Review Article

Oral Pathology in Forensic Investigation

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ABSTRACT

Forensic odontology is the subdiscipline of dentistry which analyses dental evidence in the interest of justice. Oral pathology is the subdiscipline of dentistry that deals with the pathology affecting the oral and maxillofacial regions. This subdiscipline is utilized for identification through oral and maxillofacial pathologies with associated syndromes, enamel rod patterns, sex determination using exfoliative cytology, identification from occlusal morphology of teeth, and deoxyribonucleic acid profiling from teeth. This subdiscipline is also utilized for age estimation studies which include Gustafson's method, incremental lines of Retzius, perikymata, natal line formation in teeth, neonatal line, racemization of collagen in dentin, cemental incremental lines, thickness of the cementum, and translucency of dentin. Even though the expertise of an oral pathologist is not taken in forensic investigations, this paper aims to discuss the role of oral pathology in forensic investigation.

KEYWORDS: *Age estimation, forensic investigation, forensic odontology, identification, oral pathology*

INTRODUCTION

Oral pathology is the subdiscipline of dentistry that deals with the pathology affecting the oral and maxillofacial regions.[1] This subdiscipline is now widely utilized for individuals' identification and for age estimation studies in forensic, i.e., in forensic odontology.[2] The role of oral pathology in forensic investigation is scientometrically calibrated in the scientific literature.[3-5] The scientometric calibration is based on the new working classification proposed for forensic odontology.[6] A simplified Indian coding was proposed for forensic dental identification based on the interrelationship of dental specialties including oral pathology with forensic odontology.[7] Forensic odontology is an investigative aspect of dentistry that deals with the handling and examination of dental evidence and with the proper evaluation and presentation of dental evidence in the interest of justice.[2,8] Estimating the time after death can be histologically assessed by cellular changes in postmortem gingival specimens.[9,10]

Even though the expertise of an oral pathologist is not taken in forensic investigations, this paper aims to review the role of oral pathology in forensic investigation.

A review of the literature was done using PubMed to evaluate the role of oral pathology in forensic investigation. The following keywords were searched in PubMed: Identification, enamel rod patterns, sex determination using exfoliative cytology, identification from occlusal morphology of teeth, deoxyribonucleic acid profiling from teeth, Gustafson's method, incremental lines of Retzius, perikymata, natal line formation in teeth, neonatal line, oral and maxillofacial pathologies with associated syndromes, age estimation, cemental incremental lines, dental (radicular) cementum, translucency of dentin, and racemization of collagen in dentin.

IDENTIFICATION

Oral pathology is utilized for individuals' identification through oral and maxillofacial pathologies with associated syndromes, enamel rod patterns, sex determination using exfoliative cytology, identification from occlusal morphology of teeth, and deoxyribonucleic acid profiling from teeth.[1,4]

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ORAL AND MAXILLOFACIAL PATHOLOGIES WITH ASSOCIATED SYNDROMES

The individuals are identified from oral and maxillofacial pathologies with associated syndromes and are already narrated in the review.[1,11] The individuals may be identified from dental traits of congenital syphilis and bilaterally impacted canines.[12,13]

ENAMEL ROD PATTERNS

Biometrically, the undulated groups of enamel rods which extend from the dentinoenamel junction to the external tooth surface will form specific patterns on tooth surface.[14] Enamel rod patterns are unique for each tooth in an individual, and the biometric study of enamel rod patterns from individual tooth for identification purpose is called ameloglyphics.[15] It can be recorded from a tooth using cellulose acetate film, cellophane tape, or light body dental impression material.[16]

SEX DETERMINATION USING EXFOLIATIVE CYTOLOGY

Human dentition is influenced by genetic and environmental factors that determine the position of teeth in the arch.[17,18] The characteristic features of the teeth such as morphology, crown size, and root length will help to determine the sex of the individuals.[19] The sex of a particular individual can be identified using a confocal microscope in exfoliative cytology from buccal mucosal scrapings for Barr body-positive cells.[20] Exfoliative cytology can be done using acridine orange, aceto-orcein, or Papanicolaou stains.[20-23] There is a significant decrease in the cell size ranging from 0.002 to 0.017 mm/sq with aging, evident with exfoliative study using Papanicolaou stain.[22] The sex of a male individual is determined from the pulp tissue stained with quinacrine mustard for fluorescent Y chromosome.[24] The amelogenin gene in enamel may present as identical genes in females and different genes in males.[24,25]

