Patterns of Social Identity in Relation to Tooth Ablation Among Prehistoric Jomon Foragers from the Yoshigo Site, Aichi Prefecture, Japan

D. H. TEMPLE, S. KUSAKA AND P. W. SCIULLI

Abstract

This study documents and interprets patterns of identity in relation to tooth ablation patterns at Yoshigo, a Late to Final Jomon period (3500–2300 yBP) site. Two patterns of tooth ablation are observed among the Yoshigo people: both (2) mandibular canines or four (4) mandibular incisors were extracted during life and formed a basis for identity differentiation. Three hypotheses are tested regarding these groups: (1) tooth ablation groups will be unrelated to postmarital residence; (2) tooth ablation groups will be associated with age-based achievements; (3) tooth ablation groups will be associated with occupational specialisation. Biodistance, demographic and stable isotope analyses were performed on skeletal remains recovered from Yoshigo (3500–2300 BP) to test these hypotheses. Within-group variation expressed by cranial and dental measurements was not significantly different between tooth ablation groups. This indicates that tooth ablation practices were not related to migration. Previous biodistance findings do, however, suggest that tooth ablation groups represent closely related individuals, possibly kin-based networks. Demographic analysis of age-at-death and tooth ablation suggests that tooth ablation styles were achieved at different ages. Stable isotope analysis indicates that the tooth ablation groups consumed similar foods. Based on isotopic findings from other sites and archaeological evidence for food sharing among Jomon people, these results suggest that dietary variability between tooth ablation groups was homogenised by cooperative food sharing. The totality of these findings support the hypothesis that the identities associated with tooth ablation were unrelated to migratory patterns, and instead, possibly reflect kin-based social units, where achievement or age acted as a determinant of membership. Copyright © 2010 John Wiley & Sons, Ltd.

Key words: bioarchaeology; identity; migration; stable isotope analysis; mortuary analysis; hunter–gatherer

Introduction

This study documents and interprets patterns of identity in relation to ritual tooth ablation at Yoshigo, a Late to Final Jomon period (3500–2300 yBP) site located in Japan. Biodistance, demographic and stable isotope analyses of individuals with differing types of ritual tooth ablation are employed to achieve this goal. Identity is defined as an aspect of the self that defines how rights and duties of one person distribute to other members of a community (Goodenough, 1965). Biodistance studies use metric and morphological data collected from human skeletal remains to trace biological affinity based on the assumption that populations of closer relation will express greater similarity in traits (Buikstra et al., 1990; Buikstra & Stojanowski, 2004). Intraregional migratory patterns are a major theme explored by biodistance studies (Larsen, 1997; Pietrusewsky, 2000). These explorations allow physical anthropologists to better interpret behavioural patterns and microevolutionary forces that contribute to biological variation within communities (Owsley et al., 1982; Konigsberg, 1988; Sciulli, 1990; Sciulli & Mahaney, 1991; Stefan, 1999; Schillaci & Stojanowski, 2003), and, in some cases,
help elucidate the basis for elevated prestige within social systems (Lane & Sublett, 1972; Buikstra, 1976; Konigsberg & Buikstra, 1995). In this sense, biodistance analysis acts as a useful tool for reconstructing patterns of migration in relation to identity within the mortuary record.

Patterns of identity are also understood using demographic analysis of burial practices and the distribution of physical indicators of identity (i.e., tooth ablation) between individuals of different ages. Two basic identities, achieved and ascribed, are defined within simple and complex ranked societies. Achieved identity is an aspect of the self that is earned through some special talent or identification with a particular aspect of community/familial life (Fried, 1967). Ascribed identity is an aspect of the self that is inherited and recognised by the community at large (Fried, 1967). Grave goods, energy expenditure on funerary architecture and physical indicators of identity in subadult burials help differentiate ascribed social identities (Peebles & Kus, 1977; Brown, 1981, 1995; Kobayashi, 1992; Carr, 1995). In contrast, elaborate burial treatment and physical indicators of identity are primarily reserved for adults in communities lacking identity ascription. Some caution is, however, necessary in interpreting these patterns as subadult burials with grave furniture are found in groups with high population density, exemplifying the range of identities that may exist in human communities (Brown, 1995; Hayden, 1995; Larsen, 1995).

