The Zwolle Teeth: an independent look at the data

Mary Jackes

1: Initial research project

T. S. Constandse-Westermann provided access to a large body of data on the dentitions from an early 19th century sample, excavated from the Dutch town of Zwolle (LINK). The original recording of the Zwolle dentitions was done by Tj. Pot and W.H. M. Bouts, and further analysis of the recorded data was undertaken by T. S. Constandse-Westermann, in association with W.H.M. Bouts (LINK). Access to such a large and carefully observed set of data on a sample of known age dentitions was a fine opportunity to present material in a particular way in order to enquire into its value for use in comparative studies. The presentation here is specifically the result of the present analysis only, without detailed discussion or reference to the background literature. There have been previous studies of Zwolle dentitions which will be cited as links, but these have not been closely read prior to this analysis, avoiding preconceptions.

One paper (T. S. Constandse-Westermann "Age estimation by dental attrition in an independently controlled early 19th century sample from Zwolle, The Netherlands" *Human Evolution* 1997, 12 (4): 269-285) (LINK) was published in a garbled fashion (necessary corrections are linked within the paper). Other papers in English linked here are unpublished.

1.1 Approach and sample make-up

Work on the analysis of the Zwolle data for this paper was done periodically over a number of years, using copies of the original coding sheets. The first step was to recode the complex graphical method (LINK) developed by Pot and Bouts, and programmed by H.A. Verhoeven, into variables that could be analyzed in a specific way, recoding for unobservable or present/absent observations by tooth or alveolar site. Each tooth in the graphical method was characterized by a "portmanteau" image which had to be "unpacked". There were 37 possible characterizations or "codes". One set separated out teeth that could be removed to observe the state of the socket versus those that could not be removed. This was done in order to examine whether there was a periapical abscess which had not produced a cavity in the alveolar wall. Since only two abscesses were found in alveoli from which the tooth or root could **not** be removed (code 14, two young males), it was not worthwhile to maintain the distinction, although the coding retained the original 37 tooth/alveolus states. A number of codes were not, in fact, represented in the sample.[1]

The analysis here will not consider deciduous teeth -- the youngest individuals chosen for analysis were 9, 10, 13 and 16 years: teeth which were not adult and in occlusion were excluded. Individuals without both known age and known sex were also excluded. All individuals given clear sex and age attributions on the recording sheets are included in the analyses, apart from infants.

A total of 96 individuals had ages firmly ascribed to them, as well as sex: ten had only one jaw coded, and it was necessary to consider whether a few individuals could be recreated. For example, there were two males aged 73, one with a mandible only and one with a maxilla only. They were from

---

[1] Absent codes: 4,5,6,11,12,15,16,17,19,21,22,23,30,31,32.

different graves: individual identities by grave are kept firmly apart in this analysis, but since the analysis is by alveolar sites rather than by individuals, the point is irrelevant for much of the work reported on here. The sample contains 14 males to age 39 and 30 males 40 years and over: younger females totalled 16 and there were 36 females of age 40 and over. We can be confident that, in these broad terms, the samples are statistically equivalent.

Translating the codes into variables suitable for this analysis made it clear whether a certain feature could be observed as present or absent, or was unobservable. This was accomplished by developing variables as follows: jaw, side, tooth, status, carious lesions[2] (both type and location), wear, socket, crown, root, abscess, pulp exposure. Evidence for alveolar margin changes indicating periodontal disease was not recorded during the original coding, so there is no mention of that, nor of dental calculus. Accuracy of recoding was checked by multiple cross tabulations, ensuring that all cell couplings were reasonable. Work was done in 2003, 2004, 2011 and 2015: while such delay was unfortunate, it at least ensured that everything was checked many times in many ways. The final analysis reported here was accomplished using IBM SPSS 22 in 2015.

With regard to pulp exposure, it was necessary to decide whether a code indicating "crown broken" referred to pre or postmortem breakage since this was not specified: as there were no cases recorded as breakage, this was of no consequence.

