

Possibilities and challenges in digital personal identification using teledentistry based on integration of telecommunication and dental information: a narrative review

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Shinpei Matsuda  and Hitoshi Yoshimura

Abstract

Personal identification using dental evidence is decisive in the case of unidentified bodies because dental features, including decayed, missing and filled teeth, are unique to every individual. This review explored the possibilities and problems associated with personal identification through digital methods by the integration of telecommunications and dentistry, also known as teledentistry. Establishment of a global, objective personal identification method using dental evidence through teledentistry is desirable. However, the review reports that there are various problems that need to be resolved first, in aspects such as changes in dentition over time, technology, individual privacy and ethics. It is suggested that solving such problems and constructing a world-wide dental database for personal identification from dental images, using teledentistry, as part of social services, is a new challenge for researchers in forensic odontology and dentistry.

Keywords

Telecommunication, dentistry, teledentistry, personal identification, possibilities, problems, review

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Department of Dentistry and Oral Surgery, Unit of Sensory and Locomotor Medicine, Division of Medicine, Faculty of Medical Sciences, University of Fukui, Fukui, Japan

Corresponding author:

Shinpei Matsuda, Department of Dentistry and Oral Surgery, Unit of Sensory and Locomotor Medicine Division of Medicine, Faculty of Medical Sciences, University of Fukui, 23-3 Matsuokashimoaizuki, Eiheiji-cho, Yoshida-gun, Fukui 910-1193, Japan.
Email: shinpeim@u-fukui.ac.jp



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Introduction

Dental features, including decayed, missing and filled teeth, are unique to every individual.¹⁻⁴ Hard tissues such as bone and teeth are less likely to change over time than soft tissues. Therefore, dental assessment can be crucial in personal identification (PI) of missing individuals and forensic cases such as large disasters and accidents.¹⁻⁴ Even today in forensic cases, PI with dental evidence is performed globally by traditional visual comparisons of the antemortem dental records with those obtained postmortem.¹⁻⁴ Conversely, for cases involving missing and unidentified individuals, dental information is not currently a priority in PI.²

Traditional visual comparisons may have poor objectivity in forensic cases because features in dental records that are concordant before and after the incident, which would aid in PI, have not been standardized.⁴ A digital database for PI as part of social services and humanitarian forensics, although under consideration, has not yet been implemented.^{2,4} The construction of a database by including dental records, including images of dentition and/or teeth, casts, models and orofacial soft tissues may solve these issues in PI.⁴⁻⁶ However, presently, there is no objective digital PI method using dental evidence that has been accepted as a standardized method worldwide owing to various factors.⁴

Teledentistry integrates telecommunications and dentistry thereby making it possible to exchange and use clinical information and images.⁷⁻⁹ As a consequence of the coronavirus disease 2019 (COVID-19) pandemic, digitization has revolutionized the field of healthcare, employment and education worldwide.¹⁰ Due to the COVID-19 pandemic, cities around the world have taken measures to lockdown, i.e. people should avoid crowded spaces and any unnecessary outings. Under these circumstances, teledentistry is getting a lot of

attention.⁷⁻¹⁰ There is a possibility that teledentistry may become a powerful tool for maintaining oral health, and for the diagnosis of dental/oral disorders and conditions, in members of the general public that find it difficult to visit a dentist.⁷⁻⁹

The objective of this article was to review the possibilities and problems associated with digital PI methods using teledentistry.

Possibilities and problems in PI through teledentistry

Possibilities

Awareness. Recent studies have reported that dentists are interested in the integration of telecommunications and dentistry.^{11,12} A survey of dental professionals in Saudi Arabia demonstrated that more than 70% of respondents agreed that the integration of telecommunications and dentistry would improve dental practice by enhancing communication, teaching and referral of patients.¹² These reports suggest that there is widespread recognition and support for teledentistry.^{11,12}

Technologies. In recent years, digitalization has brought remarkable changes in various dental techniques, including dental implants.^{13,14} They are predominantly based on object recognition and digital image reconstruction. Hard and soft tissues are the targets in digital technology applications, such as the development in digital technology to assist tooth preparation and placement of dental implants.^{13,14} Application of digital technology in dental clinical practice is advancing day by day.^{13,14}

Personal identification using dental image artificial intelligence was studied and convolutional neural network structures were found to have high discriminative ability for orthopantomography.¹⁵ Artificial intelligence has been applied in tooth identification and diagnostic charting

based on orthopantomography, suggesting that orthopantomography is useful for PI as it contains objective dental information.^{16–18} Advancements in the analysis of orthopantomography data using artificial intelligence may bring about the digitalization and objective evaluation of PI.^{15–18}