Paleodietary reconstruction using carbon and nitrogen isotope analysis of human bone collagen is a well-established technique (e.g., Ambrose & DeNiro, 1986; Richards et al., 2001; Bocherens et al., 2006). Stable isotope analysis suggests differences in diet based on identity in a variety of social contexts (Larsen, 1997). 'Ethno-bioarchaeological' research indicates that such differences often reflect variability in access to resources, either through social prestige or division of labour (Walker & Hewlett, 1990).

Jomon people were members of a complex foraging economy that occupied the Japanese Islands between 13,000 and 2300 BP (Imamura, 1996). These prehistoric people were the descendents of Paleolithic migrants to the Japanese Islands that displaced pre-existing 'knife–blade' cultures around 20,000 BP (Kobayashi, 2005). Following this displacement, the ancestors of Jomon people established a 'microblade' culture that evolved into Mikoshiha, then Jomon traditions between 14,000 and 13,000 BP (Imamura, 1996). Two competing hypotheses suggest that the ancestors of Jomon people migrated to Japan from either Sundaland (Turner, 1990; Hanihara, 1991) or Northeast Asia (Pietrusewsky, 1999, Seguchi et al., 2007; Hanihara & Ishida, 2009). Recent aDNA studies indicate a similarity between Jomon and contemporary people from South-eastern Siberia (Adachi et al., 2009). Jomon culture flourished through 2500/2300 BP, when it was subsumed by migrant people from the Northeast Asian continent and wet rice agriculture (Nakahashi, 1993; Imamura, 1996; Omoto & Saitou, 1997; Hammer et al., 2006). Jomon people are characterised as 'complex foragers' given significant variability in social complexity, population density and diet between regions (Habu, 2004).

One indicator of identity in Jomon communities is ritual tooth ablation. Patterns of ritual tooth ablation observed among Jomon people include those with antemortem removal of both mandibular canines (2C) and those with antemortem removal of four mandibular incisors (4I) (Figure 1). Previous studies of Jomon migration and social structure subdivided individuals into local and migrant groups on the basis of ritual tooth ablation and grave goods (Harunari, 1986). Local members of Jomon communities were defined on the basis of elaborate grave artefacts and mandibular incisor ablation, while migrants were defined by the presence of mandibular canine ablation and less elaborate grave artefacts (Harunari, 1986). At Yoshigo, proposed migrants (2C tooth ablation) were likely culled from various satellite sites (Harunari, 1986), as Yoshigo is a much larger community compared to other Late/Final Jomon period settlements within the area (Saito et al., 1952). Once 'migrants' married into Yoshigo, it is proposed that teeth were removed to differentiate these individuals from local members of the community (Harunari, 1986). It is well established that male and female community members equally expressed both patterns of tooth ablation (4I, 2C) (Harunari, 1986; Tanaka, 2001; Funahashi, 2003; Funahashi & Tanaka, 2004). Findings from Late to Final Jomon periods sites in Kanto and Tokai region suggest that these indicators of identity were achieved concordantly with age (Funahashi, 2003; Funahashi & Tanaka, 2004), though statistically rigorous tests were not performed to demonstrate true association.

Few studies of stable isotope analysis focus on patterns of diet in relation identity among Jomon period foragers. Sex-based dietary variation among Jomon people is suggested at various sites and attributed to divisions of labour (Chisholm et al., 1992; Yoneda et al., 1996; Kusaka et al., 2008). In addition, isotopic studies between individuals with differing forms of tooth ablation suggest that these indicators of identity may be associated with access to
resources, and by extension, membership in subsistence task groups (Kusaka et al., 2008).

Several hypotheses are developed on the basis of previous findings regarding ritual tooth ablation and identity distributions in prehistoric Jomon society. First, it is predicted that individuals with 2C tooth ablation were migrants to Yoshigo, while individuals with 4I tooth ablation were indigenous community members. If true, significantly greater within group morphological variability should be expressed by individuals with type 4I compared to 2C tooth ablation. Second, the hypothesis that ritual tooth ablation will be associated with age-at-death is tested. It is expected that ritual tooth ablation groups were associated with separate identities and were likely achieved at different ages. Finally, the hypothesis that members of varying tooth ablation groups consumed significantly different foods is tested. This hypothesis, if accepted, will provide empirical confirmation for dietary variation between the two groups and suggest differential access to resources based on prestige or division of labour.