Antemortem tooth loss was recorded under a very specific definition (Constandse-Westermann, personal communication, provided detailed definitions of each code and full information will be found at LINK section 4C): antemortem loss was defined as complete alveolar resorption only. Because 95/100 cases of alveoli resorbed from unknown cause or because of congenital absence were third molars, the usual problem experienced by osteologists observing archaeological dentitions was clear: without radiography, third molar status cannot be verified. There were only 13 cases of coded congenital absence, only in females, nine of them third molars, and only in age classes 1 to 5 (defined below). Congenital absence of teeth, other than third molars, was observed bilaterally for maxillary lateral incisors in a 26 year old, and bilaterally for the mandibular P4s in a 13 year old. Resorbed alveoli (tooth loss) of unknown cause for teeth other than M3 was recorded only for an upper left canine of a 40 year old woman: she was an individual who had a number of teeth missing from her mandible, in three alveolar sites with complete alveolar resorption and in two cases with only roots left in the sockets, pulp cavities exposed. Loss due to pathology is a reasonable assumption for this individual. Resorbed alveolus (tooth loss) of unknown cause has been included as antemortem tooth loss in the following analyses, but in some cases third molars are reported separately.

For the third molars, all third molar (M3) sites, except for the right mandible, had a lower percentage of teeth retained intact in the socket than other teeth in their respective jaw quadrants. In fact, M3s had the lowest representation of all intact retained teeth, except for the left and right lower M1s. We can note that close to a quarter of all the intact M3s had carious lesions, apart from the left upper M3s. But the left upper M3 sockets had a very high level of abscessing. There can be little doubt that antemortem tooth loss in third molars did occur as a result of pathology.

[2] Technically "caries" should not be used for single carious lesions. Caries refers to the disease or process of decay, not to a single focus of destruction. However, in common parlance, it can be difficult to avoid the use of caries in this sense, especially in the plural, without repetitive use of wordy expressions.

It is, of course, impossible to know the aetiology of antemortem tooth loss (whether trauma, caries, abscessing, extreme wear), but we need to have some idea of the condition of the alveolus apart from complete resorption. Since this was not recorded, we need to enquire whether that can be deduced. Here (apart from the usual M3 status uncertainty) we will suggest that all cases of "unknown cause tooth loss" can be ascribed either to caries or extreme wear. Since it appears that trauma was not seen in this sample, we will try to clarify whether attrition or pathology was responsible for the loss of teeth premortem.

Since there is no code to cover the status of a socket without complete resorption, if lacking a fragment of root or an abscess, a degree of uncertainty will remain about the "empty socket" category. While observation of attrition, caries, abscessing, in surrounding and occluding teeth may allow guessed resolutions of this issue, in general the analyses undertaken here will focus on alveolar sites, and only a few specific individual dentitions will be mentioned below. Situations where lesions have reduced a tooth to a remnant of root can be distinguished from the most extreme attrition because in only one individual, a male, does the variable (wear = 7) record such attrition. That one individual, burial 103-434-702, had wear on the other anterior teeth of 6- or 6 and is obviously a special case, especially as he was only 46 years old.[3] Tooth classes will be analyzed separately because there is a chance that extreme anterior wear or damage to the anterior teeth from pipe smoking led to tooth loss that can no longer be identified as such.

By paying close attention to cases where there was only a root in the socket, where the pulp cavity was exposed and where abscessing was recorded in the socket area, together with caries location and nature, we hope to be able to suggest something more about antemortem tooth loss.

Other specific definitions are as follows: a periapical abscess is defined as a clear lesion in the form of a cavity; an erupted tooth is in full occlusion (otherwise erupting); carious lesions are not simply discolorations - they permit the entry of a probe. When a tooth is coded as loose, there is no alveolar socket to be coded, thus "loose tooth" in the status variable can only be coupled with "missing data" in the socket variable. Data on the distribution of loose teeth will be found in Appendix I, demonstrating a link with the state of preservation, not of pathology. For a loose tooth, the alveolar region is unobservable as a result of poor preservation.

We analyze 96 dentitions, comprising in total 44 male maxillae, 43 male mandibles and 52 female maxillae and mandibles. We analyze only adult teeth in full occlusion (and their alveoli).