IDENTIFICATION FROM OCCLUSAL MORPHOLOGY OF TEETH

The individuals are identified from the occlusal morphology of the teeth. The high percentage of "+-" shaped groove pattern and low percentage of primitive "y-" shaped pattern were evident from a school population study conducted at Gujarat.[26]

The other studies done related to occlusal morphology in various populations are as follows: (a) number of cusps and occlusal groove patterns of the permanent mandibular first and second molar in a Saudi population, (b) +4 occlusal form of mandibular second molars in Iranian adolescents, (c) cusp number and groove patterns of mandibular molars in Alaskan Eskimos, and (d) Associations between Carabelli trait and cusp areas in human permanent maxillary first molars in Australians of European descent.[27-31] Other occlusal

morphologic malformations exist in human population include talon cusp and Leong's premolar.[32,33]

DEOXYRIBONUCLEIC ACID PROFILING FROM TEETH

The role of deoxyribonucleic acid profiling from teeth is already explained in the review and previous studies.[1,34-36]

AGE ESTIMATION

Oral pathology is also utilized for age estimation studies, which are carried out using ground sections of teeth.[1] The age estimation studies include Gustafson's method, incremental lines of Retzius, perikymata, natal line formation in teeth, neonatal line, racemization of collagen in dentin, cemental incremental lines, thickness of the cementum, and translucency of dentin.[6]

GUSTAFSON'S METHOD

This is the most widely used age estimation technique in individuals above 21 years. Gustafson formulated following dental changes, namely, attrition, apical migration of periodontal ligament, deposition of secondary dentin, cemental opposition, root resorption, and transparency of the root dentin to estimate age.[37] Age was estimated using the formula:

$Y = 4.56 \ X + 11.43$ where X is the total score. The standard error with this method was 3.6 years.[38] Later, Bajpai et al. modified Gustafson's method by multiple regression analysis and formulated a more accurate formula, $Y = 5.6 \ X + 1.81$ for age estimation with a standard error of 6.35 years.[39] Bajpai et al. conducted modified Gustafson's technique in an Indian population with a sample of 228 extracted teeth and Kashyap and Koteswara Rao are forerunners of modified Gustafson's method in the Indian population in 1990.[39,40] Bajpai et al. established a positive correlation between age and total scores of physiological dental changes.[39] In the present review, the author has excluded studies of Gustafson's method using radiography which comes under oral medicine and radiology speciality.

INCREMENTAL LINES OF RETZIUS

Incremental lines of Retzius represent the discrepancy in the rhythmic mineralization of enamel prisms.[41] This rhythmic mineralization appearing in enamel may be influenced by metabolic disturbances so that the lines may appear closer or the rest periods may be prolonged.[1] In forensic odontology, incremental lines of Retzius act as a tool in the chronological mapping of dental development as evident from scanning electron microscopy.[42]

PERIKYMATA

Perikymata are beautifully narrated as imbrication lines or in other words "the number and spacing of incremental

markings at the enamel surface."[1] They are important indicators of the growth patterns of the teeth because they provide information on crown formation times and the underlying developmental processes.[43] The authors have excluded animal studies related to perikymata in this review.

NATAL LINE FORMATION IN TEETH

The natal line formations (either pre or post) in teeth are considered as birth indicators.[44] These natal lines are more common in both enamel and dentin of deciduous teeth and permanent first molars which indicate the development during the transitional period between intra- and extra-uterine environments.[1]

NEONATAL LINE

The neonatal line is a hypomineralized structure seen as a step-like rupture in the enamel matrix, due to disturbances in the enamel secretion stage.[45] The presence of neonatal line indicates live birth by measuring the amount of postnatal hard tissue formation.[46,47] In a population study reported from north-central Poland, a clear increase in the width of the neonatal line was observed along with a decrease in the child's age at death.[48] Recent evidence suggests that neonatal lines are produced due to alteration in the dimension, direction, and degree of mineralization of the enamel prisms and is considered as substantial evidence in infanticide cases brought before the law in India.[49]