Materials

Data were collected from human skeletal material recovered from Yoshigo Shell Mounds. Yoshigo is a Late to Final Jomon site located in Tahara City, Aichi Prefecture, Japan along Mikawa Bay (Figure 2). Yoshigo was chosen for this analysis because of the large number of individuals recovered from the site, high frequency of ritual tooth ablation and documentation of burial locale according to physical markers of identity (Harunari, 1986). Yoshigo was excavated in 1922 and 1923 by Professor Kiyono of Kyoto University and in 1951 by the Commission for Protection of Cultural Resource Properties. Skeletal remains representing a minimum number of 305 individuals in varying states of anatomical completeness were recovered from Yoshigo. Pottery chronology dates Yoshigo from the Late to Final Jomon period, specifically ranging from approximately 3500 to 2300 yBP (Saito et al., 1952). These dates correspond with radiocarbon dated mollusc shells from Yoshigo that suggest an occupation around 2870 ± 250 and 2800 ± 600 (uncalibrated) yBP (Watanabe, 1966). Recent radiocarbon dates obtained from human remains suggest similar dates for the occupation of Yoshigo (3200–2800 calibrated BP) (Kusaka et al., 2009).

Figure 1. (a) Ablation of four mandibular incisors (4I). (b) Ablation of two mandibular canines (2C).

Figure 2. Location of the Yoshigo site.
Yoshigo cemetery includes a broad temporal component and may have been subjected to cultural changes that would have biased the composition of these samples. Patterns of ritual tooth ablation may, for example, have changed over time. There is, however, a consistent pattern of tooth ablation from the Middle (5000–4000 BP) through Final (3500–2500 BP) Jomon periods across numerous regions of Japan (Harunari, 1986; Tanaka, 2001; Funahashi, 2003). Patterns of tooth ablation associated with the Jomon period did not change until these groups were subsumed by Yayoi biological and cultural groups around 2500 BP (Nakahashi, 1993). It is, therefore, reasonable to expect that the patterns of ritual tooth ablation at Yoshigo were consistent throughout the occupation of the site. Other research highlights changes in craniofacial morphology that coincide with shifts in diet (Carlson & Van Gerven, 1977). No evidence for dietary change is reported for the Yoshigo site (Yawata, 1952; Toizumi & Yamasaki, 2007). In fact, such shifts do not occur until after the agricultural transition in western Japan (Chisholm & Koike, 1999), dated to approximately 2500 BP (Imamura, 1996). Evidence for dietary change during the Jomon period is dated to approximately 4300 BP and likely associated with climate change/resource availability (Fujita, 1995; Temple, 2007). This dietary change is reported well before the occupation of Yoshigo.

Methods

Basic osteological protocols

Biological sex was determined using morphological features of the pelvis such as ventral arc presence, thickness of the ischiopubic ramus, subpubic concavity and greater sciatic notch shape (Phenice, 1969; Walker, 2005). Morphological features of the skull were not used to determine sex as these methods are less reliable in the absence of population-specific discriminant functions applied to cranial measurements (Meindl et al., 1985). Adult age-at-death was estimated using pubic symphysis and auricular surface morphology, mandibular occlusal tooth wear, cranial suture closure, fusion of the clavicle, as well as fusion of the first and second sacral bodies (Buikstra & Ubelaker, 1994). Subadult age was estimated based on dental development and tooth eruption (Scheuer & Black, 2000).

Seven cranial measurements were recorded from 26 individuals and standardised for size (see below). Sample sizes for each group, cranial measurements, mean measurements and standard deviations are listed in Table 1. Cranial measurements were recorded from each individual using landmarks described by Buikstra & Ubelaker (1994). Distances between craniometric points were measured using an Immersion Inscribe 3.0 three-dimensional-digitiser made available by Microscribe 3-D Digitising Systems and the Laboratory of Physical Anthropology at Kyoto University. The Inscribe 3.0 was used to plot three-dimensional coordinates of cranial landmarks into a Microsoft Excel database. Distances between landmarks were then calculated using the following three-dimensional distance formula:

\[ l = (x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2 \]

In addition, maximum buccolingual and mesiodistal measurements were recorded from each individual using landmarks described by Buikstra & Ubelaker (1994). Teeth were measured with Mitutoyo digital calipers and recorded to the nearest tenth of a

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Table 1. Group specific means and standard deviations of size-standardised cranial measurements

