Morphological and Metric Description of a Rare Mesolithic Deciduous Tooth from Trail Creek Caves, Alaska

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ABSTRACT A human deciduous maxillary central incisor from Trail Creek Caves, Seward Peninsula, Alaska, is described. The tooth from ancient Beringia is radiocarbon dating to 8085 ±40 BP. The tooth is compared to the incisors from the deciduous dentition of USR1 from the Upward Sun River site in central Alaska dating to ca. 11,500 (cal) BP. Genetic analysis of the Trail Creek child and the USR1 child showed that they both belonged to an ancient eastern Beringian population that remained isolated in present-day Alaska during the late Pleistocene and early Holocene. The tooth was measured using a sliding calliper and the morphology of the tooth described directly from macroscopic evaluation as well as from a 3D surface scan. Based on tooth development, the age of the Trail Creek child corresponds to an age of 1-1.5 years. The sex of the child is determined as female from the genetic analysis. The tooth was expected to show the characteristic shovel-shape of Native Americans but was without marked shovel-shape. The variability of shovel-shape in maxillary deciduous and permanent incisors is discussed and it is suggested that the trait shovel-shape in a deciduous dentition is more reliably recorded on the maxillary lateral incisors than the central incisors.

This is a morphological and metric description of a deciduous maxillary central incisor excavated from the archaeological site Trail Creek Cave 2 on the Seward Peninsula in western Alaska by Helge Larsen in 1949 and 1950 (Larsen, 1968). The tooth stored at the National Museum in Copenhagen was the only human skeletal remain among thousands of animal bones retrieved from excavation (Pasda, 2012). Pasda (2012) identified the tooth as a left I^1 (upper left permanent central incisor), instead of a left i^1 (upper left deciduous central incisor) and described it as a slightly worn tooth with the root not fully formed. The tooth derives from Cave 2, Section 4m, Layer III. The deciduous tooth is radiocarbon dated to 8085 ±40 BP, hence from early Holocene (Moreno-Mayar et al., 2018). The morphological examination was requested by the Centre for GeoGenetics in Copenhagen, Denmark prior to the destructive genetic analysis. Images of the tooth were provided before the root was cut for radiocarbon dating (Figure 1a and 1b). Additionally, a 3D surface scan was provided of the crown which could be digitally rotated and from where images could be extracted with different views of the tooth.

Within dental anthropology, tooth morphology can be related to regional populations (Hanihara, 1967; Scott and Turner, 1997). This applies to the deciduous as well as the permanent dentition. Most researchers today favour the hypothesis that Upper Palaeolithic populations of hunter-gatherer reached northeast Asia 30,000+ years before the last glacial maximum (LGM) (Pitulko et al., 2004). During the LGM the landmass between Asia and North America called Beringia became a refugium

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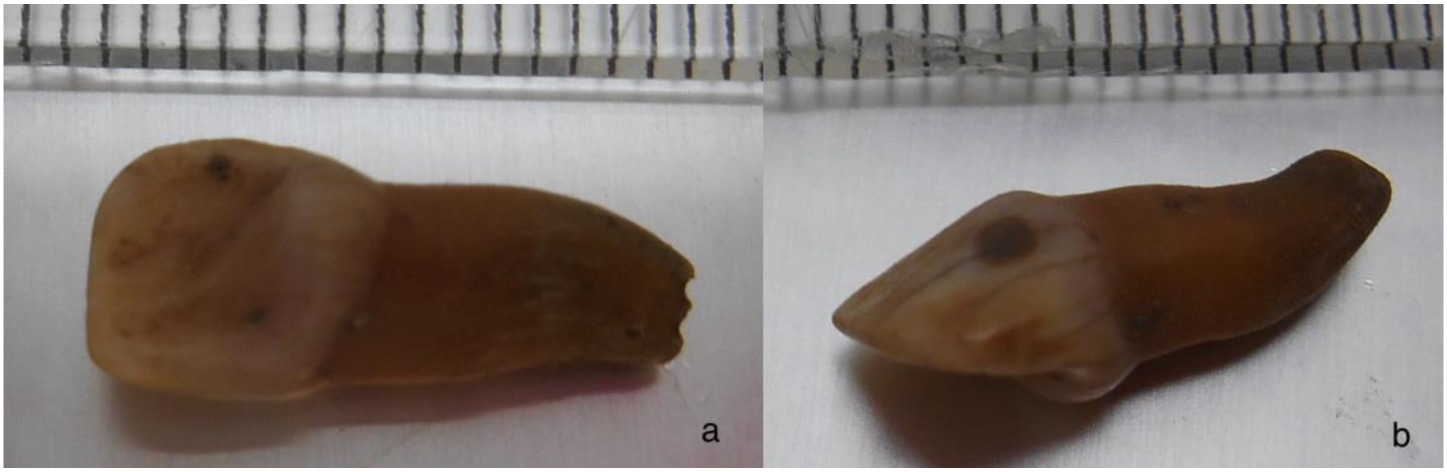

