ile ilişkilendirilmelidir. Ayrıca, yapay zekâ tabanlı adli sistemlerde etik etki değerlendirmesinin zorunlu hale getirilmesiyle veri güvenliği ve karar şeffaflığı sağlanmalıdır. Son olarak, üniversiteler ile akredite kurumlar arasındaki iş birliği ile adli biyometri, kalite yönetimi ve yapay zekâ etiği alanlarında modüler eğitim ve sertifikasyon programlarının geliştirilmesi, söz konusu dönüşümün insan kaynağı boyutunu güçlendirecektir.

Geleceğin iz inceleme laboratuvarları, yüksek teknoloji, yapay zekâ ve insan uzmanlığını bütünleştiren hibrit yapılara dönüşecektir. Bu bağlamda parmak izi analizleri, yalnızca bireysel kimlik tespitinde değil; suç analitiği, davranışsal biyometri, dijital adli bilişim ve adli yapay zekâ alanlarında da önemli bir rol oynayacaktır. Ancak teknolojik ilerleme, etik denetim ve kalite standartlarıyla desteklenmediği takdirde adalet sisteminin güvenilirliği zedelenebilir. Bu nedenle, sürdürülebilir bir gelecek için "bilimsel doğruluk, kalite bütünlüğü ve insan merkezli etik" üçlüsünün vazgeçilmez olduğu açıktır.

KAYNAKLAR

1. Ross A, Neuteboom W. Implementation of quality management from a historical perspective:the forensic science odyssey. *Australian Journal of Forensic Sciences.* 2021;53(3):359–371. doi:10.1080/00450618.2019.1704058
2. Roux C, Ribaux O, Crispino F. Forensic science 2020 – The end of the crossroads? *Australian Journal of Forensic Sciences*. 2018;50(6):607–618. doi:10.1080/00450618.2018.1485738
3. Doyle S. QHFSS DNA laboratory – ISO/IEC 17025 conformance and accreditation. *Forensic Science International*. 2024;8:100449. doi:10.1016/j.fsisyn.2023.100449
4. Ross A, Neuteboom W. ISO-accreditation - is that all there is for forensic science? *Australian Journal of Forensic Sciences*. 2022;54(1):2–14. doi:10.1080/00450618.2020.1819414
5. Doyle S. *Quality Management in Forensic Science.* 1st ed. NY: Academic Press; 2019.