We examine here a total of 2644 teeth, sockets or alveolar sites. Maxillae were represented by 569 male and 707 female sites, and mandibles by 707 and 749 alveoli respectively. Overall, there are fewer male than female alveoli in the sample, so it is important to test every comparison for significance: here the difference between the jaws by sex is non-significant.

Age class 1 includes individuals still with deciduous elements (the sample here is to age 13), individuals in late adolescence and early adulthood (15-24) are in age class 2, the following age classes are each of 5 years until the last, age class 13. The age class 13 includes adults from 77 to 89 in the one oldest age grouping. Wear in age class 1 is up to 2+, except in a very few cases of incisors:

---

[3] The individual is not the same as appears in LINK Plate 2. Attrition coding will be discussed in several places further below.

one 13 year old female has strong wear on the upper central incisors – strongest on the right. We can only assume some specific task was undertaken employing the incisors as tools.

An important question is which teeth are most likely to be absent (that is, represented by an empty socket with no sign of abscessing, no root fragment, no suggestion of resorption or antemortem loss coded). Maxillary sockets are more likely to be empty than those for mandibular teeth, a common taphonomical feature in dental anthropology. Anterior teeth are more often lost postmortem than cheek teeth, as could be expected from the morphology of the tooth roots. The teeth available for observation of caries will not be a random selection. Again, care must be taken that results are in fact significant when there are sample size differences. Not all alveoli have an equal chance of survival. Of the 99 teeth found loose, a higher proportion are maxillary in males (Appendix I): the sex difference in distribution of loose teeth by jaw is significant (P of $\chi^2 =$ **0.00557**).

Our attention in this paper is focused on pathology with the idea of understanding the observations made by the original investigators and evaluating the value of the material for comparative studies.

1.2 General observations

Table 1.1 shows caries incidence in 1491 observable intact adult teeth, in occlusion, including loose teeth, and demonstrates that our discussion on dental pathology will need to focus on sex differences.

Caries absent/present	%	P of χ^2
males	14.9 (n = 787)	**0.00150***
females	21.2 (n = 704)	
right	16.2 (n = 746)	0.102
left	19.5 (n = 745)	
maxilla	17.6 (n = 710)	0.851
mandible	18.1 (n = 781)	

*significant values are in bold, to 5 decimal places rounded to nearest even number

Table 1.1 Caries incidence in observable intact adult teeth, significant comparisons in bold

Abscessing and antemortem tooth loss (the 13 cases of "congenital absence" now excluded) are shown in Table 1.2. The dichotomies tested here suggest that resorption alone and resorption/abscessing versus absence of resorption or abscessing is significantly higher in females (Table 1.2). Thus, caries incidence and antemortem tooth loss are higher in females, but abscessing is not. An empty socket could represent a tooth which has actually been lost antemortem, but, to repeat, the method of observation and recording defined antemortem tooth loss as complete alveolar resorption. That uncertainty is joined by another question: is complete resorption the result of teeth being extracted? We will not immediately give specific emphasis to empty sockets with abscessing, but note that they may indicate antemortem tooth loss as well as postmortem tooth loss.

We use simple χ^2 analyses in this paper (two-tailed, without Yates correction), without enquiring into interactions of variables directly: the reasoning is that with such complex data, very clear straight forward analyses are most informative. The only interaction of possible relevance is that of a broad age grouping (split point 39/40 years) and sex within the maxillary alveolar sites, but at P of $\chi^2 =$ 0.084 (non-significant) this can be put aside during preliminary analyses.

χ^2 testing presence vs. absence	P of χ^2	presence/ total n* %
Abscessing at patent sockets		
males	0.644	15.1 (n = 894)
females		14.3 (n = 797)
right	0.986	14.7 (n = 848)
left		14.7 (n = 843)
maxilla	**0.00216**	17.4 (n = 833)
mandible		12.0 (n = 858)
Resorption of socket		
males	**< 0.00001**	22.5 (n = 1153)
females		42.2 (n = 1379)
right	0.899	33.3 (n = 1272)
left		33.1 (n = 1260)
maxilla	*0.0465***	31.3 (n = 1212)
mandible		35.0 (n = 1320)
Resorption and/or abscess		
males	**< 0.00001**	34.2 (n = 1153)
females		50.5 (n = 1379)
right	0.909	43.1 (n = 1272)
left		42.9 (n = 1260)
maxilla	0.857	43.2 (n = 1212)
mandible		42.9 (n = 1320)