RACEMIZATION OF COLLAGEN IN DENTIN

The individual's age at the time of death can be calibrated by the extent of racemization of aspartic acid in coronal dentin of normal permanent teeth.[36,50] As age advances, there will be conversion of L-aspartic acid to D-aspartic acid.[1] The same principle is also applied to calculate the racemization rate for age estimation of pink teeth.[51] Pink teeth arise as a result of the seepage of hemoglobin caused by dental pulp decomposition.[51] Trauma and moist environment may play a vital role in the appearance of pink teeth.[52] Ground sections of pink teeth will show reddish brown discoloration of dentin.[52] Clinically, the cervical region of the tooth will show pink appearance compared to the root portion, and it is highly appreciated in incisors, canines, and premolars.[51] Pink teeth are a common finding related to medicolegal cases such as strangulation, drowning, and suffocation.[53]

CEMENTAL INCREMENTAL LINES

The incremental lines of cementum will guide to determine the age of adults.[54] A major disadvantage of this method is that you cannot salvage the tooth (the tooth may either be extracted or sectioned) and it is not practical among living individuals.[1]

THICKNESS OF THE CEMENTUM

The thickness of the cementum will aid in age estimation.[54,55] It was observed that the thickness of cementum is more statistically evident at the apex compared to the one-third of the root length from the apex.[55]

TRANSLUCENCY OF DENTIN

The dentinal translucency is used frequently to estimate age because of its accuracy and simplicity.[56] The estimation of dentinal translucency in elderly individuals is not feasible because the junction at translucent and nontranslucent zones is irregular.[1] Age estimation using the dentinal translucency is more accurate in the methods by Singhal et al. and by Prince and Ubelaker, with respect to that of Lamendin.[57]

CONCLUSION

This article hopes to sensitize the dental fraternities around the globe to know about the relationship of oral pathology with forensic odontology. In the present scenario of mass disasters, the necessity of dental disaster squad in various nations is recommended.[58-60]

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CONFLICTS OF INTEREST

There are no conflicts of interest.

REFERENCES

1. Shamim T. Forensic odontology. J Coll Physicians Surg Pak 2012;22:240-5.
2. Divakar KP. Forensic odontology: The new dimension in dental analysis. Int J Biomed Sci 2017;13:1-5.
3. Shamim T. Publication trends in the journal of forensic dental sciences 2009-2012. J Scientometric Res 2013;2:152-6.
4. Shamim T. The relationship of forensic odontology with various dental specialties in the articles published in the journal of forensic odonto-stomatology from 2005 to 2012. Indian J Dent 2015;6:75-80.
5. Thetakala RK, Chandrashekar BR, Sunitha S, Sharma P. The relationship of forensic odontology with various dental specialties in the articles published in a national and an international forensic odontology journal: A 5-year content analysis. J Forensic Dent Sci 2017;9:65-72.
6. Shamim T. A new working classification proposed for forensic odontology. J Coll Physicians Surg Pak 2011;21:59.
7. Shamim T. A simplified Indian coding proposed for forensic dental identification. J Coll Physicians Surg Pak 2014;24:609-10.
8. Shamim T, Varghese VI, Shameena PM, Mahesh MR. Forensic odontology to the rescue: A case report. Med Legal Update 2006;6:115-8.
9. Yadav AB, Angadi PV, Kale AD, Yadav SK. Histological assessment of cellular changes in postmortem gingival specimens for estimation of time since death. J Forensic Odontostomatol 2015;33:19-26.
10. Mahalakshmi V, Gururaj N, Sathya R, Sabarinath TR, Sivapathasundharam B, Kalaiselvan S, et al. Assessment of histological changes in antemortem gingival tissues fixed at various time intervals: A method of estimation of postmortem interval. J Forensic Dent Sci 2016;8:114.

11. Rajshekar M, Mithun T, Idiculla JJ, Tennant M. Developmental anomalies of teeth and their applications in forensic odontology. Eur J Forensic Sci 2016;3:39-49.

12. Shamim T, Renjini PS. Dental traits of congenital syphilis revisited in dental outpatient department (OPD). Head Neck Pathol 2017;11:517-8.

13. Shamim T, Renjini PS. Asymptomatic bilateral maxillary and mandibular impacted permanent canines: Serendipity in Dental Outpatient Department. J Korean Assoc Oral Maxillofac Surg 2017;43:427-8.

14. Manjunath K, Sivapathasundharam B, Saraswathi T. Efficacy of various materials in recording enamel rod endings on tooth surface for personal identification. J Forensic Dent Sci 2011;3:71-6.

15. Juneja M, Juneja S, Rakesh N, Bhoomareddy Kantharaj YD. Ameloglyphics: A possible forensic tool for person identification following high temperature and acid exposure. J Forensic Dent Sci 2016;8:28-31.