6. Doyle S. A review of the current quality standards framework supporting forensic science: Risks and opportunities. *WIREs Forensic Science*. 2020;2(3). doi:10.1002/wfs2.1365
7. International Organization for Standardization, International Electrotechnical Commission. *ISO/IEC Guide 2:2004 — Standardization and related activities: General vocabulary.* Available from: https://www.iso.org/obp/ui/#iso:std:iso-iec:guide:2:en (Accessed 6th September 2025).
8. He X, Li C. Development of forensic standards in China: A review. *Forensic Sciences Research.* 2022;7(1):1–doi:10.1080/20961790.2021.1912877
9. Scurich N, Faigman DL, Albright TD. Scientific guidelines for evaluating the validity of forensic feature-comparison methods. *Proceedings of the National Academy of Sciences of the United States of America*. 2023;120(41):e2301843120. doi:10.1073/pnas.2301843120
10. Zhai W, Zhang N, Hua F. The development of forensic science standards in China. *Forensic Science International.* 2020;2:187–193. doi:10.1016/j.fsisyn.2020.06.001
11. Wilson-Wilde L. The international development of forensic science standards — A review. *Forensic Science International.* 2018;288:1–9. doi:10.1016/j.forsciint.2018.04.009
12. ISO. *Certification 2023.* Available from: https://www.iso.org/certification.html (Accessed 6th September 2025).
13. ISO. *Competency or management systems based standards? Frequently asked questions 2016.* Available from: https://www.iso.org/files/live/sites/isoorg/files/archive/pdf/en/casco-faq.pdf (Accessed 6th September 2025).
14. Jones N, Forry E, Sirk D, Demystifying accreditation a framework for accreditation of forensic units, grant/contract reports (NISTGCR), *National Institute of Standards and Technology*, 2023:1-36. doi:10.6028/NIST.GCR.23-043
15. European Network of Forensic Science Institutes (ENFSI). *Guidelines for the Single Laboratory Validation of Instrumental and Human Based Methods in Forensic Science.* Available from: https://enfsi.eu/docfile/guidelines-for-the-single-laboratory-validation-of-instrumental-and-human-based-methods-in-forensic-science-2/ (Accessed 6th September 2025).
16. Dror IE, Pierce ML. ISO standards addressing ıssues of bias and ımpartiality in forensic work. *Journal of Forensic Sciences*, 2020;65(3), 800–808. doi:10.1111/1556-4029.14265
17. National Commission on Forensic Science (NCFS). *Critical Steps to Accreditation 2016.* Available from: https://www.justice.gov/ncfs/file/831796/dl?inline (Accessed 6th September 2025).
18. ISO. *ISO/IEC 17025:2017 - General requirements for the competence of testing and calibration laboratories 2017*. Available from: https://www.iso.org/standard/66912.html (Accessed 6th September 2025).
19. ISO. *ISO/IEC 17020:2012 - Conformity assessment — Requirements for the operation of various types of bodies performing inspection 2012.* Available from: https://www.iso.org/standard/52994.html (Accessed 6th September 2025).
20. ISO. *ISO 21043-1:2025 - Forensic sciences — Part 1: Vocabulary* 2025. Available from: https://www.iso.org/standard/87128.html (Accessed 6th September 2025).
21. ISO. *ISO 21043-2:2018 - Forensic sciences — Part 2: Recognition, recording, collecting, transport and storage of items* 2018. Available from: https://www.iso.org/standard/72041.html (Accessed 6th September 2025).
22. ISO. *ISO 21043-3:2025 - Forensic sciences — Part 3: Analysis* 2025 Available from: https://www.iso.org/standard/72040.html (Accessed 6th September 2025).
23. ISO. *ISO 21043-4:2025 - Forensic sciences — Part 4: Interpretation* 2025. Available from: https://www.iso.org/standard/72039.html (Accessed 6th September 2025).
24. ISO. *ISO 21043-5:2025 - Forensic sciences — Part 5: Reporting* 2025. Available from: https://www.iso.org/standard/73896.html (Accessed 6th September 2025).
25. ISO. *ISO/IEC Working Draft 17020*. Available from: https://www.iso.org/standard/86292.html (Accessed 6th September 2025).
26. European Network of Forensic Science Institutes (ENFSI). *Best Practice Manual for the Implementation of a Quality Management System and Accreditation Model for Crime Scene Investiga-*