Figure 1. Images provided prior to this examination. 1a is the lingual surface seen from the mesial side. 1b is the facial surface seen from the distal side. Scale bars represent millimetres.

for Northeast Asian groups of hunters (ca. 20.000 – 15 thousand years ago). At the end of the LGM the hunters migrated along the coast and along land corridors into North America (Scott et al., 2016). These prehistoric Native Americans had their dentitions described by Turner (1983). He observed three fairly clear geographic clusters: 'Alaska interior-Northwest Coast mainly Na-Dene-speaking Indians; Arctic coast (Aleut-Eskimo) and all the rest of North and South America (Indian)'. All three clusters had a Sinodont dental pattern in their permanent dentitions. The anterior teeth in such a dental pattern have a high frequency of shovel-shape. It is the purpose of this examination to study the morphology of the Trail Creek incisor and compare with anterior teeth from another and more ancient Alaskan child (USR1, dated ca. 11,500 cal. years BP) (Potter et al., 2014). The hypothesis was that the Trail Creek tooth would show a Sinodont morphology, like USR 1 and other Native Americans. The genomes of the children from the Trail Creek and USR1 sites have been analysed by geneticists and the results are included in recent literature on the First Americans (Moreno-Mayar et al., 2018; Hoffecker et al., 2020, 2021).

Genetic analysis

The genetic analysis revealed the Trail Creek individual as female. Sequencing of ancient DNA recovered from the Trail Creek specimen was expanded to ~0.4× genomic depth of coverage, using Illumina high-throughput sequencing. The results of the genomic analyses were previously described in detail (Moreno-Mayar et al., 2018). In brief, initial multidimensional scaling analysis indicated genomic affinity between Trail Creek and another contemporaneous specimen (USR1) from the same region and showed similar proportions of Siberian and Native American genomic components. The mtDNA haplotype belonged to B2 (shared with USR2 -a low-coverage genome of a close relative to USR1), although different from the derived B2 variant found throughout other parts of the American continents (Moreno-Mayar et al., 2018). Furthermore, f3-statistical analysis suggested that Trail Creek (like USR1) are similarly related to other Native Americans. Finally, D-statistics and admixture graph-fitting, using qpGraph, supported a model in which the Trail Creek genome form a clade with USR1 to the exclusion of other known North- and South- Native Americans. The collective genetic evidence from Trail Creek and USR1, which also showed similar archaeological artefacts, support that the Trail Creek tooth came from an individual that belonged to an ancient metapopulation present in eastern Beringia. This population who remained isolated in present-day Alaska during the late Pleistocene and early Holocene were equally related to North- and South- Native American populations (Moreno-Mayar et al., 2018).

Age assessment of the child

The incisal edge of the crown was slightly worn, and the root formation not completed. From inspection of the provided photos (see Figure 1a and 1b) the root length was estimated to be 2/3 to 3/4 completed. The apical opening was wide and the root walls very thin (Stage F according to Liversidge and Molleson, 2004). The development of the tooth corresponds to an age of 1-1.5 years (AlQahtani et al., 2010, Figure 6, Liversidge and Molleson, 2004, Table 2).