16. Christopher V, Murthy S, Ashwinirani SR, Prasad K, Girish S, Vinit SP, et al. Can dead man tooth do tell tales? Tooth prints in forensic identification. J Forensic Dent Sci 2017;9:47.

17. Shamim T, Varghese VI, Shameena PM, Sudha S. Human bitemarks: The tool marks of the oral cavity. J Indian Acad Forensic Med 2006;28:52-4.

18. Chidambaram R. Forensic odontology: A Boon to community in medico-legal affairs. JNMA J Nepal Med Assoc 2016;54:46-54.

19. Shamim T, Sudha S, Shameena PM, Varghese VI. An insight to forensic odontology. Kerala Dent J 2006;29:45-7.

20. Reddy DS, Sherlin HJ, Ramani P, Prakash PA. Determination of sex by exfoliative cytology using acridine orange confocal microscopy: A short study. J Forensic Dent Sci 2012;4:66-9.

21. Datar U, Angadi PV, Hallikerimath S, Kale AD. Cytological assessment of barr bodies using aceto-orcein and papanicolaou stains in buccal mucosal smears and their sex estimation efficacy in an Indian sample. Acta Cytol 2013;57:516-21.

22. Shetty DC, Wadhwan V, Khanna KS, Jain A, Gupta A. Exfoliative cytology: A possible tool in age estimation in forensic odontology. J Forensic Dent Sci 2015;7:63-6.

23. Baby TK, Thomas P, Palani J, Pillai RK, Ramakrishnan BP. Sex determination efficacy of papanicolaou and acriflavine schiff stains in buccal smears. J Forensic Dent Sci 2017;9:46.

24. Shamim T, Varughese VI, Shameena PM, Sudha S. Forensic odontology: A new perspective. Med Legal Update 2006;6:1-4.

25. Praveen Kumar ST, Aswath N. DNA isolation from teeth by organic extraction and identification of sex of the individual by analyzing the AMEL gene marker using PCR. J Forensic Dent Sci 2016;8:18-21.

26. Phulari RG, Rathore R, Takvani MD, Jain S. Evaluation of occlusal groove patterns of mandibular first and second molars in an Indian population: A forensic anthropological study. Indian J Dent Res 2017;28:252-5.

27. Felemban NH, Manjunatha BS. Prevalence of the number of cusps and occlusal groove patterns of the mandibular molars in a Saudi Arabian population. J Forensic Leg Med 2017;49:54-8.

28. Gupta SK, Saxena P. Prevalence of cusp 7 in permanent mandibular first molars in an Indian population: A comparative study of variations in occlusal morphology. J Investig Clin Dent 2013;4:240-6.

29. Mosharraf R, Ebadian B, Ali Z, Najme A, Niloofar S, Leila K, et al. Occlusal morphology of mandibular second molars in iranian adolescents. Indian J Dent Res 2010;21:16-9.

30. Hasund A, Bang G. Morphologic characteristics of the Alaskan Eskimo dentition: IV. Cusp number and groove patterns of mandibular molars. Am J Phys Anthropol 1985;67:65-9.

31. Kondo S, Townsend GC. Associations between carabelli trait and cusp areas in human permanent maxillary first molars. Am J Phys Anthropol 2006;129:196-203.

32. Mallineni SK, Panampally GK, Chen Y, Tian T. Mandibular talon cusps: A Systematic review and data analysis. J Clin Exp Dent 2014;6:e408-13.

33. Sharma G, Mutneja AR, Nagpal A, Mutneja P. Dens evaginatus and dens invaginatus in a double tooth: A rare case report. Indian J Dent Res 2015;26:545-9.

34. Shamim T. Deoxyribonucleic acid profiling in forensic dental identification. Indian J Hum Genet 2013;19:513.

35. Shamim T. Forensic odontology. In: Rajiv Saini R, Saini S, editors. Dental Horizons: Essentials of Oral Health. 1st ed. Hyderabad: Paras Medical Publishers; 2011. p. 201-14.

36. Adserias-Garriga J, Thomas C, Ubelaker DH, C Zapico S. When forensic odontology met biochemistry: Multidisciplinary approach in forensic human identification. Arch Oral Biol 2017;87:7-14.

37. Shamim T. Forensic odontology. J Coll Physicians Surg Pak 2010;20:1-2.

38. Shamim T, Ipe Varghese V, Shameena PM, Sudha S. Age estimation: A dental approach. J Punjab Acad Forensic Med Toxicol 2006;6:14-6.