<table>
<thead>
<tr>
<th>Group</th>
<th>MCL</th>
<th>MCB</th>
<th>MFB</th>
<th>UFB</th>
<th>ML</th>
<th>PC</th>
<th>FC</th>
</tr>
</thead>
<tbody>
<tr>
<td>4I Mean (n = 18)</td>
<td>1.77</td>
<td>1.40</td>
<td>0.93</td>
<td>1.14</td>
<td>0.31</td>
<td>1.14</td>
<td>1.08</td>
</tr>
<tr>
<td>4I SD</td>
<td>0.06</td>
<td>0.08</td>
<td>0.16</td>
<td>0.09</td>
<td>0.02</td>
<td>0.06</td>
<td>0.05</td>
</tr>
<tr>
<td>2C Mean (n = 8)</td>
<td>1.80</td>
<td>1.40</td>
<td>1.03</td>
<td>1.08</td>
<td>0.30</td>
<td>1.11</td>
<td>1.08</td>
</tr>
<tr>
<td>2C SD</td>
<td>0.06</td>
<td>0.07</td>
<td>0.19</td>
<td>0.10</td>
<td>0.03</td>
<td>0.05</td>
<td>0.05</td>
</tr>
</tbody>
</table>

*All measurements are listed in millimetres.

Table 2. Group specific means and standard deviations of size-standardised dental measurements

<table>
<thead>
<tr>
<th>Group</th>
<th>M</th>
<th>BL</th>
<th>MD</th>
<th>M1</th>
<th>BL</th>
<th>M1</th>
</tr>
</thead>
<tbody>
<tr>
<td>4I Mean (n = 16)</td>
<td>1.05</td>
<td>0.92</td>
<td>1.01</td>
<td>1.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4I SD</td>
<td>0.03</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2C Mean (n = 15)</td>
<td>1.03</td>
<td>0.96</td>
<td>1.00</td>
<td>1.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2C SD</td>
<td>0.04</td>
<td>0.04</td>
<td>0.03</td>
<td>0.03</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*All measurements are listed in millimetres.
Biodistance analyses

Cranial and dental sexual dimorphism is primarily related to size differences associated with biomechanical and selective pressures (Hillson, 1996; White, 2000). Prior to use of the multivariate statistical methods outlined below, Jomon cranial and dental measurements were size-standardised. This standardisation follows procedures described by Darroch & Mosimann (1985), where size-standardised data are calculated as the ratio of each variable to the geometric mean for all variables of a given individual. Geometric means were derived by multiplying together every measurement (cranial, dental separately) for each individual and calculating the nth root of this product (Darroch & Mosimann, 1985). The nth root is determined by the overall number of measurements for the individual.

Multivariate procedures used a pooled sex sample. It is noted that size is sometimes correlated with shape in inter-sex or species comparisons even after measurements are standardised by individual geometric means (Jungers et al., 1995) and this may create unrealistic similarities between groups of different sizes (Corruccini, 1987). Errors such as these are, however, mostly reported among distantly related species or between males and females within species that have considerable levels of sexual dimorphism (Corruccini, 1987; Jungers et al., 1995).

Standardised cranial and dental measurements were tested for normality by computing the generalised (Mahalanobis') squared distances ($D^2$) between the ith observation vector and the mean vector for the total samples. $D^2$ is the multivariate analogue of the square of the standard score for a single variable, but measures distance from the mean vector in relation to the covariance matrix. With p variables $D_i^2$ is distributed approximately as $\chi^2$ with p degrees of freedom for samples from a multivariate normal distribution. The Q–Q plot of the ordered distance values, $D_i^2$, against the corresponding quantiles of the $\chi^2$ ($p$) distribution should yield a straight line through the origin for multivariate normal data.

Standardised cranial and dental measures of the covariance matrix were determined for each group and the natural log of the ratio of the determinants of the matrices ($\ln 2C/\ln 4I$) was used as an indicator of covariance equality. If approximately equal within group variation exists between two populations, the ratio of the covariance determinants will yield a quotient closer to one (Konigsberg, 1988). Statistical significance was evaluated using resampled (with replacement) ratio estimates due to the relatively small sample sizes. The two samples were combined and the rows of this combined group were randomly shuffled. The combined group was then separated into two new samples (resampled), with sizes equal to the original samples, and a determinant ratio was calculated. This procedure was repeated over 1000 iterations. $p$-values were generated by dividing the number of times that the differences between resampled determinant ratios were greater than the original quotient by the number of times the data were re-sampled.