Overall description of the Trail Creek tooth
The facial surface of the crown was flat without double-shovel and almost square with a mesiodistal breadth of 6.7 mm and a crown height of 6.6 mm (Figure 2a). The apical part of the root was bent in a facial direction as expected from deciduous maxillary incisors (see Figure 1b). The lingual surface of the crown had weakly developed marginal ridges on each side of a very shallow central fossa (Figure 2b). This corresponds to trace of shoveling in the terminology of Hanihara (1967) or Sciulli (1998). Of the two marginal ridges, the distal ridge is more distinct. The basal cingulum occupied the gingival half of the lingual surface. From this bulging eminence, there was an extension in the direction of the incisal edge (Figure 3a and 3b). This was observed on the scan, while it was indistinct from visual

Figure 2. The tooth at the time of examination. Figure 2a is the facial surface with the mesial edge to the left. Figure 2b is the lingual surface with the distal edge to the left. Scale bar represents millimetres.

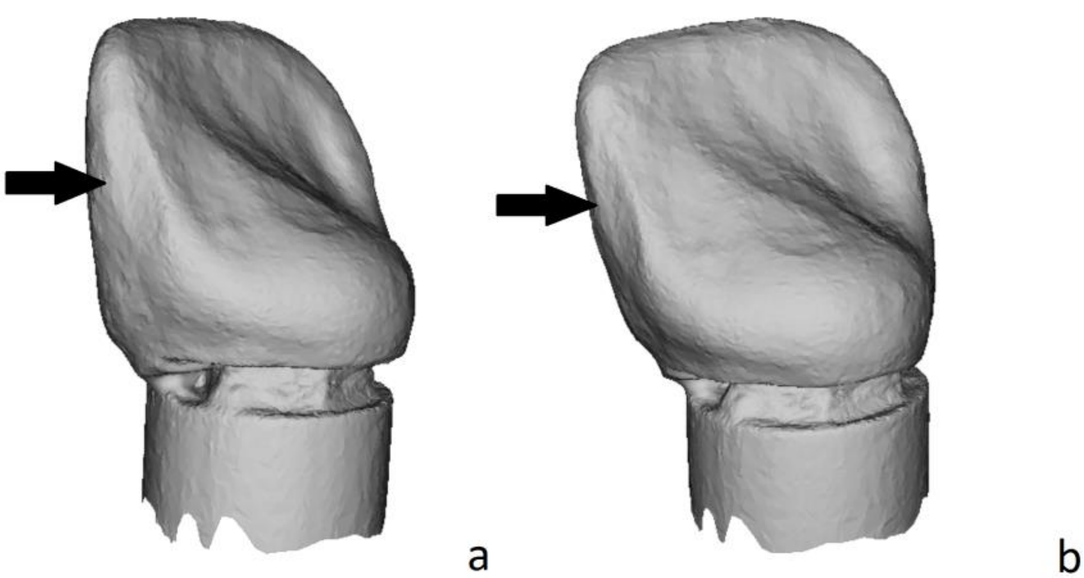

Figure 3. Scanning images of the deciduous central incisor crown showing the attritional facet (arrows). 3a is seen from the mesial side. 3b is seen from the lingual surface. 3D scanning was after the root was removed for radiocarbon dating, so tooth crown was mounted on a stance.

inspection or from the photograph (see Figure 2b). In Table 1, the results are presented with use of the terminology described by (Sciulli, 1998).

The 3-dimensional digital model created by surface scanning using a Trio scanner (3shape, Copenhagen) deserves further comment. The scanning images illustrated a small attritional facet visible on the mesial surface of the crown, caused by friction between the two central incisors (see Figure 3a and 3b). Hence the tooth had been erupted and in use for some time. The scanning images showed no visible microwear.

The mesial attritional facet visible on the scanning images was not apparent on the tooth when viewed directly. This imaging method was therefore a valuable addition to the macroscopic examination of the tooth. The facet was formed during a very short functional period from the eruption of the central incisors at circa 10 months of age to the death of the child at about 18 months of age (see above). It is important to note that enamel of deciduous teeth is not fully mineralized at the time of eruption (Nanci, 2013; Harris and Lease, 2005).

A larger brown discoloured spot was observed on the facial surface of the crown (see Figure 2a) and a minor spot on the lingual surface (see Figure 2b). These extrinsic discolorations are most likely due to absorption of pigment particles from the soil. The *post-mortem* cracks in the enamel are likewise stained by unknown material (see Figure 2a).