A remote forensic odontological analytical system was developed based on radiographs, photographs and images from videos and 3-dimensional scans.¹⁹ It suggested that the integration of telecommunications and forensic dentistry is effective in PI.¹⁹

Problems

Changes in dentition. For PI, it is essential that the hard tissues, including teeth and bones, remain stable for successful analysis (Figure 1).⁴ Information regarding dentition, such as number of teeth, teeth status, teeth types, position, crown and root morphology, crown and root pathology, root canal morphology, and dental restorations, is crucial for establishing digital methods of PI.⁴

In surviving missing individuals, dental information could be altered due to conditions such as periodontitis, dental caries and trauma. Cases of missing individuals are often associated with psychiatric disorders and in such cases, it may be difficult for the individual to maintain oral hygiene themselves.²

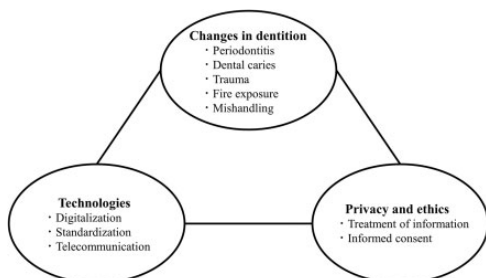


Figure 1. The problems of personal identification through teledentistry.

In forensic cases, dentition could be altered due to trauma, fire exposure, infectious disease, inflammatory disease and mishandling as follows:^{20–23} (i) trauma – traumatic injury in the head and neck region may influence dentition through teeth and bone fracture.²⁰ In particular, incisors and single rooted teeth are susceptible to traumatic effects; (ii) fire exposure – high temperatures cause extensive bone fracture and changes in tooth structure and dental restorations;^{20,21} (iii) infectious and inflammatory diseases – post-mortem tooth loss and fracture may occur in association with pre-existing bacterial infections and inflammatory diseases;^{22,23} (iv) mishandling – tooth loss can occur as a result of post-mortem mechanical stress, including burial, excavation and drying out after cleaning.²²

Technologies. To put digital PI methods via teledentistry into practice, the digitization of dental records and common programs to process them are necessary. Digital Imaging and Communications in Medicine was developed as an international standard for medical imaging and examination data and has been widely adopted in the medical field, although its adoption in dentistry has been insufficient.²⁴ A systematic review on the development of digital technology in forensic dentistry revealed that no methods using digital technology have been accepted worldwide because of factors such as expensive equipment and the cost of components.⁴ Artificial intelligence is effective in improving objectivity, but its application in dental imaging is in its infancy.^{15–18}

Privacy and ethics. Privacy and ethical considerations are paramount while handling personally identifiable information.^{25,26} The concept of privacy impact assessment, formulated by the International Organization for Standardization and the International Electrotechnical Commission, is considered

the international standard to promote them.²⁷ The concept has been discussed in many countries since the 1990s and was published as an international standard in 2008.²⁷ The International Criminal Police Organization has built automated fingerprint identification systems using important criminal records from 190 countries since 2012.²⁸ PI methods using dental evidence based on digital technology are in the early stages of development and discussion regarding their treatment of personal information may be insufficient.^{2,4,15} It is important to discuss how consent for database construction could be obtained from individuals for digital PI methods based on dental records.^{25,26}

Discussion

The authors considered that researchers in various fields and politicians should work to establish PI systems, as a social service, based on biological information in preparation for human and natural disasters. These data should be treated as private and sensitive information, and may become part of the public safety services.

Personal identification using dental evidence including electronic and non-electronic records is useful in some situations including unidentified bodies and missing individuals because dentition is unique to each individual and is stable for long periods of time compared with soft tissues. In the future, studies for developing PI methods using dental evidence with or without artificial intelligence may be integrated with telecommunications and considered as part of social services. Recent studies reported increasing awareness regarding the efforts to integrate telecommunication and dentistry, known as teledentistry; and the recent efforts to develop PI methods using teledentistry.^{7-9,11-19} Conversely, this current review has identified problems that need to be solved in

various aspects such as changes in dentition, technology, and privacy and ethics.²⁰⁻²⁶ Therefore, at this time, dental researchers have to recognize that teledentistry is a complementary method for PI.

Incomplete dental records as a consequence of tooth loss might limit the usefulness of PI methods based on dental evidence.²⁹ There has been a growing interest in oral hygiene and health over recent years and even the elderly now have a large number of retained natural teeth.³⁰⁻³² Moreover, artificial intelligence has recently been applied to image recognition in various fields. In the future, with the resolution of the problems identified in this review, digital PI methods using dental information and telecommunications will advance closer to clinical application.

