

# Chewing the very teeth because it bites: An anthropological forensics by stable isotope profiling



Dental anthropology is a vital part of bioarchaeology, which covers a range of topics germane to the study of human and other primate teeth. The "Forensic" aspect is prefixed when this application is presented as part of legal evidence and addresses questions of interest to the legal system. Teeth, due to their durability, are often the only remaining traces of humans and animals from the past. The information that teeth can offer greatly increases our knowledge about people and society from ancient times. A major development in forensic science is isotope analysis, where stable isotopes within a biological specimen can be identified and from which can be drawn direct inferences regarding diet, trophic level and subsistence. Stable isotopes in the environment generally get incorporated into the teeth as the animal feeds. When deoxyribonucleic acid (DNA) methods fail to yield the identification of an individual, or where authorities need to determine the recent geographical life history of people, the application of stable isotope profiling (SIP)<sup>[1]</sup> may be prudent.

Isotope ratios can be measured from mineralized dental tissues recovered from archaeological sites using mass spectrometry, which separates the different isotopes of an element on the basis of their mass-to-charge ratio. Exploiting the link between the isotopic signal of dietary components and the isotopic composition of the body tissue, a non-invasive method of analyzing human material such as teeth, scalp hair, and fingernails could be explored to acquire a fair degree of natural variability in these profiles. It is, however, important to note that the precise picture of palaeodiets gained from isotope analysis is possible only by being able to compensate for changes that occur following burial (diagenesis). Due to its increased porosity, diagenesis affects bone more severely than enamel or dentine.

Carbon and nitrogen isotopes are used to reconstruct diet, while oxygen and strontium isotopes are used to determine geographic origin. Strontium and lead isotopes in teeth and bone can also be used to reconstruct migration in human populations and cultural affinity.<sup>[2]</sup> The stable isotopes of carbon (C), <sup>12</sup>C and <sup>13</sup>C get incorporated into plants during photosynthesis. Consumption of these by animals will result in the integration of carbon isotopes in both the organic (collagen) and inorganic components (hydroxyapatite crystallites) of the mineralized tissues. Analyzing the ratios of <sup>12</sup>C and <sup>13</sup>C in a sample of collagen from the bone or dentine, or from the carbonate in the mineral phase, provides information concerning the herbivorous nature of the diet and whether the diet was predominantly composed of C3 or C4 plants. However, it is also important for the researcher to know the variations of isotopes within individuals, between individuals, and over a period of time.<sup>[3]</sup> Similarly, the ratios of two stable nitrogen (N) isotopes <sup>15</sup>N and <sup>14</sup>N in the collagen of bone and dentine can also be utilized to reveal dietary information. In general, one can say that, in humans, <sup>15</sup>N values of structural proteins such as bone and dentine collagen or hair keratin reflect the relative level of meat protein in our diet. A decrease in <sup>15</sup>N value based on stable isotope analysis of teeth taken from a victim's body categorizes the individual as a primary consumer (and more likely a vegan). Also, the use of stable isotopes, and in particular <sup>15</sup>N values, determines to some extent when the weaning has occurred, as children being breast fed have <sup>15</sup>N values approximately three parts per million higher than their mothers.<sup>[4]</sup> Tooth dentine laid down in the infant tooth during breast-feeding, will retain an enriched <sup>15</sup>N value throughout the individual's life since it does not readily turn over.

Oxygen exists as three naturally occurring isotopes, <sup>16</sup>O, <sup>17</sup>O, and <sup>18</sup>O. In isotopic analysis, the absolute abundance of isotopic oxygen is not considered. Rather, the ratio of <sup>18</sup>O to <sup>16</sup>O in the sample is compared to the standard ratio. The stable isotope signatures of teeth, bone, and hair are well-established proxies of climate and water source and are therefore considered as indicators of geographic life trajectories of animals and humans.<sup>[5]</sup> Isotopic oxygen is incorporated into the body primarily through ingestion at which point it is used in the formation of bones and teeth. <sup>16</sup>O and <sup>18</sup>O, which are incorporated into the hydroxyapatite crystals of mineralized structure, are derived from drinking

## Access this article online

Website:  
www.jfds.org

DOI:  
10.4103/0975-1475.85279

## Quick Response Code



water. Crystallites from enamel, being the most stable, would give precise information about the environment during the period of crown formation in teeth. A comparison between the isotopes values from different teeth formed at different times during the life of the same individual would also indicate any migration to areas with different isotope values. Since teeth are not subject to continual remodeling, their isotopic oxygen ratios remain constant from the time of formation.<sup>[5]</sup>