Comparative material from Alaska

For comparison with the Trail Creek tooth, it is relevant to mention the complete deciduous dentition of the young child from an Upward Sun River site (USR1) in central Alaska, reported in the paper by Potter et al. (2014). The nonmetric crown traits of the teeth belonging to USR1 were compared to a pooled prehistoric sample of Ohio Native Americans studied by Sciulli (1998) (see Table 1). The maxillary central incisors of USR1 showed only a trace of shoveling. The upper lateral incisors and the lower lateral incisors showed a higher grade of the trait shovel- shape than the upper central incisor and it was concluded that USR1 was a Native American child with a Sinodont-like deciduous dentition.

Discussion of shovel-shape in the deciduous dentition

Shovel-shape in the deciduous dentition was first classified by Hanihara (1963) and later followed up by Sciulli (1998) with the following definitions: 0: no shovel-shape, lingual surface smooth, 1: semi shovel-shape, slight elevation of marginal ridges, 2: shovel, marginal ridges easily seen, and 3: strong or marked shovel when marginal ridges are broad and high. A shovel-shaped incisor means grade 2 or 3 to most researchers. In Europeans and Western Eurasians, the maxillary incisors are usually without shovel-shape in

Table 1. Nonmetric crown traits for deciduous upper central incisors

	Comparative sample			Individual USR1*		Trail Creek	
Trait	**N**	**Break-points****	**%****	**Status**	**Grade**	**Status**	**Grade**
Shovel	163	2-3/0-3	77.3	Absent	1	Absent	1
Double Shovel	157	1-3/0-3	20.4	Absent	0	Absent	0
Interruption groove	161	1-4/0-4	0.0	Absent	0	Absent	0
Tuberculum dentale	155	1-4/0-4	11.6	Present?	1?	Absent	0

*Values for USR1 are from Potter et al., 2014.

** Comparative sample of 370 individuals from 26 prehistoric Ohio Valley populations (ca. 3000-350 BP), Sciulli, 1998.

grade 2 and 3 while it is common in East Asian populations and Native Americans and Inuit (Table 2).

Shovel-shape of maxillary incisors is often more distinct on the lateral than the central incisors in the same dentition (Sciulli, 1998). Lukacs and Kuswandari (2013) therefore recorded shovel-shape on maxillary lateral incisors in their study of Malayan children. In the permanent dentition shovel-shape is more common than in the deciduous dentition (Table 3). It does not follow from the lack of marked shovel-shape in the Trail Creek central incisor that shovel-shape also was missing on the upper lateral incisors.

The strength of correlation between deciduous and permanent incisors in the same individual has been studied by Saunders and Mayhall (1982). They studied individuals of European ancestry with a low frequency of marked shovel-shape. They found that absence or trace shoveling in the deciduous dentition also meant absence in the permanent successor but occasionally was absent followed by some degree of shovel in the permanent dentition (Table 4). Edgar and Lease (2007) likewise studied European Americans as children and adults. Hanihara´s and Sciulli´s descriptions were used for their recordings of deciduous teeth while the ASU dental anthropology system was used for the permanent teeth (Scott and Irish, 2017). Edgar and Lease (2007) expected high correlation between the two dentitions, but their null hy-

Table 2. Population frequencies for shovel-shape of deciduous maxillary central incisors

Population	N	Grade 0 and 1 (%)	Grade 2 and 3 (%)	Reference
Eskimo	16	50.0	50.0	Hanihara, 1966
Pima Indian	78	38.4	61.5	Hanihara, 1966
Pima Indian	53	49.1	50.9	Tocheri, 2002
Amerindian, Ohio	163	22.7	77.3	Sciulli, 1998
Japanese (Wajin)	124	23.4	76.6	Hanihara, 1963
Prehistoric Jomon	24	62.5	37.5	Kitagawa et al., 1995
Ainu	4	50.0	50.0	Kitagawa et al., 1995
Malay	129	93.0	7.0	Lukacs and Kuswandari, 2013
Australian Ab.	38	23.7	76.3	Hanihara, 1963, 1965
Amer. W/Danish	19	84.2	15.8	Present authors (unpublished)
American white	20	100.0	0.0	Hanihara, 1966
Jats	68	95.6	4.4	Kaul and Prakash, 1981
Inamgoan, Chalchol.	39	84.6	15.4	Lukacs and Walimbe, 1984