tion 2022 Available from: www.enfsi.eu. (Accessed 6th September 2025).
27. Nešić L, Marić A, Lončar M, et al. Implementatıon of the new standard ISO/IEC 17025:2017 and ıts ımpact on the qualıty of work ın forensic laboratories. In: *International Scientific Conference "Archibald Reiss Days" Thematic Conference Proceedings of International Significance*. Belgrade: Academy of Criminalistic and Police Studies; 2018. (pp. 535–46).
28. Dzierżanowska J. Accreditation of forensic laboratories. *Teka Komisji Prawniczej PAN Oddział w Lublinie.* 2023;29;16(2):41–53. doi:10.32084/tkp.6355
29. Kulić L, Arsić KG, Kulić V. Legal frame of different levels of medical forensic testing/expertisis in the narcomania. *Zdravstvena Zaštita*. 2011;40(1):43–52. doi: 10.5937/ZZ1101043K
30. Saldivar A. Minimum education requirements for crime scene ınvestigators. *Themis: Research Journal of Justice Studies and Forensic Science.* 2017;5(1):10. doi:10.31979/THEMIS.2017.0510
31. ISO. *Technical Committee ISO/TC 272 – Forensic sciences 2012* Available from: https://www.iso.org/committee/4395817.html (Accessed 6th September 2025).
32. Morrison GS, Elliott S, Guiness J, Sonden L, Syndercombe Court D. A guide to ISO 21043 Forensic sciences from the perspective of the forensic-data-science paradigm. *Science & Justice*. 2025;65(5):101304. doi:10.1016/j.scijus.2025.101304
33. Meuwly D. Implications of the forthcoming forensic sciences standard ISO/IEC 21043 for forensic biometrics. In: *12th International Workshop on Biometrics and Forensics, IWBF.* 11-12 April 2024, Enschede, Netherlands, (pp. 6-7).
34. Berger CEH. Finally a really forensic worldwide standard: ISO 21043 Forensic sciences, Part 4, Interpretation. *Forensic Science International*. 2025;10:100589. doi:10.1016/j.fsisyn.2025.100589
35. Stigler SM. Galton and identification by fingerprints. *Genetics* 1995;140(3):857–60. doi:10.1093/genetics/140.3.857
36. Council NR. *Strengthening forensic science in The United States: A path forward.* (1st eds.). Washington, DC:National Academies Press; 2009.
37. Executive Office of the President President's Council of Advisors on Science and Technology. *Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods 2016.* Available from: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_forensic_science_report_final.pdf (Accessed 6th September 2025).
38. U.S. Supreme Court. *Daubert v. Merrell Dow Pharmaceuticals 1983.* vol. 509. Available from: https://supreme.justia.com/cases/federal/us/509/579/ (Accessed 6th September 2025).
39. Mnookin JL. The validity of latent fingerprint identification: confessions of a fingerprinting moderate. *Law, Probability and Risk*. 2008;7(2):127–141. https://doi.org/10.1093/lpr/mgm022
40. Ulery BT, Hicklin RA, Buscaglia JA, et al. Accuracy and reliability of forensic latent fingerprint decisions. *Proceedings of the National Academy of Sciences of the United States of America*. 2011;108(19):7733–7738. 10.1073/pnas.1018707108
41. Neumann C, Evett IW, Skerrett J. Quantifying the weight of evidence from a forensic fingerprint comparison: A new paradigm. *Journal of the Royal Statistical Society Series A: Statistics in Society.* 2012;175(2):371–415. doi:10.1111/j.1467-985X.2011.01027.x
42. Neumann C, Hendricks J, Ausdemore M. Statistical support for conclusions in fingerprint examinations. In: Banks D, Kafadar K, Kaye DH, Tackert M (eds.) *Handbook of forensic statistics*. 1st ed. Boca Raton, FL; Chapman and Hall/CRC; 2020. p. 277–324.
43. Cole SA. More than zero: Accounting for error in latent fingerprint identification. *Journal of Criminal Law and Criminology.* 2005;95(3):985. https://ssrn.com/abstract=1025772
44. Martins N, Silva JS, Bernardino A. Fingerprint recognition in forensic scenarios. *Sensors* 2024;24(2):664. doi:10.3390/s24020664
45. Yusof RM, Sulaiman N. Simultaneous latent fingerprint detection. *IOSR Journal of Computer Engineering (IOSRJCE).* 2013;8(3):39–46. www.iosrjournals.org
46. Perkins D. *The forensic analysis, comparison and evaluation of friction ridge skin ımpressions*. (1st ed). Chichester:John Wiley & Sons; 2022.
47. Dror IE, Charlton D. Why experts make errors. *Journal of Forensic Identification.* 2006;56(4),600.

Available from: https://www.researchgate.net/publication/248440075_Why_Experts_Make_Errors

