F44 Carbon Isotope Analysis of Dental Enamel Provides Precise Birth Dating and Clues to Geographical Origin

Bruce A. Buchholz, PhD, Lawrence Livermore National Laboratory, Center for Accelerator Mass Spectrometry, Mail Stop L-397, 7000 East Avenue, Livermore, CA 94550; Kanar Alkass, BSc, and Henrik Druid, MD, PhD, Deptartment of Forensic Medicine, Karolinska Institutet, Retzius v. 3, Stockholm, SE-171 77, SWEDEN; and Kirsty L. Spalding, PhD, Department of Cell and Molecular Biology, Medical Nobel Institute, Karolinska Institutet, Stockholm, 17177, SWEDEN*

After attending this presentation, attendees will understand how dental enamel produced in the past 55 years can be dated using the radiocarbon bomb-pulse. Attendees will also learn how the carbon-14 (14C) content of dental enamel can be used to determine year of birth of persons born after 1942.

The presentation will impact the forensic science community by showing how isotopic carbon analysis of enamel offers a precise age determination with geographic information that can be applied in forensic casework, particularly to assist in investigations of unidentified human cadavers.

Determining the age of an individual is an important step in identification and a common challenge in forensic medicine. Age determination can be performed with high precision up to adolescence by analysis of dentition, but establishing the age of adults has remained difficult. The enamel of individual permanent teeth is formed at distinct, well-characterized time points during childhood. After formation there is no turnover of enamel, and its ^{14}C concentration reflects the level in the food at the time of enamel formation. Atmospheric testing of nuclear weapons doubled the global $^{14}CO_2$ level between 1950 and 1963. After cessation of atmospheric tests in 1963, the level of atmospheric $^{14}CO_2$ started to decrease exponentially with a mean life of about 16 years due to transport into large carbon reservoirs such as the oceans. The enhanced level of ^{14}C worked its way up the food chain from CO_2 so that all living things are labeled with the pulse.

The concentration of ^{14}C in tooth enamel was measured of 95 teeth from 84 individuals from around the globe and related it to the known concentration in the atmosphere from 1955 to present to establish the time of tooth formation. The use of the stable isotope ^{13}C was investigated and used as an indicator of geographical origin of the individual. Using established ages of tooth formation, the dates were then used to estimate the year of birth of the person. The crown of the tooth was cut away from the root at the level of the cervical line. The crown was then immersed in 10N NaOH, and placed in a water-bath sonicator. The enamel was then washed with DDH_2O and re-submersed in 10N NaOH every 24 hrs for 3-5 days until only enamel remains. Samples were rinsed with DDH_2O and shipped overnight for isotope analysis. Upon arrival enamel samples were pretreated in 1.0N HCl for 1 h, rinsed 3 times with DDH_2O and placed on a heating block at 95°C to dry overnight. Enamel splits were hydrolyzed to CO_2 in individual reaction chambers, evacuated, heated and acidified with orthophosphoric acid at 90°C. The evolved CO_2 was purified, trapped, and reduced to graphite in the presence of iron catalyst in individual reactors. Graphite targets were measured for ^{14}C content by accelerator mass spectrometry (AMS).

The technique of analysis of ^{14}C content in enamel matched known age during the rising part of the pulse (1955-1963, N=12) and after the peak (post 1963, N=66) with average absolute errors of 1.9 ± 1.4 and 1.3 ± 1.0 years, respectively. Geographical location had no effect on the precision of ^{14}C enamel birth dating. Much of the variability can be attributed to inter-individual differences in tooth formation and possible variations in carbon food sources at the time of enamel formation. Enamel formed prior to 1955 contained no ^{14}C elevation above atmosphere at the time in 16 of 17 cases. Analyzing multiple teeth with different formation ages from a single individual can place date of birth on the ascending or descending side of the anthropogenic ^{14}C spike and improve the temporal precision. In 46 teeth, measurement of ^{13}C was also performed. Scandinavian teeth showed a substantially greater depression in average $\delta^{13}C$ (-14.8) than teeth from subjects raised in Japan (-13.5), Middle East and North Africa (-12.7) and South America (-10.9). The differences in $\delta^{13}C$ are due to differences in plants and diets in the different regions and thus can provide important information about the geographical origin of an individual.

Isotopic carbon analysis of enamel offers a precise age determination with geographic information that can be applied in forensic casework, particularly to assist in investigations of unidentified human cadavers.

Date of Birth, ^{14}C Bomb Pulse, ^{13}C

 ** Presenting Author*