Grade 0 and 1: includes no shovel-shape and semi-shovel 1; Grade 2 and 3: marked shovel-shape. Grade 3 is rarely observed according to Hanihara (1963), who only found it in few American Indians. Lukacs and Kuswandari (2013) and Kitagawa et al. (1995), likewise observed no children with shovel grade 3, only with grade 2. The authors acknowledge that some of the terminology within this paper is no longer acceptable, but references as the originally presented to avoid confusion within the literature.

Table 3. Frequencies of the various expressions of shovel-shape in deciduous and permanent incisors

	Permanent I1 absent	Permanent I1 trace	Permanent I1 Semi-shovel	Permanent I1 Shovel-shaped
Deciduous i1 absent	76.6%	16.9%	1.5%	0.5%
Deciduous i1 trace	2.5%	2.5%	1.5%	0.0%

From Saunders and Mayhall (1982), Table 1, p.46, based on 650 children from Burlington, Canada. Ninety percent of all parents of these children had their ancestry traced to the British Isles or Continental Europe; the remainder was also of Caucasoid origin. The figures add up to 100% di1.

Table 4. Frequency distributions of shovel-shape in deciduous and permanent dentitions

Population	Permanent (I1and I2) % (N)	Deciduous (di1) % (N)
Eskimo	100.0 (21)	50.0 (16)
Pima Indian	99.1 (222)	61.6 (78)
Japanese Ainu	81.4 (97)	50.0 (4)
American whites	27.7 (83)	0.0 (20)

From Hanihara et al. (1975), Tables 3.5-1 and 2, page 258. Shovel-shape grade 2+3.

pothesis was nevertheless that there is not a strong significant correlation between trait expression in the deciduous and permanent teeth. Their results showed that correlations for maxillary incisors were non-significant supporting Saunders and Mayhalls (1982) results and the null hypothesis was likewise supported for all other types of incisors with one exception. Surprisingly the correlation for mandibular second incisor shoveling was significant, negating the null hypothesis. There is, however, a need for similar studies in populations with high frequency of shovel-shape where a higher inter-dentition correlation for shovel-shape possibly can be observed.

Tooth size

The mesiodistal and buccolingual crown diameters of the Trail Creek incisor were measured and compared to results from studies of archaeological skeletal material and plaster casts from modern living children. The tooth was measured with a Mitotoyo sliding calliper to an accuracy of 0.1 mm. Mesiodistal measurements can be made with the same precision near the incisal edges on actual teeth and casts. However, measurements of the buccolingual diameters require the basal cingulum to be fully exposed. This is the case for teeth in skeletal material or isolated teeth. In casts with teeth *in situ*, made from living individuals, the basal cingulum of the central deciduous incisor can be partly covered by gingiva. A minor unknown error in buccolingual crown sizes measured on plaster casts compared to skeletal material is thereby a possibility.

In Table 5, the size of very few central decid-

Table 5. Tooth size of the deciduous maxillary central incisor in archaeological material

	Mesiodistal diameter			Buccolingual diameter			
Population	N	($\bar{x}$)	SD	N	($\bar{x}$)	SD	Reference
Mesolithic							
Trail Creek	1	6.7	N/A	1	5.6	N/A	Present study
Mehrgahr 3 (Preceramic, <8000 BP)	8	7.1	0.43	9	5.58	0.2	Lukacs and Hemphill, 1991
Vedbæk (Denmark, 7500-7300 BP)	1	7.1	N/A	1	5.3	N/A	Alexandersen, 1976
Western Europe (Arene Candide, Ofnet, Muge, Hohlenstein, 8-5000 BP)	7	7.2	0.46	7	5.3	0.34	Frayer, 1978
Neolithic							
Mehrgahr 2 (Chalcolithic, 6500 BP)	4	6.83	0.39	4	5.38	0.46	Lukacs and Hemphill, 1991
Tell Leilan, Syria (4300-4200 BP, Bronze Age)	2	6.75	N/A	2	5.25	N/A	Haddow and Lovell, 2003
Ohio Indians (ca. 3000 BP)	24	6.5	0.41	24	4.8	0.33	Sciulli, 1990

