A CRITIQUE OF AGE ESTIMATION USING ATTRITION AS THE SOLE INDICATOR

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ABSTRACT

The age determination of skeletal remains has been carried out using anthropological examination of the remaining bones and dentition. The aging of the dentition is based on attrition which, if physiological will correlate with age. Occasionally the only material available is a single tooth or a few teeth, or in the case of a living person, teeth *in situ*. In certain cases microscopic examination of the teeth may not be possible and the age estimation is then often determined by the degree of attrition associated with the tooth. In more recent times the causes of attrition have involved other factors such as bruxism, diet, environment and medication. The weaknesses and limitations of age estimation by examination of dental attrition as the sole indicator of age are highlighted. **(J Forensic Odontostomatol 2002;20:38-42)**

Key Words: Age estimation, attrition, bruxism, weaknesses

INTRODUCTION

This paper reviews the literature covering tooth wear as an indicator of age of an adult skeleton and shows why in the absence of microscopic examination of the sectioned tooth, attrition should not be relied upon as a sole indicator of age.

REVIEW

The aging of subadults can usually be determined very accurately because of a large number of age-dependent morphological features and dental development in particular is one of the most accurate indicators of age. All but the third molars are completely calcified by 16 yrs followed at age 25 yrs by the third molars.[1]

At the end of skeletal growth the number of these age-dependent morphological features declines. The teeth are formed, most epiphyses are united and longitudinal bone growth is complete. However, in a recent study on the development of the medial clavicular epiphysis and its fusion with the clavicular shaft it was recorded that complete union first occurred at 22 yrs with all subjects showing complete union by 27 yrs.[2]

In the aging of an adult skeleton a number of criteria need to be considered and assessed together and these include macroscopic changes such as metamorphosis of the pubic symphysis, suture closure in the skull, and age-related changes such as degeneration of the spine, skull and joints, resorption of cancellous bone and dental attrition. Microscopic changes occur in the long-bone cortex and the teeth.[3]

In aging cases, occasionally all that remains are some teeth, or just one tooth. This is because teeth are less affected than other parts of the body by exogenous factors such as heat, fire, bodily trauma or scavenging animals. The first anthropological method used to age an adult skeleton by the teeth was attrition which is the physiological wearing away of the tooth as a result of tooth to tooth contact, as in mastication or bruxism. This is in contrast to abrasion which is the pathological wearing away of the tooth through some abnormal mechanical process which can be caused by food or non-food items such as pipes, pins and tooth brushes. Attrition is assessed by examining the occlusal and incisal tooth surfaces and there have been a number of attempts to quantify the wear of teeth and then to allocate an age to the skeleton.[4-10]

This method has been based on anthropological/ archaeological theory which relies on the fact that attrition occurs at a specific or linear rate throughout an adult's lifetime.[11] In archaeological specimens however an adult's longevity was considerably less than contemporary man and the attrition was the result of a coarse diet. Miles[5] suggested that the Breedon Anglo-Saxon population in his study lived to approximately 31 years compared with 62 years in 1937 and 71 years in 1963 for the British population.

Most of the methods used to determine and quantify attrition contain a degree of subjectivity and often the results were difficult to reproduce without some training in the technique used.[12-15]

In 1950 Gustafson[4] developed a method for aging adult teeth by looking at the six variables: degree of attrition, changes in the periodontium, the amount of secondary dentine, cementum apposition, the degree of root resorption and the degree of root transparency. The teeth were scored for each variable then combined in a formula, and an age determined for the teeth and the skeleton. Some of these variables required microscopic examination after sectioning and histological preparation of the tooth. Despite criticism[12,16] the Gustafson technique has remained the definitive method of determining age-at-death of the adult skeleton, but it has over the years been modified.[8-10,17]

More recently much research has focused on techniques using the transparency of the root dentine[18-20] and the application of image analysis to a number of microscopic changes,[21,22] which can be regarded as objective methods.