One major assumption of these methods is that the biological variation among the Yoshigo cemetery sample reflects the level of biological variability that existed in the living population of Yoshigo at any given time. Since cemeteries are cumulative in nature, there is a potential for biased results if genetic variation changed across the temporal spectrum of a cemetery (Pietrusewsky, 2000). Morphological variability between regions is relatively equal for Honshu Jomon samples (Kondo, 1994; Matsumura, 1989, 2007), though greater degrees of variability are observed among contemporaneous groups from Hokkaido (Hanihara & Ishida, 2009). In addition, little evidence for gene flow from distant regions during the Jomon period is recognised indicating that this cultural group was reasonably isolated (Hammer et al., 2006).

Demographic and dietary analysis

Approximately 130 individuals were divided into age and proposed identity (i.e. tooth ablation patterns) based classes to understand the relationship between these features (Table 3). Age classes were assigned as follows: subadult (6–14.9 years); young adult (15–24.9

<table>
<thead>
<tr>
<th>Groups</th>
<th>Subadults</th>
<th>Young Adults</th>
<th>Older Adults</th>
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<tbody>
<tr>
<td>4I</td>
<td>1</td>
<td>6</td>
<td>45</td>
</tr>
<tr>
<td>2C</td>
<td>0</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>None</td>
<td>18</td>
<td>4</td>
<td>36</td>
</tr>
</tbody>
</table>

Table 3. Sample composition for the demographic analysis
years); old adult (25+ years). These groups may seem to favour the placement of relatively younger individuals into the older adult age class. The relationship between age groups and tooth ablation groups was tested using multiple correspondence analysis (MCA). MCA output includes a two-dimensional display that graphs the relationship between columnar and row variables. In MCA, variation between columns and rows is condensed into two dimensions each yielding eigenvectors that express the amount of variation explained by each dimension (Greenacre, 1981). These dimensions represent 'deconstructed' $\chi^2$ statistics, where the eigenvector for each dimension yields a specific percentage of the $\chi^2$ value. Similarity in location along these axes suggests a similar pattern of relative frequency for the columnar and row variables. This study expects similar axes for tooth ablation and age groups if tooth ablation patterning is associated with achievement or age-based entry.

Dietary variation between tooth ablation groups was evaluated using stable isotope analysis of human bone. Sample composition for these groups is listed in Table 4. Bone samples were collected from the ribs each skeleton. Extraction of bone collagen was carried out in the Laboratory of the Research Institute for Humanity and Nature. Extraction followed the procedure described by Yoneda et al. (2004). About 1 g of bone sample was ultrasonically cleaned in pure water in order to remove any soil. Humic and fulvic acids were removed from the sample by soaking in 0.2 M NaOH overnight and the sample was neutralised in pure water. The sample was lyophilised and crushed by a mill. Then, the sample was sealed in a cellulose tube and soaked in 1 M HCl overnight to remove hydroxyapatite. The remaining material was separated by centrifugation and lyophilised. The sample was heated at 90°C for 12 h in pure water. Both fractions were freeze-dried, and extracted gelatin samples were used for isotopic analyses.

About 0.5 mg of the extracted collagen was measured for carbon and nitrogen isotopic ratios, using an elemental analyser (FLASH EA™) connected to an isotope ratio mass spectrometer (DELTA plus XP™). The natural abundances of $^{13}$C and $^{15}$N are expressed as per mil (‰) deviation from international standards: $\delta^{13}$C or $\delta^{15}$N = ($R_{\text{sample}} - R_{\text{standard}}$) × 1000, where $R$ in $\delta^{13}$C or $\delta^{15}$N is $^{13}$C/$^{12}$C or $^{15}$N/$^{14}$N, respectively. Vienna Pee Dee Belemnite and atmospheric nitrogen were used as the international standards for carbon and nitrogen, respectively. Based on the standard materials measured with unknown samples, the measuring errors for each measurement were less than 0.2‰ for $\delta^{13}$C values and 0.2‰ for $\delta^{15}$N values. Differences in isotopic values between tooth ablation groups were compared using a two-sample $t$-test, while an $F$-test was used to evaluate equality of variances.

Results

Biodistance analysis

Standardised cranial and dental measurements are normally distributed. Q–Q plots of the Mahalanobis’ $D^2$ between the $i$th observation and the mean vector for each sample resulted in relatively linear plots through points near the origins indicating that the scores were essentially multivariate normal.

The ratio of determinants of the observed covariance matrices for the proposed locals and migrants indicate that the proposed migrants had a greater amount of variation for both cranial and dental measurements (Table 5). Resampling analysis finds no significant differences in the amount of within-group variation between tooth ablation classes for either cranial or dental measurements (Table 5). These results refute the hypotheses of previous research that suggest ritual tooth ablation indicates residency (Harunari, 1986). Results reported here are supported by studies of dental non-metric traits in western Japan that refute the hypothesis that ritual tooth ablation patterns are associated with postmarital residence at other contemporaneous sites (Tanaka, 2001).