The COVID-19 pandemic, caused by the severe acute respiratory syndrome coronavirus 2, has negatively impacted on general health, mental health and economic conditions.^{10,32} The COVID-19 pandemic has exacerbated existing racial/ethnic and socioeconomic disparities in all health-related aspects.³³ This has strained ties between relatives and also between residents of local communities.^{34,35} This will lead to an increase in the number of unidentified bodies and missing individuals in the future.³⁵ In our opinion, it is important in this situation to construct a database of dental images and records obtained during routine dental check-ups as a social service to be used in digital PI method.³⁵ This might be one of the few ways without ethical issues to obtain valid data for PI. Preliminarily, stake-holders including researchers and politicians should strive to improve the accuracy of PI systems that use dental evidence, reach consensus on how to handle dental records and determine the method of getting informed consent from individuals (from parents or caregivers in cases of minors) to be registered in the database based on dental records.³⁵

Researchers in dentistry should contribute not only to oral health and diet but also to technological innovation to achieve the 17 Sustainable Development Goals adopted by the United Nations.³⁶ Medical care, longevity and telecommunication technologies including the Internet has advanced greatly during the last 25 years. The construction of a worldwide PI database based on dental records, as a social service, with the help of telecommunication technology using dental images, is a new challenge for dental researchers.

The authors worked to improve the quality of this review in accordance with a scale for the quality assessment of narrative review articles.³⁷

Conclusion

The possibilities and problems of digital PI methods using teledentistry were reviewed in this article. It is suggested that solving such problems and constructing a worldwide dental database for PI from dental images, using teledentistry, as part of the social services and humanitarian forensics, is a new challenge for researchers in forensic odontology and dentistry. Although teledentistry could be a resource for best practices in the field of digital PI, it needs to be recognized that it remains a complementary method at this time.


Declaration of conflicting interest

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ORCID iD

Shinpei Matsuda  <https://orcid.org/0000-0002-0299-7188>

References

1. Sweet D. Why a dentist for identification? *Dent Clin North Am* 2001; 45: 237–251.
2. Matsuda S and Yoshimura H. Personal identification systems for persons with dementia: a systematic review. *Psychogeriatrics* 2021; 21: 832–838.
3. Kolude B, Adeyemi BF, Taiwo JO, et al. The role of forensic dentist following mass disaster. *Ann Ib Postgrad Med* 2010; 8: 111–117.
4. Matsuda S, Yoshida H, Ebata K, et al. Forensic odontology with digital technologies: A systematic review. *J Forensic Leg Med* 2020; 74: 102004.
5. Gupta N, Jadhav K, Ahmed Mujib BR, et al. Is re-creation of human identity possible using tooth prints? An experimental study to aid in identification. *Forensic Sci Int* 2009; 192: 67–71.
6. Herrera LM, Fernandes CMDS and Serra MDC. Evaluation of lip prints on different supports using a batch image processing algorithm and image superimposition. *J Forensic Sci* 2018; 63: 122–129.
7. Howell SEI and Fukuoka B. Teledentistry for patient-centered screening and assessment. *Dent Clin North Am* 2022; 66: 195–208.
8. Ghai S. Teledentistry during COVID-19 pandemic. *Diabetes Metab Syndr* 2020; 14: 933–935.
9. Goriuc A, Sandu D, Tatarciuc M, et al. The impact of the COVID-19 pandemic on dentistry and dental education: a narrative review. *Int J Environ Res Public Health* 2022; 19: 2537.
10. World Health Organization. Coronavirus disease (COVID-19), https://www.who.int/health-topics/coronavirus#tab=tab_1 (2021, accessed 12 January 2022).
11. Subhan R, Ismail WA, Musharraf S, et al. Teledentistry as a supportive tool for dentists in Pakistan. *Biomed Res Int* 2021; 2021: 8757859.
12. Al-Khalifa KS and AlSheikh R. Teledentistry awareness among dental professionals in Saudi Arabia. *PLoS One* 2020; 15: e0240825.
13. Turkyilmaz I, Wilkins GN and Varvara G. Tooth preparation, digital design and