Despite the existence and relative accuracy of aging the skeleton by observing microscopic changes in the teeth, for a number of reasons these techniques are not always employed. Rogers[23] has suggested that while the techniques are quite accurate, they have limited forensic use mainly because the teeth have to be removed and destroyed. The procedures are exacting and time consuming, and are often beyond the immediate capability of many agencies that need the information. Kvaal[24] agrees with Rogers pointing out that a destructive approach may not be acceptable for ethical, religious, cultural or scientific reasons and that furthermore in a living person these techniques require extraction which may not be acceptable. Some methods are difficult to perform and the necessary laboratory equipment (ranging from a simple microscope to a scanning electron microscope connected to suitable computer software) and necessary expertise may not be available.[19,20] Metzger[14] points out that if these techniques are not often used, it is difficult to develop operator skill. Finally, many of these techniques are costly to carry out.

One of the non-microscopic techniques for the aging of a contemporary skeleton using the dentition at death is attrition. It is a relatively simple procedure, requiring minimal equipment, is inexpensive and less invasive. It does however require some expertise[12-15] but is still subjective and not very accurate as demonstrated in the amount of correlation variation between studies[25] resulting in very broad age ranges. Attrition in contemporary man is furthermore subject to a number of variables which can affect the estimation of age.

Different scoring methods result in different correlations between age and attrition. Teeth wear at different rates, so different correlations also exist between them, as Solheim[26] found in second premolars which had the highest correlation and canines and maxillary central incisors which had the weakest. Lopez-Nicolas[19] reported that the correlation between age and attrition improved with progression from anterior to the posterior teeth. The number of teeth examined from an individual affects the correlation[4,25,27] and age estimation from a single tooth is very weak. There is general agreement that accuracy of the technique declines as age increases, resulting in a broad age range, a view supported by Hongwei and Jingtao[28] using contemporary skeletons and a mathematical model, who found that accuracy decreased with age and they believe that aging by attrition had limited dento-legal applications. This was especially true in resolving the chronological age of living people who have inadequate identification papers.[29]

When attrition is used by anthropologists to age non-contemporary skeletons, the main cause of tooth wear

is grit and a coarse diet and when linked to age[30] is regarded as normal physiological wear. In 1970 Lavelle stated that masticatory function, type of food, timing and sequence of tooth eruption, tooth form, position of the tooth, thickness of the enamel, hardness of the enamel and predisposition to enamel hypoplasia all played roles in attrition. This list is almost identical to that drawn up by Murphy[6] and fits in with factors outlined by McKee [11] while other studies have found that rates of attrition vary within a population.[10,19,27,30]

In contemporary man the causes of some attrition have changed in the last 50 years and attrition is no longer considered to be related to age[15] but its cause is multifactorial. Including the factors listed by Lavelle,[31] other causes are the number of teeth, the quality and quantity of tooth contacts, the location of the tooth in the jaw, the relationship with the opposing jaw, the mobility and periodontal status, cuspal height, the bite force, the amount of bruxing, quality and quantity of saliva, chemical and mechanical factors related to diet, gender, age and gastrointestinal disturbances.[15]

It is well established that bruxing is a complex disorder caused by a number of factors which Pavone[32] summarized as psychological, emotional, dental, systemic, occupational and idiopathic. Xhong[33] attributed attrition to bruxing, nervous tension and occlusal prematurities, causing tooth wear to progress faster in bruxers than non-bruxers. She found that wear facets occurred three times more in bruxers than non-bruxers and concluded that physiological wearing of the teeth no longer had a linear relationship with an increase in age.

In a 20-year study in Queensland, Xhong[33] also found that a relationship existed between bruxing and erosion, attributing the erosion to a high intake of acidic, flavoured drinks associated with the hot climate. The erosion was a result of acid demineralization which softened the teeth making them more susceptible to the forces of bruxism.

A study of mentally challenged people concluded that "the degree of dental wear in this group of individuals is significantly different from that of an urban population in the same geographical area".[34] The increased wear was attributed to unconscious clenching or bruxing habits, developed by these individuals as a kind of self-stimulation, regurgitation and as a result of the side effects of psychopharmacological therapy. The side effects claimed for some of these drugs does include bruxing.