Demographic and dietary analyses

Correspondence analysis performed on age-at-death and status markers finds that individuals with physical

<table>
<thead>
<tr>
<th>Table 4. Sample composition for isotopic analysis</th>
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<tbody>
<tr>
<td>Tooth Ablation</td>
</tr>
<tr>
<td>4I</td>
</tr>
<tr>
<td>2C</td>
</tr>
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<table>
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<tr>
<th>Table 5. Determinants of variance–covariance matrices and randomised probability values for Yoshigo tooth ablation groups</th>
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<tr>
<td>Measurement</td>
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<tr>
<td>Cranial</td>
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<tr>
<td>Dental</td>
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markers of local identity are associated with the older adult age group, whereas individuals with physical markers of migrant identity are related to the younger adult age group; subadults are not associated with physical indications of identity (Figure 3) ($\chi^2 = 92.47$, df = 4, $p \leq 0.005$). These results support previous assertions that physical indicators of identity were based on accomplishments experienced over the life history of an individual (Funahashi, 2003; Funahashi & Tanaka, 2004).

The carbon and nitrogen stable isotope ratios of the bone samples are listed in Table 3. Because C/N ratios of all samples are within the range 2.9–3.6 (DeNiro, 1985), it was confirmed that diagenetic effects did not influence the isotope ratios.

The carbon and nitrogen isotope ratios obtained for the Yoshigo site are reported by Kusaka et al. (2008). The average $\delta^{13}C$ value at the Yoshigo site is $-16.3 \pm 1.7\%$ (mean $\pm 1$ SD), and the average $\delta^{15}N$ value was $10.8 \pm 1.9\%$. $\delta^{13}C$ and $\delta^{15}N$ values were linearly correlated ($R^2 = 0.948$, $p \leq 0.001$). The isotopic values of potential protein sources ($C_3$ plants, terrestrial herbivores, marine finfish and marine shellfish) are also shown in Figure 4. The specific protein sources were selected based on the evidence of organic remains collected from the Yoshigo site (Yawata, 1952). $C_4$ plants do not appear in Figure 4 because there is no archaeological evidence suggesting significant consumption of $C_4$ plants. Isotopic compositions of the protein sources are cited from Yoneda et al. (2004). In the process of assimilation, heavy isotopes accumulate in human tissue and isotopic enrichment of the $\delta^{13}C$ for $\delta^{15}N$ values in collagen occurs (Ambrose & DeNiro, 1986). Therefore, 4.5% for the $\delta^{13}C$ values and 3.4% for the $\delta^{15}N$ values (Ambrose & Norr, 1993) were added to the isotopic values of the protein sources. The isotopic values of bone collagen are distributed within the range of the isotopic values of the selected protein sources. Comparisons of stable isotope ratios between ritual tooth ablation groups are not significantly different ($\delta^{13}C$: $t = 0.62$, $p \leq 0.54$; $\delta^{15}N$: $t = 0.40$, $p \leq 0.54$). These results fail to support the hypothesis that tooth ablation groups represent occupational differences.

**Discussion**

**Biodistance analyses**

Approximately equal degrees of within-group genetic variation between tooth ablation classes reject the hypothesis that 2C individuals were associated with a migrant group and 4I individuals were associated with a...
local group. This result is supported by recently published strontium isotope analysis of tooth ablation groups (Kusaka et al., 2009). Alternatively, it is proposed that ritual tooth ablation may reflect membership in kin-based descent groups. Broad cross-cultural surveys of mortuary practices repeatedly find spatial segregation within cemeteries associated with kin-based social units (Binford, 1971; Goldstein, 1981; Carr, 1995), although more recent studies indicate that broader social networks including sodalities also contribute to discrete spatial patterning within cemeteries (Carr, 1995). Segregation of kin within past cemeteries is noted from a variety of contexts including the American Southwest (Corruccini, 1972; Howell & Kintigh, 1996), Southeastern United States (Ortner & Corruccini, 1976; Stojanowski, 2005), Japan (Shinoda & Kunisada, 1994, Mizoguchi, 2002), Great Plains (Owsley & Jantz, 1978; Byrd & Jantz, 1994), Caribbean (Corruccini et al., 1982), Egypt (Prowse & Lovell, 1996) and Peru (Corruccini et al., 2002). These studies all utilised human morphological features and/or ancient DNA analysis to confirm kin-based social patterning within cemeteries and support archaeological interpretations that suggest separate burial units reflect descent.