39. Bajpai M, Pardhe N, Kumar M, Agrawal S. A comparative evaluation of gustafson's formula and new formula for age estimation in India – A forensic study. Prague Med Rep 2015;116:203-9.

40. Kashyap VK, Koteswara Rao NR. A modified gustafson method of age estimation from teeth. Forensic Sci Int 1990;47:237-47.

41. Simmer JP, Papagerakis P, Smith CE, Fisher DC, Rountrey AN, Zheng L, et al. Regulation of dental enamel shape and hardness. J Dent Res 2010;89:1024-38.

42. Risnes S, Li C. Aspects of the final phase of enamel formation as evidenced by observations of superficial enamel of human third molars using scanning electron microscopy. Arch Oral Biol 2018;86:72-9.

43. Smith TM, Reid DJ, Sirianni JE. The accuracy of histological assessments of dental development and age at death. J Anat 2006;208:125-38.

44. Dolphin AE, Goodman AH, Amarasiriwardena DD. Variation in elemental intensities among teeth and between pre- and postnatal regions of enamel. Am J Phys Anthropol 2005;128:878-88.

45. Sabel N. Enamel of primary teeth – Morphological and chemical aspects. Swed Dent J Suppl 2012;222:1-77.

46. Janardhanan M, Umadethan B, Biniraj K, Kumar RV, Rakesh S. Neonatal line as a linear evidence of live birth: Estimation of postnatal survival of a new born from primary tooth germs. J Forensic Dent Sci 2011;3:8-13.

47. Canturk N, Atsu SS, Aka PS, Dagalp R. Neonatal line on fetus and infant teeth: An indicator of live birth and mode of delivery. Early Hum Dev 2014;90:393-7.

48. Kurek M, Żądzińska E, Sitek A, Borowska-Strugińska B, Rosset I, Lorkiewicz W, et al. Neonatal line width in deciduous incisors from neolithic, mediaeval and modern skeletal samples from north-central Poland. Ann Anat 2016;203:12-8.

49. Srinivasan S, Murthy PS, Deshmukh S, Shamsundar NM. A comparative study to associate the presence of neonatal line in deciduous teeth of infants with the occurrence of live birth. J Indian Soc Pedod Prev Dent 2017;35:249-53.

50. Rastogi M, Logani A, Shah N, Kumar A, Arora S. Age estimation of living Indian individuals based on aspartic acid racemization from tooth biopsy specimen. J Forensic Dent Sci 2017;9:83-90.

51. Sakuma A, Saitoh H, Ishii N, Iwase H. The effects of racemization rate for age estimation of pink teeth. J Forensic Sci 2015;60:450-2.

52. Gowda BC, Sivapathasundharam B, Chatterji A, Chatterji BL. Histological appearance of postmortem pink teeth: Report of two cases. J Forensic Dent Sci 2015;7:168-70.

53. Soriano EP, Carvalho MV, Santos FB, Mendoza CC, Araújo MD, Campello RI, et al. The post-mortem pink teeth phenomenon: A case report. Med Oral Patol Oral Cir Bucal 2009;14:E337-9.

54. Kasetty S, Rammanohar M, Raju Ragavendra T. Dental cementum in age estimation: A polarized light and stereomicroscopic study. J Forensic Sci 2010;55:779-83.

55. Pinchi V, Forestieri AL, Calvitti M. Thickness of the

dental (radicular) cementum: A parameter for estimating age. J Forensic Odontostomatol 2007;25:1-6.

56. Acharya AB. Forensic dental age estimation by measuring root dentin translucency area using a new digital technique. J Forensic Sci 2014;59:763-8.

57. Santoro V, Fiandaca C, Roca R, Marini C, De Donno A, Introna F. Validity comparison of three dental methods for age estimation based on tooth root translucency. J Forensic Sci 2015;60:1310-5.

58. Shamim T. Dental disaster squad: Necessity of the hour in Iran. Arch Iran Med 2017;20:330.

59. Arora KS, Kaur P. Role of forensic odontology in the Indian Armed Forces: An unexplored arena. J Forensic Dent Sci 2016; 8:173.

60. Rathod V, Desai V, Pundir S, Dixit S, Chandraker R. Role of forensic dentistry for dental practitioners: A comprehensive study. J Forensic Dent Sci 2017;9:108-9.