In a study on Indian vegetarians[35] it was found that although the attrition was not great, when compared to non-vegetarians the vegetarians had greater tooth wear which they attributed to consumption of harder, more acidic foods, a finding supported by Dahl and Olio.[15]

A study comparing wear rates of 19 year-old Norwegians living in Norway and a similar age group of Indians living in Saudi Arabia found that the Indians had a higher wear rate which was attributable to the environment which would have included ambient fine sand particles where in the Norwegians no obvious environmental factor could be identified.[36]

The general population has a desire to retain the natural dentition rather than losing teeth which often results in endodontic treatments in order to retain them. Ingle[37] suggests that the restoration of choice for a large endodontically treated tooth is full coverage crowning, which can also apply to cases of severe attrition. This can result in masking the nature of the wear and rendering age estimation by attrition useless particularly when using image analysis and linear measurements.[38] A similar finding was reported by Kvaal[24] when using dental radiographs to estimate age and Lavelle[31] who found that even simple amalgam fillings interfered with attrition scoring for an individual. A degree of attrition also occurs when modern restorative materials oppose the natural dentition[18,39] with different types of materials affecting the pattern and the degree of wear.

CONCLUSION

Age estimation by examination of dental attrition as a sole indicator should be avoided if possible. Where applicable it should be used in conjunction with other techniques, both dental and anthropological. There are circumstances where minimal skeletal remains preclude anthropological aging, or where more sophisticated dental aging techniques are not

available. In these instances the following procedure needs to be employed. Two operators utilizing the same scoring method need to examine as many teeth as possible from the same individual which should include an assessment of the occlusion if possible.[14] The weaknesses and limitations of this method also need to be kept in mind. These include the relative inaccuracy of the technique, different attrition rates of different teeth within and between different populations of people, coupled with the increasing occurrence of multifactorial bruxing in contemporary man. All of these factors contributing to attrition make it difficult to determine if the attrition is a result of physiological wear or bruxing. There are also only a few population standards for estimation of age on the basis of dental attrition.

ACKNOWLEDGEMENTS

I wish to thank the Centre for Forensic Science, University of Western Australia for their support.

The review formed part of a Postgraduate Diploma in Forensic Science. I would also like to thank Dr Stephen Knott for his encouragement in the production of the article and Mrs Jan Wood for her assistance.

REFERENCES

1. Bhasker SN, ed. Orban's oral histology and embryology.Saint Louis:CV Mosby Company, 1976:373.

2. Kreitner KF, Schweden FJ, Riepert T, Nafe B,Thelen M. Bone age determination based on the study of the medial extremity of the clavicle. Eur Radiol 1998;8:1116-22.

3. Ubelaker D. Human skeletal remains.Washington: Smithsonian Institute, 1989:63-95.

4. Gustafson G. Age determinations on teeth. J Am Dent Assoc 1950; 41:45-54.

5. Miles AE. The dentition in the assessment of individual age in skeletal material. In: Brothwell DR. Ed. Dental Anthropology. Oxford: Pergamon Press, 1963:191-209.

6. Murphy T. Gradients of dentine exposure in human molar tooth attrition. Am J Phys Anthropol 1959;17:179-86.

7. Molnar S. Human tooth wear, tooth function and cultural variability. Am J Phys Anthropol 1971;34:175-90.

8. Scott EC. Dental wear scoring technique. Am J Phys Anthropol 1979;35:213-8.

9. Dahl BL, Olio G, Andersen A, Bruaset O. The suitability of a new index for the evaluation of dental wear. Acta Odontol Scand 1989; 47:205-10.

10. Li C, Ji G. Age estimation from the permanent molar in northeast China by the method of average stage attrition. Forensic Sci Int 1995;75:189-96.

11. McKee JK, Molnar S. Measurements of tooth wear among Australian Aborigines: Intrapopulational variation in patterns of dental attrition. Am J Phys Anthropol 1988;76:125-36.

12. Maples WR, Rice PM. Some difficulties in the Gustafson dental age estimation. J Forensic Sci 1979;24:168-72.

13. Cross JF, Kerr NW, Bruce MF. An evaluation of Scott's method for scoring dental wear. In: Cruwys E, Foley RA. Eds.Teeth and anthropology. Oxford: BAR International Series 291, 1986:101-9.

14. Metzger Z, Buchner A, Gorsky M. Gustafson's method for age determination from teeth - a modification for the use of dentists in identification teams. J Forensic Sci 1980;25:742-9.