48. Saks MJ, Koehler JJ. The individualization fallacy in forensic science evidence. *Vanderbilt Law Review.* 2008;61(1):199. https://scholarship.law.vanderbilt.edu/vlr/vol61/iss1/4
49. NIST. *NIST Evaluation of latent fingerprint technologies (ELFT) 2025.* Available from: https://www.nist.gov/programs-projects/nist-evaluation-latent-fingerprint-technologies-elft. (Accessed 14th November 2025).
50. Isenberg AR, Oien CT. Scientific excellence in the forensic science community. *Fordham Law Review*. 2017;86(1):12. https://ir.lawnet.fordham.edu/flro/vol86/iss1/12
51. Hefetz I, Kimchi S, Zampa F, Mattei A. Analysis, comparison and evaluation of latent prints: The results of the 2021 collaborative exercise of the ENFSI fingerprint working group. *Journal of Forensic Identification.* 2024;74(3):282–313. https://openurl.ebsco.com/contentitem/edm:179681824?sid=ebsco:plink:crawler&id=ebsco:edm:179681824&crl=c
52. Gorener A, Toker K. Quality improvement in manufacturing processes to defective products using pareto analysis and FMEA. *Beykent Üniversitesi Sosyal Bilimler Dergisi.* 2013;6(2):1307–5063. doi:10.18221/BUJSS.91362
53. Bécue A, Anthonioz A, Harris G, et al. Benchmarking of proficiency tests for the fingerprint field. *Forensic Science International*. 2025;367:112384. doi:10.1016/j.forsciint.2025.112384
54. Reason J. Human error: models and management. *BMJ.* 2000;320(7237):768–770. doi:10.1136/bmj.320.7237.768
55. Sadikoglu E, Temur T. The relationship between ISO 17025 quality management system accreditation and laboratory performance. In: Kim SN (ed.) Quality Management and Practices, 1st ed. Rijeika; 2012. p. 221-230.
56. European Network of Forensic Science Institutes (ENFSI). *best practice manual for fingerprint examination 2015* Available from: https://enfsi.eu/wp-content/uploads/2016/09/6._fingerprint_examination_0.pdf (Accessed 6th September 2025).
57. European Network of Forensic Science Institutes (ENFSI). *Guıdance on the conduct of profıcıency tests and collaboratıve exercıses wıthın enfsı fıngerprınt workıng group 2021* https://enfsi.eu/wp-content/uploads/2021/05/2021-05-03_FINAL-PT-Guidance-Draft_AM-format.pdf (Accessed 6th September 2025).
58. Press R. National Institute of Standards and Technology (NIST) and NIST-sponsored programs. *Forensic Science Review*. 2019;31(1),8. doi.org/10.6028/NIST.IR.8225
59. Butler JM. Recent activities in the United States involving the National Commission on Forensic Science and the Organization of Scientific Area Committees for Forensic Science. *Australian Journal of Forensic Sciences.* 2017;49(5):526–40. doi.10.1080/00450618.2016.1243153
60. Igonor OS, Amin MB, Garg S. The application of blockchain technology in the field of digital forensics: A literature review. *Blockchains*. 2025;3(1):5. Doi:10.3390/blockchains3010005
61. Mohammed Mustafa M, Kishore TC, Krithika N, Loga Bharathi M. Forensic evidence management using blockchain technology. *International Journal of Innovative Science and Research Technology (IJISRT).* 2024;17;268–73. doi:10.38124/ijisrt/IJISRT24APR354
62. Tang Y, Gao F, Feng J, et al. FingerNet: An unified deep network for fingerprint minutiae extraction. *IEEE International Joint Conference on Biometrics (IJCB)* 2017;108–116. doi:10.48550/arXiv.1709.02228
63. Cao K, Nguyen DL, Tymoszek C, Jain AK. End-to-end latent fingerprint search. *IEEE Transactions on Information Forensics and Security.* 2020;15:880–94. doi.10.48550/arXiv.1812.10213
64. Buolamwini J, Gebru T. *Gender Shades: Intersectional Accuracy Disparities in Commercial Gender Classification*. In: 1st Conference on Fairness, Accountability and Transparency PMLR. 23-24 February 2018, New York, NY, USA. (pp. 77-91).
65. Çiçek M. Türkiye'de biyometrik veri güvenliği: kişisel verilerin korunması kanunu çerçevesinde etik bir değerlendirme. *Kişisel Verileri Koruma Dergisi.* 2024;6(2):54–76. https://dergipark.org.tr/en/download/article-file/4337693

BÖLÜM 7

TÜRKİYE'DE PARMAK VE AVUÇ İZLERİNİN TOPLANMASI, MUHAFAZASI VE İNCELENMESİ: CEZA MUHAKEMESİ VE KİŞİSEL VERİLERİN KORUNMASI BAĞLAMINDA BİR MEVZUAT ANALİZİ

Cengizhan YOLDAŞ [1]
Yakup GÜLEKÇİ [2]

GİRİŞ

Kişiye özgü bir biyometrik özellik olan parmak izi, gebeliğin yaklaşık 10. haftasında oluşmaya başlayıp 16. haftada gelişimini tamamlamakta ve bireyin yaşamı boyunca esas itibarıyla değişmeden kalmaktadır (1,2). El bileğinden parmak tırnaklarına kadar uzanan el ayası bütün olarak ele alındığında; parmakların birinci boğumu ile tırnak ucu arasında kalan kısımda yer alan papiller hatların yüzeyde bıraktığı izler "parmak izi", birinci boğumdan el bileğine kadar olan kısımda yer alan papiller hatların yüzeyde bıraktığı izler ise "avuç izi" olarak tanımlanmaktadır (3).