As for strontium (Sr), the two stable isotopes of strontium used in such studies are <sup>87</sup>strontium and <sup>86</sup>strontium. Sr readily substitutes for calcium in the inorganic hydroxyapatite crystallites and can attain relatively high concentrations. <sup>87</sup>Sr: <sup>86</sup>Sr ratios provide a unique "fingerprint" to the geology of an area. The Sr isotope composition measured in skeletal elements (e.g., bone, teeth, or antlers) can be used to infer the geographic region that an animal or human inhabited, because different regions tend to have distinct Sr isotope composition, and natural variations in the relative abundance of Sr isotopes are not changed as Sr is processed through the food chain. Therefore, an organism that ingests Sr from one region can have Sr isotope composition that is different from that of an organism that ingests Sr from another region. The Sr isotope composition measured in human teeth will reflect the average Sr isotope composition that was ingested as a child, due to the immobile nature of Sr and Ca in teeth after formation, whereas the Sr isotope composition of bone will reflect the average isotopic composition over the last 10 years of life, due to continuous biological processing of Sr and Ca in bone. Inferring the average isotopic composition of dietary Sr is best done by analyzing skeletal fragments from control groups, which might be animals that have the same feeding habits as the animal in question, or, in the case of humans, analysis of close family relatives. In cases where it is not possible to construct an Sr isotope database from control groups, it becomes necessary to estimate the isotopic composition of dietary Sr based on geologic principles.<sup>[6]</sup>

Lead (Pb) isotopic analyses have proved to be a very efficient tool for tracing the sources of local and global Pb pollution. The relative amounts of lead isotopes <sup>206</sup>Pb, <sup>207</sup>Pb, and <sup>208</sup>Pb in different geographic regions can differ from 17% to 36%. The sources and intensity of lead exposure in utero and in early childhood has been determined using stable lead isotopic ratios and lead concentrations of incisal and cervical sections of deciduous teeth from exposed and non-exposed children. Incisal sections, consisting mostly of enamel, generally have low amounts of lead and isotopic compositions consistent with those expected in the mother during pregnancy. Cervical sections, consisting mostly of dentine with secondary dentine removed by resorption and reaming, generally have higher amounts of lead than the enamel and isotopic compositions consistent with the source of postnatal exposure. Based on changes in the isotopic composition of enamel and dentine,

it is provisionally estimated that lead is added to dentine at a rate of approximately 2-3% per year.<sup>[7]</sup>

In conclusion, three kinds of applications are made possible through these natural isotopic signatures: determination of subsistence strategies in ancient human populations, determination of the diet of extinct species and the analysis of past environmental changes. Stable isotope analysis of biogenic tissues such as tooth enamel and bone mineral has become a well-recognized and increasingly important method for determining the provenance of human remains, and it has been used successfully in bio-archaeological studies as well as forensic investigations. This brief introduction to what teeth can tell us may provide clues and address numerous issues archaeologists and historians are concerned with, including diet changes, general stress, how closely the groups were related and thereby serve as markers of social identity.

From the above account, it can be seen that analysis of mineralized tissues supports the contention that you are what you eat and you were what you ate.<sup>[8]</sup> So in the end, the question is – as dentists can we handle teeth or do we chew the very teeth because it bites.

**Raghu Radhakrishnan**

*Department of Oral Pathology,  
Manipal University, Manipal, Karnataka, India  
E-mail: raghu.radhakrishnan@gmail.com*

## References

1. Benson S, Lennard C, Maynard P, Roux C. Forensic applications of isotope ratio mass spectrometry - A review. *Forensic Sci Int* 2006;157:1-22.
2. Meier-Augenstein W. *Stable Isotope Forensics: An Introduction to the Forensic Application of Stable Isotope Analysis*. New Jersey (United States): Wiley Blackwell; 2010; ISBN: 978-0-470-51705-5.
3. Alkass K, Buchholz BA, Druid H, Spalding KL. Analysis of <sup>14</sup>C and <sup>13</sup>C in teeth provides precise birth dating and clues to geographical origin. *Forensic Sci Int* 2011;209:34-41.
4. Fogel ML, Tuross N, Owsley D. Nitrogen isotope tracers of human lactation in modern and archaeological populations. Annual report of the Director, Geophysical Laboratory. Washington, DC: Carnegie Institution of Washington; 1988-89. p. 111-6.
5. Fraser I, Meier-Augenstein W, Kalin RM. The role of stable isotopes in human identification: A longitudinal study into the variability of isotopic signals in human hair and nails. *Rapid Commun Mass Spectrom* 2006;20:1109-16.
6. Beard BL, Johnson CM. Strontium isotope composition of skeletal material can determine the birthplace and geographic mobility of humans and animals. *J Forensic Sci* 2000;45:1049-61.
7. Gulson BL. Tooth analyses of sources and intensity of lead exposure in children. *Environ Health Perspect* 1996;104:306-12.
8. Berkovitz BK, Holland GR, Moxham BJ. *Oral Anatomy, Histology and Embryology*. 4<sup>th</sup> ed. Amsterdam: Elsevier Ltd; 2009. p. 382.

**How to cite this article:** Radhakrishnan R. Chewing the very teeth because it bites: An anthropological forensics by stable isotope profiling. *J Forensic Dent Sci* 2011;3:1-2.