15. Dahl B, Olio G. Wear of teeth and restorative materials. In: Owall B, Kayser A, Carlsson G.Eds. Prosthodontics. Principles and management strategies. Baltimore: Mosby-Wolfe,1996:187-200.

16. Lamendin H, Humbert JF, Baccino E, Tavernier JC, Nossintchouk RM, Zerilli A. A simple technique for age estimation in adult corpses: the two criteria dental method. J Forensic Sci 1992;37:1376-9.

17. Maples WR. An improved technique using dental histology for estimation of adult age. J Forensic Sci 1978;23:764-70.

18. Bang G, Ramm E. Determination of age in humans from root dentin transparency. Acta Odontol Scand 1970;28:3-35.

19. Lopez-Nicolas M, Morales A, Luna A. Application of dimorphism in teeth to age calculation. J Forensic Odontostomatol 1996;14:10-3.

20. Amariti ML, Restori M, De Ferrari F, Paganelli C, Legnani G. A histological procedure to determine dental age. J Forensic Odontostomatol 2000;18:1-5.

21. Lopez-Nicolas M, Luna A. Application of automatic image analysis (IBAS system) to age calculation. Efficiency in the analysis of several teeth from a single subject. Forensic Sci Int 1991;50:195-202.

22. Xiaohu X, Jiazhen Z, Philipsen HP, Pang KM. Age estimation by Chinese permanent teeth with image analysis. Med Sci Law 1994;34:284-8.

23. Rogers, S. Personal identification from human remains. Springfield:Charles C Thomas, 1987.

24. Kvaal SI, Kolltveit KM, Thomsen IO, Solheim T. Age estimation of adults from dental radiographs. Sigrid Kvaal. Age related changes. Thesis. 1995:Paper VII Department of Oral Pathology and Section for Forensic Odontology, Dental Faculty, University of Oslo, Norway.

25. Solheim T. Dental attrition as an indicator of age. Gerodontics 1988:4;299-304.

26. Solheim T. A new method for dental age estimation in adults. Forensic Sci Int 1993;59:137-47.

27. Lovejoy CO. Dental wear in the Libben population; its functional pattern and role in determination of adult skeletal age at death. Am J Phys Anthropol 1985; 68;47-56.

28. Hongwie S, Jingtao J. The estimation of tooth age from attrition of the occlusal surface. Med Sci Law 1989; 29:69-73.

29. Thomas CJ, Nortjé CJ, van Rensburg BGJ, van Wyk CW. Age determination in a living individual – a case report. J Forensic Odontostomatol 1987;5:59-66.

30. Sengupta A, Whittaker DK, Barber G, Rogers J, Musgrave JH. The effects of dental wear on third molar eruption and on the curve of Spee in human archeological dentitions. Arch Oral Biol 1999;.44:925-34.

31. Lavelle CL. Analysis of attrition in adult human molars. J Dent Res 1970;49:822-8.

32. Pavone BW. Bruxism and its effect on the natural teeth. J Prosthet Dent 1985;58:692-6.

33. Xhong FA. Bruxism and its effect on the teeth. J Oral Rehabil 1977;4:65-76.

34. Olio G, Hatle G, Gad A-L, Dahl BL. Wear of teeth in a mentally retarded population. J Oral Rehabil 1990;17;173-7.

35. Sherfudhin H, Adbullah A, Shaik H, Johansson A. Some aspects of dental health in young adult Indian vegetarians. Acta Odontol Scand 1996; 54:44-8.

36. Adbullah A, Sherfudhin H, Omar R, Johansson A. Prevalence of occlusal tooth wear and its relationship to lateral and protrusive contact schemes in a young adult Indian population. Acta Odontol Scand 1994;52:191-7.

37. Ingle J, Bakland L. Endodontics. 4th edn. Baltimore: Williams and Wilkins,1994:879.

38. Kolltveit KM, Solheim T, Kvaal SI. Comparison between image analysis and manual measurements. Forensic Sci Int 1998;94:87-95.

39. Williams DR, Woodhead CM. Attrition - a contemporary dental viewpoint. In: Cruwys E, Foley RA. Eds. Teeth and Anthropology. Oxford: BAR International Series 291, 1986:109- 21.

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