Benzersizlik ve değişmezlik özellikleri nedeniyle parmak izi, adli bilimlerde suçların aydınlatılmasında en güvenilir delil türlerinden biri olarak kabul edilmektedir (4,5). Parmak izinin adli soruşturmada ilk kullanımı, 1880 yılında Japonya'da meydana gelen bir şarap hırsızlığı olayı kapsamında Dr. Henry Faulds tarafından gerçekleştirilmiş; söz konusu olayda parmak izleri failin tespiti amacıyla kullanılmıştır (6,7). Bu tarihten itibaren parmak izi analizleri, modern teknolojilerle desteklenerek gelişimini sürdürmüş ve günümüzde de önemini koruyan temel bir adli inceleme yöntemi hâline gelmiştir (8).

[1] Parmak İzi Uzmanı, Samsun İl Jandarma Komutanlığı, Kriminal Şube Müdürlüğü, cengizhanyoldas@jandarma.gov.tr, ORCID iD: 0009-0004-5903-9839

[2] Dr. Öğr. Üyesi, Kütahya Sağlık Bilimleri Üniversitesi, Adli Bilimler Bölümü, yakup.gulekci@ksbu.edu.tr, ORCID iD: 0000-0001-9643-6850

KAYNAKLAR

1. Champod C, Lennard CJ, Margot P, Stoilovic M. *Fingerprints and other ridge skin impressions.* 1st ed. Boca Raton:CRC press; 2004. https://doi.org/10.1201/9780203485040
2. Kücken M, Newell, AC. Fingerprint formation. *Journal of Theoretical Biology*. 2005;235(1):71-83. doi:10.1016/j.jtbi.2004.12.020
3. Yoldaş C, *Avuç izinden kimlik tespiti için gerekli karakteristik özelliklerin incelenmesi* (Yüksek lisans tezi). Ankara: Polis Akademisi, Güvenlik Bilimleri Enstitü; 2005;17-18. (23/10/2025 tarihinde https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=mHY9iYTQgcDXg21poCM-GWg&no=O2MqlGYWna39keM3RoW--g adresinden ulaşılmıştır).
4. Gomes FM, de Pereira CMP, de Cássia Mariotti K, et al. Study of latent fingerprints–a review. *Forensic Chemistry*. 2003;35,100525. https://doi.org/10.1016/j.forc.2023.100525
5. Asano KG, Bayne CK, Horsman KM, et al. Chemical composition of fingerprints for gender determination. *Journal of Forensic Sciences*, 2002;47(4):805-807. doi: 10.1520/JFS15460J
6. Ashbaugh, D.R. Quantitative-qualitative friction ridge analysis: an introduction to basic and advanced ridgeology. 1st ed. Boca Raton: CRC press; 1999. https://doi.org/10.1201/9781420048810
7. Richard M. Caplan MD (1990). How fingerprints came into use for personal identification, *Journal of the American Academy of Dermatology,* 1990;23(2): 09–114. https://doi.org/10.1016/0190-9622(90)70194-M
8. Maltoni D, Maio D, Jain AK, Prabhakar, S. *Handbook of fingerprint recognition*. 2nd ed., Berlin:Springer Science & Business Media:2009.
9. Jain AK, Ross A. Bridging the gap: from biometrics to forensics. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 2015;370(1674), 20140254. https://doi.org/10.1098/rstb.2014.0254
10. Neumann C, Evett IW, Skerrett J. *Quantifying the weight of evidence from a forensic fingerprint comparison: a new paradigm.* Journal of the Royal Statistical Society Series A: Statistics in Society, 2012;175(2):371-415. https://doi.org/10.1111/j.1467-985X.2011.01027.x
11. Bécue A, Eldridge H, Champod C. Interpol review of fingermarks and other body impressions 2016–2019. *Forensic Science International: Synergy*, 2020;2:442–480. https://doi.org/10.1016/j.fsisyn.2020.01.013
12. Lessig R, Rothschild M. International standards in cases of mass disaster victim identification (DVI). Forensic Science, Medicine, and Pathology, 2012;8(2):197-199. https://doi.org/10.1007/s12024-011-9272-3
13. Johnson BT. Advances in postmortem fingerprinting: Applications in disaster victim identification. *Journal of Forensic Sciences,* 2024;69(5):1681-1689. https://doi.org/10.1111/1556-4029.15513
14. United Nations Human Rights Office of the High Commissioner (OHCHR) 2023. *Digital border governance: A human rights-based approach.* Available from: https://repository.essex.ac.uk/36656/1/Digital%20Border%20Governance%20-%20A%20Human%20Rights%20Based%20Approach.pdf (Accessed 29th November 2025).
15. Zhou B, Han C, Liu Y, et al. Fast minutiae extractor using neural network. *Pattern Recognition,* 2020;103, 107273. https://doi.org/10.1016/j.patcog.2020.107273
16. Nachar R, Inaty E, Bonnin PJ, et al. Hybrid minutiae and edge corners feature points for increased fingerprint recognition performance. *Pattern Analysis and Applications,* 2020;23(1):213-224. https://doi.org/10.1007/s10044-018-00766-z
17. T.C. Resmî Gazete. *5271 sayılı Ceza Muhakemesi Kanunu.* Available from: https://mevzuat.gov.tr/mevzuat?MevzuatNo=5271&MevzuatTur=1&MevzuatTertip=5. (Accessed 21th October 2025).