*13 congenital absence sites in females are excluded

** marginally significant values are in italics and non-significance is marked by the report to three decimal places

Table 1.2 Testing significance for abscessing and alveolar resorption in comparisons between sexes, sides and jaws

Adding pulp exposure may clarify whether more severe carious disease is higher in females (Table 1.3), but no comparison is significant, apart from the already noted caries incidences for males and females (Table 1.1).

	% intact teeth with caries	% of carious teeth with multiple or gross* lesions	% of carious teeth with pulp exposure	% of sites with both caries and alveolar abscessing	% of teeth with either pulp cavity exposed or only root fragment left in socket	% of that subsample (loose excluded) having exposed pulp cavity and abscessing
males	14.9	40.2	41.0	5.8	8.2	93.6
females	21.2	40.9	37.6	9.1	8.2	98.3
Male n	787	117	117	752	790	63
Female n	704	149	149	640	705	58

*a gross lesion is so extensive that it is impossible to determine the initial focus of carious destruction and/or how many caries were originally present.

Table 1.3 Further comparison by sex, percentages with pulp exposure added

1.3 Frequencies by tooth

Next we need to look at the significant comparisons to enquire whether the samples are comparable. This is because carious lesions differ by tooth site: some teeth are more susceptible to pathology than others because of their morphology. Since there is a slight indication that pathology may differ by side (for caries, though not for abscessing and tooth loss antemortem) and by jaw (very strongly for abscessing), we need to examine teeth, not just by tooth class, but by jaw and side.

Tooth*	% intact teeth with caries (root fragment included as carious)	Total teeth observed (intact, loose, root fragments)	% Patent sockets, (including root fragments) with abscessing	Total patent sockets observed (root fragments included)	% total alveolar sites with complete resorption	Total alveolar sites observed (root remnant included; congenital absence, anomalous lack of eruption, loose teeth excluded)
11	12.0	50	15.9	63	21.3	80
12	10.0	50	14.1	64	20.0	80
13	9.8	51	15.3	59	21.3	75
14	20.0	40	25.0	52	35.0	80
15	13.5	52	13.8	58	26.6	79
16	17.5	40	16.7	42	46.2	78
17	25.0	36	22.0	41	44.6	74
18	26.5	34	14.3	35	46.2	65
21	18.5	54	6.3	63	21.3	80
22	17.3	52	16.7	60	24.1	79
23	9.3	54	15.4	65	14.5	76
24	18.2	44	24.1	54	30.8	78
25	17.8	45	12.0	50	33.3	75
26	27.0	37	29.5	44	43.6	78
27	33.3	42	22.9	48	33.3	72
28	17.2	29	22.9	35	44.4	63
31	14.0	50	8.3	60	28.6	84
32	12.1	58	4.7	64	24.7	85
33	16.7	60	11.6	69	15.9	82
34	11.5	61	6.6	61	26.5	83
35	19.2	52	8.8	57	29.6	81
36	40.0	35	23.5	34	60.5	86
37	31.6	38	26.2	42	48.8	82
38	26.5	34	13.5	37	51.3	76
41	10.0	50	6.9	58	31.0	84
42	10.5	57	4.5	66	22.4	85
43	7.9	63	7.4	68	17.1	82
44	13.3	60	13.2	68	19.0	84
45	17.0	53	16.7	60	25.9	81
46	36.1	36	30.6	36	57.6	85
47	27.5	40	15.8	38	54.2	83
48	23.5	34	17.5	40	48.1	77
Total N	17.8	1491	14.7	1691	33.2	2532

*11-18 upper right incisor to third molar; 21-28 upper left; 31-38 lower left; 41-48 lower right

Table 1.4 Pathology and sample sizes by tooth

Table 1.4 indicates a reasonably equal distribution of alveolar sites for observation across dentitions (apart from third molars), but we can also see from Table 1.4 that overall sample sizes of intact (including loose) adult erupted teeth are quite small. Right lower canines (tooth 43) provide the largest sample, and canines, as expected, have the fewest carious lesions, except for the curious exception of the left lower canine (tooth 33). Another noteworthy point is the (relatively) low rate of caries in the left maxillary M3 (tooth 28) coupled with quite a high rate of abscessing.