uous incisors known from Mesolithic and Neolithic archaeological sites in Europe, Syria and Pakistan are presented. The Mesolithic period is here considered to begin after the Ice Age at about 11,500 BP, thus including the tooth from Trail Creek. The mesiodistal diameter of the tooth from Trail Creek is close to 1 standard deviation (SD) below the mean value for the two small Mesolithic samples while it is comparable to the few Neolithic Near East incisors. The buccolingual diameter of the Trail Creek tooth is within 1 SD of the mean values for the comparative Mesolithic samples.

The diachronic change in tooth size is very small, if existing at all, in the deciduous dentition as seen from Table 5. The archaic Native Americans from the Ohio Valley had smaller central deciduous incisors than the Trail Creek tooth, but the recent Pima Indians from Southern Arizona and the Asiatic Japanese and Taiwanese children had matching mesiodistal diameters although smaller buccolingual diameters. Recent Europeans have mesiodistal diameters comparable to the Alaskan tooth, but again smaller buccolingual diameters.

Table 6 show sizes of modern populations where sex is known, hence data are sex specific. In modern populations the smallest deciduous incisors occur in Europeans. The Trail Creek incisor fits among the modern Asiatic and New World samples represented in Table 5.

Conclusions

This metric and morphological examination has documented a rare deciduous left central incisor from Trail Creek Cave 2, Alaska, dated to 8085+/-40 BP. The age of the child corresponds to an age of 1-1.5 years based on incomplete development of the root. The lingual surface of the crown showed only a trace of shovel-shape and a prominent basal cingulum. Comparison with the central incisor from the USR1 child (Potter et al., 2014) showed that this incisor (USR1) also had minimum trace of shovel-shape. Several anterior teeth were available from the USR1 child and the lateral maxillary and mandibular incisors in this dentition showed a higher grade of shovel -shape and was characterized as a Sinodont dentition belonging to a Native American child.

Review of the literature has shown that shovel-shape occurs with a lower frequency in deciduous than in permanent maxillary inci-

Table 6. Tooth size of the deciduous maxillary central incisor in modern samples

Population	Mesiodistal diameter			Buccolingual diameter			Reference
	N	($\bar{x}$)	SD	N	($\bar{x}$)	SD	
Pima Native Indians, boys	22	6.83	0.49	23	5.20	0.35	Alvrus, 2000
Pima Native Indians, girls	22	6.81	0.28	22	5.06	0.49	
Japanese, boys	42	6.87	0.46	N/A	N/A	N/A	Mizoguchi, 1998
Taiwanese, boys	60	6.77	0.38	60	4.89	0.22	Tsai, 2000
Taiwanese, girls	57	6.62	0.42	57	4.78	0.36	
American white, boys	90	6.46	0.39	N/A	N/A	N/A	Meredith and Knott, 1970
American white, girls	90	6.32	0.42	N/A	N/A	N/A	
American white, boys	25	6.50	0.29	23	5.20	0.25	Alexandersen, 1969
American white, girls	18	6.31	0.50	17	4.95	0.41	
Jordanians, boys	34	6.54	0.39	43	4.95	0.33	
Jordanians, girls	40	6.46	0.32	31	4.87	0.27	Hattab et al., 1999
Icelanders, boys	20	6.49	0.45	29	5.08	0.26	Axelsson and Kirveskari, 1984
Icelanders, girls	18	6.43	0.45	20	5.01	0.30	
Australians, boys	28	7.34	0.47	N/A	N/A	N/A	
Australians, girls	10	7.15	0.46	N/A	N/A	N/A	Brown et al., 1980

sors of the given population. The trait shovel-shape occurs with a higher frequency on lateral than central incisors in the deciduous dentitions. It is also pointed out that the degree of shovel-shape is not necessarily the same in both dentitions of a given individual. Lack of strong correlation has been established for European Americans but there is need for a similar study in individuals of Native American origin. The mesiodistal crown diameter of the Trail Creek tooth was of modern size. The buccolingual diameter was large as expected considering the prominent basal cingulum.

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