18. T.C. Resmî Gazete. *Ceza Muhakemesinde Beden Muayenesi, Genetik İncelemeler ve Fizik Kimliğin Tespiti Hakkinda Yönetmelik.* Available from: https://mevzuat.gov.tr/mevzuat?MevzuatNo=8202&MevzuatTur=7&MevzuatTertip=5 (Accessed 21th October 2025).
19. Emniyet Genel Müdürlüğü. *2559 sayılı Polis Vazife ve Salhiyet Kanunu.* Available from: https://www.egm.gov.tr/hukukmusavirligi/2559-polis-vazife-ve-selahiyet-kanunu (Accessed 21th October 2025).
20. T.C. Resmî Gazete. *5275 sayılı Ceza ve Güvenlik Tedbirlerinin İnfazı Hakkında Kanun* Available from: https://mevzuat.gov.tr/mevzuat?MevzuatNo=5275&MevzuatTur=1&MevzuatTertip=5. (Accessed 21th October 2025).
21. T.C. Resmî Gazete. *Jandarma Teşkilat Görev ve Yetkileri Yönetmeliği.* Available from: https://mevzuat.gov.tr/mevzuat?MevzuatNo=20169741&MevzuatTur=21&MevzuatTertip=5. (Accessed 21th October 2025).
22. T.C. Resmî Gazete. *Yabancılar ve Uluslararası Koruma Kanununun Uygulanmasına İlişkin Yönetmelik*. Available from: https://mevzuat.gov.tr/mevzuat?MevzuatNo=21460&MevzuatTur=7&MevzuatTertip=5. (Accessed 21th October 2025).
23. Eurpon Union. *Eurodac: European system for the comparison of fingerprints of asylum applicants* 2024. Available from: https://eur-lex.europa.eu/legal-content/EN/LSU/?uri=CELEX%3A32013R0603 (Accessed 08 November 2025).
24. Federal Register: The Daily Journal of the United States Government. *Collection and Use of Biometrics by U.S. Citizenship and Immigration Services* 2025. Available from: https://www.federalregister.gov/documents/2025/11/03/2025-19747/collection-and-use-of-biometrics-by-us-citizenship-and-immigration-services. (Accessed 08 November 2025).
25. T.C. Resmî Gazete. *5490 sayılı Nüfus Hizmetleri Kanunu.* Available from: https://mevzuat.gov.tr/mevzuat?MevzuatNo=5490&MevzuatTur=1&MevzuatTertip=5. (Accessed 21th October 2025).
26. T.C. İçişleri Bakanlığı. *Türkiye Cumhuriyeti Kimlik Kartı (TCKK) projesi.* Available from: https://www.icisleri.gov.tr/turkiye-cumhuriyeti-kimlik-karti-tckk-projesi. (Accessed 24th October 2025).
27. T.C. Resmî Gazete. *Türkiye Cumhuriyeti Kimlik Kartı Yönetmeliği.* Available from: https://mevzuat.gov.tr/mevzuat?MevzuatNo=34001&MevzuatTur=7&MevzuatTertip=5. (Accessed 21th October 2025).
28. T.C. Sağlık Bakanlığı. *Türkiye'de Organ Bağışı Bilinci ve Nakil Sayıları Umudu Artıyor.* Available from: https://www.saglik.gov.tr/TR-100600/turkiyede-organ-bagisi-bilinci-ve-nakil-sayilari-umudu-artiyor.html (Accessed 23th October 2025).
29. Kong AWK, Zhang D, Lu G. A study of identical twins' palmprints for personal verification. *Pattern Recognition,* 2006;39(11):2149-2156. https://doi.org/10.1016/j.patcog.2006.04.035
30. Kong A, Zhang D, Kamel M. A survey of palmprint recognition. *Pattern Recognition*, 2009; 42(7), 1408-1418. https://doi.org/10.1016/j.patcog.2009.01.018
31. Dhiman A, Gupta K, Sharma DK. An introduction to deep learning applications in biometric recognition. *Trends in Deep Learning Methodologies*, 2001;1-36. https://doi.org/10.1016/B978-0-12-822226-3.00001-5
32. Wu X, Zhang D, Wang K, et al. Palmprint classification using principal lines. *Pattern Recognition,* 2004;37(10), 1987-1998. https://doi.org/10.1016/j.patcog.2004.02.015
33. Rodríguez-Ruiz J, Medina-Pérez MA, Monroy R, et al. A survey on minutiae-based palmprint feature representations, and a full analysis of palmprint feature representation role in latent identification performance. *Expert Systems with Applications*, 2019;131:30-44. https://doi.org/10.1016/j.eswa.2019.04.018
34. Stokes J. Next generation identification—A powerful tool in cold case investigations. *Forensic Science International,* 2019;299:74-79. https://doi.org/10.1016/j.forsciint.2019.03.033