- milling process considerations for CAD/CAM crowns: understanding the transition from analog to digital workflow. *J Dent Sci* 2021; 16: 1312–1314.
14. Cosyn J, Wessels R, Garcia Cabeza R, et al. Soft tissue metric parameters, methods and aesthetic indices in implant dentistry: A critical review. *Clin Oral Implants Res* 2021; 32: 93–107.
 15. Matsuda S, Miyamoto T, Yoshimura H, et al. Personal identification with orthopantomography using simple convolutional neural networks: a preliminary study. *Sci Rep* 2020; 10: 13559.
 16. Tuzoff DV, Tuzova LN, Bornstein MM, et al. Tooth detection and numbering in panoramic radiographs using convolutional neural networks. *Dentomaxillofac Radiol* 2019; 48: 20180051.
 17. Başaran M, Çelik Ö, Bayrakdar IS, et al. Diagnostic charting of panoramic radiography using deep-learning artificial intelligence system. *Oral Radiol* 2021. doi: 10.1007/s11282-021-00572-0.
 18. Ahmed N, Abbasi MS, Zuberi F, et al. Artificial intelligence techniques: analysis, application, and outcome in dentistry – a systematic review. *Biomed Res Int* 2021; 2021: 9751564.
 19. Nuzzolese E. VIRDENTOPSY: virtual dental autopsy and remote forensic odontology evaluation. *Dent J (Basel)* 2021; 9: 102.
 20. Ubelaker DH. Recent advances in understanding hard tissue alterations related to trauma. *Forensic Sci Int* 2019; 299: 235–237.
 21. Reesu GV, Augustine J and Urs AB. Forensic considerations when dealing with incinerated human dental remains. *J Forensic Leg Med* 2015; 29: 13–17.
 22. Hillson S. Recording dental caries in archaeological human remains. *Int J Osteoarchaeol* 2001; 11: 249–289.
 23. Charlier P, Augias A, Benmoussa N, et al. The mandible of Saint-Louis (1270 AD): retrospective diagnosis and circumstances of death. *J Stomatol Oral Maxillofac Surg* 2020; 121: 172–174.
 24. Farman AG. Applying DICOM to dentistry. *J Digit Imaging* 2005; 18: 23–27.
 25. Tseng HT, Hung WF, Hwang HG, et al. Do patients' privacy concerns influence their intention toward medical image exchange consent in Taiwan? *Healthcare (Basel)* 2020; 8: 14.
 26. Deepika J, Rajan C and Senthil T. Security and privacy of cloud- and IoT-based medical image diagnosis using fuzzy convolutional neural network. *Comput Intell Neurosci* 2021; 2021: 6615411.
 27. International Organization for Standardization and the International Electrotechnical Commission. ISO/IEC 29134:2017(en) Information technology – Security techniques – Guidelines for privacy impact assessment, <https://www.iso.org/obp/ui/#iso:std:iso-iec:29134:ed-1:v1:en> (2021, accessed 12 January 2022).
 28. Leone M. From fingers to faces: visual semiotics and digital forensics. *Int J Semiot Law* 2020; 34: 579–599.
 29. Brachetta Aporta N and D'Addona LA. Applying multivariate methods to dental development sequences for subadults from archaeological samples. *Int J Osteoarchaeol* 2020; 30: 218–224.
 30. Matsuda S, Saito T, Yoshida H, et al. Prevalence of tongue cleaning using a toothbrush: a questionnaire survey in Fukui prefecture, Japan. *Biomed Res Int* 2019; 2019: 6320261.
 31. Matsuda S, Goi T, Yoshida Y, et al. Periodontal disease in preoperative patients with digestive cancer: a retrospective, single-institution experience in Fukui, Japan. *BMC Oral Health* 2021; 21: 3.
 32. Matsuda S, Yoshida H, Yoshimura H, et al. Has the COVID-19 pandemic influenced the oral health and nutritional status of elderly patients with digestive cancer?: a retrospective study in Fukui, Japan. *Medicine (Baltimore)* 2021; 100: e27500.
 33. Bharmal N, Bailey J, Johnson V, et al. Addressing COVID-19 health disparities through a regional community health response. *Cleve Clin J Med* 2021; doi: 10.3949/ccjm.88a.ccc072.
 34. Fiorella KJ, Coffin-Schmitt J, Gaynor KM, et al. Feedbacks from human health to household reliance on natural resources during the COVID-19 pandemic. *Lancet Planet Health* 2020; 4: e441–e442.

35. Matsuda S and Yoshimura H. Personal identification with artificial intelligence under COVID-19 crisis: a scoping review. *Syst Rev* 2022; 11: 7.
36. United Nations. Department of Economic and Social Affairs. The 17 Goals, <https://sdgs.un.org/goals> (2021, accessed 12 January 2022).
37. Baethge C, Goldbeck-Wood S and Mertens S. SANRA-a scale for the quality assessment of narrative review articles. *Res Integr Peer Rev* 2019; 4: 5.