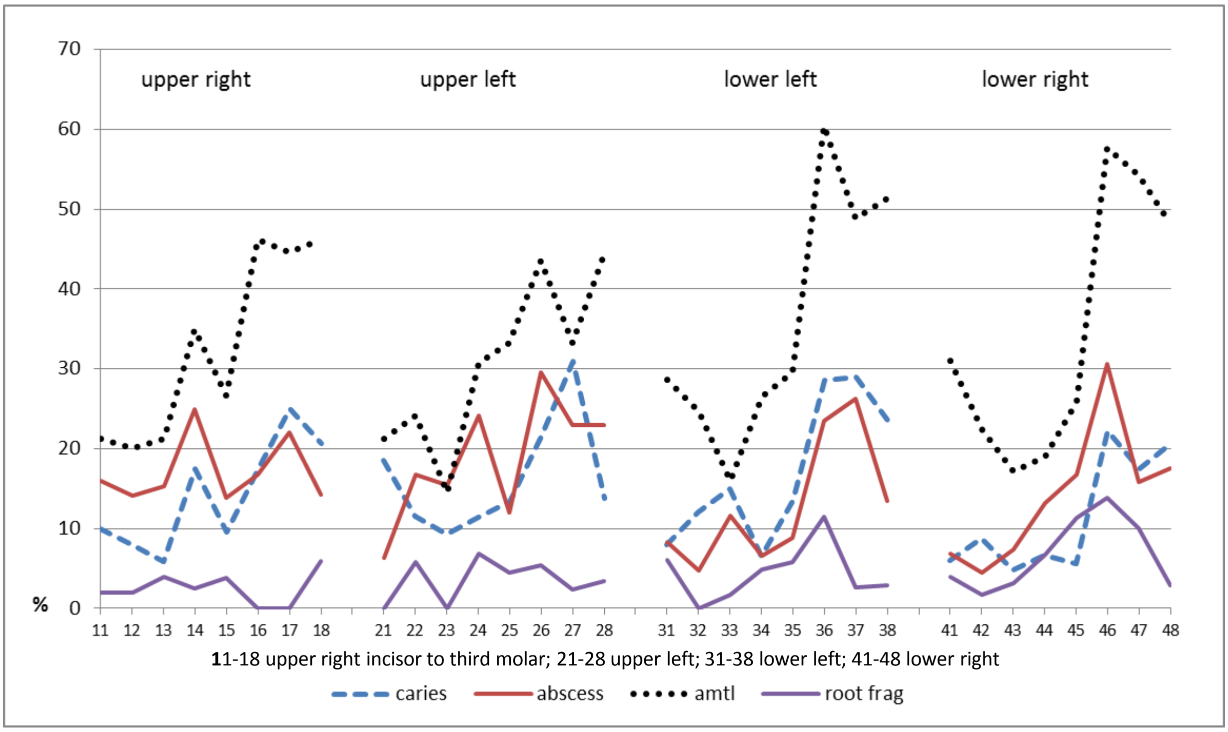


Figure 1 Distribution across alveolar site of carious lesions, abscessing, antemortem tooth loss (amtl) and crown destruction (root frag) in all age classes and both sexes

Root fragments were included as carious in Table 1.3, but could there be non-carious root fragments recorded for anterior teeth resulting from attrition? Root fragments appear only in one code category (i.e., always accompanied by pulp exposure and abscessing), there being no discernable difference in the data between anterior and cheek teeth. In Figure 1 the caries data from Table 1.4 are shown partitioned into clearly defined "caries" and "root fragment", since a root fragment, particularly in the anterior teeth, could be the result of trauma or extreme attrition. This may well apply to teeth 22 (upper left lateral incisor) and 31 (lower left central incisor): tooth 31 also displays a high incidence of antemortem tooth loss. "Root fragment" will be discussed further below.