35. Tom KR, Knorr KB, Davis CE. (2022). Next Generation Identification system: Latent print matching algorithm and casework practices. *Forensic Science International,* 2022;332, 111180. https://doi.org/10.1016/j.forsciint.2022.111180
36. Gülekci Y, Cavus Yonar F, Ozseker PE, et al. The other side of the paper as the evidence: impacts of fingermark development reagents on fingermark development ve cocaine amount in cocaine-impregnated paper. *Forensic Science, Medicine ve Pathology*, 2024;1-10. https://doi.org/10.1007/s12024-024-00897-2
37. Ramotowski R. *Composition of latent print residue, advances in fingerprint technology*. 2nd ed. London: CRC Press; 2001.
38. Bumbrah GS. Cyanoacrylate fuming method for detection of latent fingerprints: A review. *Egyptian Journal of Forensic Sciences,* 2017; 6(4):378-382. https://doi.org/10.1186/s41935-017-0009-7
39. Dominick AJ, Daeid NN, Bleay SM. The recoverability of fingerprints on nonporous surfaces exposed to elevated temperatures. *Journal of Forensic Identification,* 2011;61(5):520-536.https://pureportal.strath.ac.uk/files/23804422/JFI_2011_05_0520.pdf
40. Dorakumbura BN, Busetti F, Lewis SW. Analysis of squalene and its transformation by-products in latent fingermarks by ultrahigh-performance liquid chromatography-high resolution accurate mass Orbitrap™ mass spectrometry. *Forensic Chemistry*, 2020;17, 100193. https://doi.org/10.1016/j.forc.2019.100193
41. Official Journal of the European Union. *Regulation (EU) 2016/679 of the European Parliament and of the Council. Regulation (eu) 679,* 2016;10-13. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679 (Accessed 07th November 2025).
42. Federal Bureau of Investigation (FBI). *Criminal Justice Information Services (CJIS) Security Policy, Version 2.0. 2025.* Available from: https://portal.ct.gov/-/media/cjis/ciss/related_docs_publications /ct_cjis_security_policy_final.pdf (Accessed 07th November 2025).
43. European Commission. *Interoperability between EU information system. 2024* Available from: https://home-affairs.ec.europa.eu/policies/schengen/interoperability_en. (Accessed 07 November 2025).
44. T.C. Resmî Gazete. *6698 sayılı Kişisel Verilerin Korunması Kanunu*. Available from: https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=6698&MevzuatTur=1&MevzuatTerti=5. (Accessed 07th November 2025).
45. T.C. Resmî Gazete. *Türkiye Cumhuriyeti Anayasası.* Available from: https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=2709&MevzuatTur=1&MevzuatTertip=5. (Accessed 23 October 2025).
46. Türkiye Cumhuriyeti Anayasa Mahkemesi. *Bireysel başvuru basin dosyaları.* Erişim linki: https://www.anayasa.gov.tr/tr/haberler/bireysel-basvuru-basin-duyurulari/parmak-izi-kayit-sistemiyle-mesai-takibi-nedeniyle-kisisel-verilerin-korunmasini-isteme-hakkinin-ihlal-edilmesi/. (Accessed 23 October 2025).
47. Kişisel Verileir Koruma Kurumu. *Kurul karar özetleri*. Erişim linki: https://www.kvkk.gov.tr/Icerik/6738/2020-167. Accessed 23 October 2025.
48. International Organization for Migration [IOM], United Nations Children's Fund [UNICEF], & Office of the United Nations High Commissioner for Refugees [UNHCR]. (2018, March 13). *Joint statement: Coercion of children to obtain fingerprints and facial images is never acceptable*. https://www.iom.int/news/joint-statement-coercion-children-obtain-fingerprints-and-facial-images-never-acceptable
49. Cooper GS, Meterko V. Cognitive bias research in forensic science: A systematic review. *Forensic Science International*, 2019(297):35–46. https://doi.org/10.1016/j.forsciint.2019.01.016
50. Dror IE. Combating bias: The next step in fighting cognitive and psychological contamination. *Journal of Forensic Sciences*, 2012:57(1);276–277. https://doi.org/10.1111/j.1556-4029.2011.01940.x