Tooth ablation groups at Yoshigo are distributed in elliptically shaped burial clusters that were spatially segregated: There are two main burial clusters at Yoshigo further segregated into at least eight sections that express clear delineations of tooth ablation groups (Harunari, 1986). This trend is repeated at other Late/Final Jomon cemeteries on the Astumi Peninsula such as Ikawazu and Inariyama (Harunari, 1986). At Yoshigo, specifically, burial clusters exist in circular arrangements similar to the patterning of village and domicile layouts (Harunari, 1986; Imamura, 1996). This burial patterning suggests that tooth ablation groups may represent household or kin-based social units, rather than postmarital residence patterns.

Previous biodistance studies report hereditary differences between the two groups (Hashimoto & Baba, 1998; Mouri & Oku, 1998; Tanaka, 2001), yet similar levels of residential mobility (Tanaka, 2001; this study). Twenty three non-metric dental traits were studied among a large sample of Jomon people and approximately seven traits discriminated local samples (Hashimoto & Baba, 1998). These seven traits were then compared between tooth ablation groups and the degree of trait expression between groups significantly differed (Hashimoto & Baba, 1998). Cumulative values of cranial non-metric traits were also significantly different between tooth ablation groups at Yoshigo (Mouri & Oku, 1998). These findings indicate that tooth ablation groups may reflect kin-based units, though measurements recorded from individuals within all burial clusters should be recorded and analysed before a definitive conclusion is reached.

**Demographic analysis**

Demographic analysis of age-at-death and tooth ablation groups failed to reject the hypothesis that physical indicators of identity were associated with age. Models of Ainu social organisation suggest that the most sedentary members of society were children, elders and women (Watanabe, 1968). In contrast, younger adult males were involved in kin-based hunting/fishing networks: one group associated with bear hunting and the second group involved in fishing (Watanabe, 1968). Entrance into these networks was dictated by familial identity, age and accomplishment. Young men of a specific age, who demonstrated proficient skills, were permitted membership into kin-based occupational groups (Watanabe, 1972).

Archaeological models of Jomon social organisation argue that these societies were egalitarian in nature, where features such as lifetime accomplishments or age-based rights-of-passage acted as identity determinants (Watanabe, 1986; Kobayashi, 1992; Imamura, 1996, 2006; Mizoguchi, 2002). The relationship between ritual tooth ablation and age argue for a social system where accomplishments, whether related to specific achievements or simply rights-of-passage, acted as one determinant of identity. Biodistance analyses of tooth ablation groups do, however, suggest that these groups were kin-based (Hashimoto & Baba, 1998, Mouri & Oku, 1998), while ethnographic analogies of complex foragers suggest the possibility that these societies were egalitarian in nature, where features such as lifetime accomplishments or age-based rights-of-passage acted as identity determinants (Watanabe, 1986; Kobayashi, 1992; Imamura, 1996, 2006; Mizoguchi, 2002).

Taken together, the available evidence suggests that ritual tooth ablation groups represent units of familial identity that were achieved at a certain age. That is, patterns of tooth ablation likely indicated membership in a kin-based social network that was not possible to access before a specific age or occupational proficiency was achieved.

**Dietary analyses**

Stable isotope analysis suggests that members of differing tooth ablation groups at Yoshigo consumed similar foods. This finding does not conform to the
expectation of dietary variation between the two groups. Dietary patterns between tooth ablation groups at Yoshigo may have been homogenised by a food-sharing network. Food sharing is thought to offset risk of resource stress by encouraging the storage of excess foods and/or food sharing obligations between groups (Winterhalder, 1986; Halstead & O’Shea, 1989; Hawkes et al., 2001). Examples of food sharing among foragers from the Northern Pacific region include those practiced by the Klamath and Modoc from California and Oregon (Sobell & Bettles, 2000). This system of exchange was the most important coping strategy to combat seasonal resource scarcity and included both intrafamilial and intercommunity exchange networks (Sobell & Bettles, 2000). Ainu foragers also stored many foods including fresh-water fish and plant foods; these products were preserved through drying, grilling, processing and smoking (Kohara, 1999). Preserved food was kept in a communal storehouse (Kohara, 1999). Numerous examples of food storage, including the caching of plants and salmon, are reported from Jomon sites (Imamura, 1996; Kobayashi, 2005). This suggests the possibility that diet at Yoshigo was homogenised by food-sharing networks, possibly those designed to offset the risk of resource stress.