51. Dror IE, Mnookin JL. The use of technology in human expert domains: Challenges and risks arising from the use of automated fingerprint identification systems in forensic science. *Law, Probability & Risk*, 2010;9(1), 47–67. https://doi.org/10.1093/lpr/mgp031
52. Dror IE, Charlton D, Peron AE. Contextual information renders experts vulnerable to making erroneous identifications. *Forensic Science International*, 2006;156(1), 74–78. https://doi.org/10.1016/j.forsciint.2005.10.017
53. Eldridge H, De Donno M, Champod C. Testing the accuracy and reliability of palmar friction ridge comparisons – A black box study. *Forensic Science International*, 2021:318110457. https://doi.org/10.1016/j.forsciint.2020.110457
54. National Research Council. *Strengthening forensic science in the United States: A path forward*. Washington: National Academies Press;2009.
55. President's Council of Advisors on Science and Technology (PCAST) 2016. *Forensic science in criminal courts: Ensuring scientific validity of feature-comparison methods*. Available from: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_forensic_science_report_final.pdf. Accessed 28 November 2025.
56. European Court of Human Rights 2008. *S. and Marper v. the United Kingdom (Applications Nos. 30562/04 and 30566/04).* Available from: https://hudoc.echr.coe.int. Accessed 27 November 2025.
57. European Parliament, & Council of the European Union 2013. Regulation (EU) No 603/2013 of the European Parliament and of the Council, L 180;1–30. Available from: https://eur-lex.europa.eu/eli/reg/2013/603/oj/eng. Accessed 20 November 2025.
58. United Nations. *Convention on the Rights of the Child 1989*, 1577 U.N.T.S. 3. Available from: https://www.ohchr.org/en/instruments-mechanisms/instruments/convention-rights-child Accessed 21 November 2025.
59. Kontak M. Biometric borders envisaged by Frontex: Fundamental rights in the backseat. *European Papers – A Journal on Law and Integration*, 2024; 9(2):621–640. https://doi.org/10.15166/2499-8249/773
60. Saks MJ, Koehler JJ. The coming paradigm shift in forensic identification science. *Science, 2005;309(*5736):892–895. https://doi.org/10.1126/science.1111565
61. Ulery BT, Hicklin RA, Buscaglia J, et al. Accuracy and reliability of forensic latent fingerprint decisions. *Proceedings of the National Academy of Sciences of the United States of America, 2011;108(19):7733–7738*. https://doi.org/10.1073/pnas.1018707108
62. Cole SA. More than zero: Accounting for error in latent fingerprint identification. *Journal of Criminal Law & Criminology,* 2005;95(3):985–1078. https://scholarlycommons.law.northwestern.edu/jclc/vol95/iss3/10/
63. Riedl MA, *Biometric borders and minors' rights: A critical analysis of European migration management under the new Eurodac Regulation.* Enschede: University of Twente, Behavioural, Management and Social Sciences; 2024. Available from: https://essay.utwente.nl/essays/101676. (Accessed 23 November 2025).