Additionally, ethnographically documented food sharing is often reported among hunter-gatherers in association with social signalling. Members of resource procurement groups will, for example, share foods with other social units before their own families to reinforce social bonds (Hawkes et al., 2001). Social bonds referenced here are associated with alliance building networks that promote cooperative social strategies (Hawkes et al., 2001). It is, therefore, also possible that the Jomon people from Yoshigo shared food with cooperative partners as a social signal.

One additionally important aspect to explore regarding diet and identity at the Yoshigo site relates to the use of cemeteries as territorial displays and access to resources. Megalithic tombs dating to approximately 6500 BP in western Europe are hypothesised to represent territorial expansions of small scale societies (Renfrew, 1976). This suggests that cemeteries represent ‘formal disposal areas’ utilised by communities in establishing claim over a particular region, and possibly, the resources within that area (Chapman, 1981, 1995). Establishment of cemeteries allows populations to claim areas with restricted access to resources by establishing an ancestral affiliation within the given area (Chapman, 1995). Claims to this territory are strengthened by ‘ritualisation’ of the land, though some flexibility in this hypothesis is noted due to cross-cultural variability in ritual behaviour (Goldstein, 1976, 1981). It is further predicted that these expansions represent a corporate group with access to/control over specific resources in the area (Goldstein, 1976, 1981).

The Yoshigo cemetery includes over 350 burials (Saito et al., 1952). This number is quite large compared with other contemporaneous cemeteries on the Atsumi peninsula including Hobi, Ikawazu and Inariyama (Harunari, 1986). Burials of leaders associated with the possible ‘ceremonialisation’ of Yoshigo are observed. Individuals with 4I tooth ablation combined with forked maxillary incisors are reported at the Yoshigo site and represent approximately 0.02% of the burial sample (Harunari, 1986). These individuals were buried with objects of possible ritual function including hip accessories. Hip accessories are made from polished deer antlers and placed at the hip of individuals within graves (Kobayashi, 2005). Two sites on the Atsumi peninsula feature burials with forked incisors (five at Yoshigo, one at Ikawazu), with the largest number of hip accessories recovered from Yoshigo. These findings provide some support for a greater degree of ‘ritualisation’ at Yoshigo, though ritual artefacts are recovered from other sites on the Atsumi peninsula. This result is consistent with cautionary comments by Goldstein (1976, 1981) that the ‘ritualisation’ of land may not be straightforward due to the fact that ceremonial behaviour varies considerably between groups.

Yoshigo residents did, however, consume greater amounts of finfish than individuals from Inariyama, where shell fish was consumed in greater quantity (Kusaka et al., 2008). Greater evidence for systemic stress in terms of enamel hypoplasia prevalence is observed at Inariyama compared to Yoshigo (Temple, 2007). In addition, differences in diet between tooth ablation groups are noted at Inariyama in contrast to Yoshigo. Individuals with type 4I tooth ablation consumed greater amounts of terrestrial mammals, while individuals with type 2C tooth ablation consumed greater amounts of maritime resources at Inariyama (Kusaka et al., 2008). These findings indicate that members of Yoshigo had greater access to certain resources and may suggest that this cemetery represents an extension of this control over resource acquisition in the Atsumi peninsula. Greater communal access to resources may well have allowed the people of Yoshigo to share food...
between social groups. Stable isotope analysis of sites such as Hobi and Ikawazu is, however, necessary to further explore these possibilities.

Conclusions

This paper explored patterns of social identity associated with tooth ablation at the Yoshigo site, dating to the Late/Final Jomon period. Members of differing tooth ablation groups experienced approximately equal patterns of residential mobility. This suggests that tooth ablation does not indicate post-marital residence. Instead, morphological evidence for hereditary differentiation is observed between tooth ablation groups suggesting kin-based identities. In addition, there are strong associations between age and tooth ablation groups, while dietary variability between tooth ablation groups was minimal. Tooth ablation identities were likely accessed following certain age-specific achievements, while cooperative food sharing likely homogenised diet between the two groups. Dietary distinctions between Yoshigo and other local communities suggest that this cemetery acted as an extension of communal access to resources in surrounding territories. Greater access to these resources likely allowed members of the Yoshigo community to share foodstuffs.

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