Lower incisors may be particularly vulnerable to loss because their roots are markedly less robust than those of other teeth, but examining the difference between males and females (the comparison here is of empty sockets from postmortem tooth loss and of resorbed alveolar sites from antemortem tooth loss between the sexes) shows a highly significant difference (χ^2 P value = **.00001**). Females display a much higher antemortem tooth loss; but it is important to note that the female postmortem tooth loss of anterior teeth is equivalent to that of males. Adding to the analysis those sockets in which only root fragments remain, simply increases the female (in comparison with male) tendency for anterior teeth to lose crown integrity. Note, again, that postmortem loss is equivalent between the sexes.

In fact, the more anterior teeth (that is, teeth 1 to 5) display a pattern different left from right, i.e., by side, a feature to be examined in more detail at several points below. The association of pipe smoking (LINK pages 24-25) with abnormal anterior dentitions, in terms of attrition, trauma, pulp exposure and abscessing -- interrelated factors difficult to discriminate amongst -- suggests that we concentrate on the cheek teeth (teeth 4 to 8) in examining pathology rates and interactions in this population. However, Table 1.5 confirms that much of the difference between males and females will focus on the anterior teeth (teeth 1-3: χ^2 P value = **<0.00001**, and **0.00001** if the 16 root fragment alveoli are excluded from the 649 total anterior teeth). The difference between the sexes for carious cheek teeth is non-significant. Table 1.5 provides information on these details.

1.4 Tooth class

Carious teeth (root fragment included)	% anterior teeth: incisors and canines	% premolars	% M1-M2 only	% M3 only
males	6.1 (n = 326)	15.8 (n = 215)	27.5 (n = 167)	21.5 (n = 79)
females	18.6 (n = 323)	16.1 (n = 192)	32.1 (n = 137)	26.9 (n = 52)

Table 1.5 Carious teeth by tooth class and sex

While it might be expected that examining M1-2 in more detail could be useful, based on experience with dentitions in Canadian Iroquoian horticulturalist and Portuguese Mesolithic and Neolithic samples, in fact the P of χ^2 value is only 0.385 (0.460 if 16 root fragment sites are excluded from the calculation), a completely non-significant difference between males and females on caries alone. While caries differences are not significant, teeth lost antemortem must not be ignored when considering whether the significant differences in dental pathology by sex are biological or cultural.

In Figure 1 the expected relationship of caries, abscessing and antemortem tooth loss is well displayed in the lower molars (teeth 36 to 38, 46 to 48), but side differences lead to rather perturbed patterns, specifically with left lower P3 caries/abscessing. This could be because the high rate of dental attrition (wear) in more anterior teeth reduces caries levels. In males the proportion of individuals with attrition rates of 4 and above is highest in left and right upper lateral incisors, left and right upper canines, and the left and right lower canines. But of the cheek teeth, the left lower first premolar (tooth 34) has by far the greater degree of attrition (i.e., the highest proportion of individuals with wear levels of 4 and above). The degrees of attrition are much lower in females. For example, the most worn tooth among females is the left upper first incisor, with 29.6% having wear of level 4 and above: in males, the left lateral upper incisor has wear 4 and above in 66.7% of individuals (for attrition coding see LINK Figure 1).

Molars 1 and 2	Antemortem loss absent	Antemortem loss present	P of χ^2
males	178	110 (38.2%)	**< 0.00001**
females	147	203 (58.0%)	

Table 1.6 Male and female molar antemortem tooth loss

And indeed, other features of the first and second molars are significantly different between the sexes: the patent sockets versus resorbed sockets comparison is extremely significant as seen in Table 1.6, although abscessing by itself is no more significantly different (P of χ^2 = 0.223) in the M1-2 tooth class than in the anterior, premolar or M3 classes.

1.5 Age

Initially, we can check on age class equivalence in terms of sample sizes between the sexes. Firstly, 55% of the sample is female. Secondly, there are peaks of deaths in certain age categories. For example, 11.3% of males died between the ages of 15 and 24, and 15.4% in the years between age 45 and 49. Other than those two peaks, 36.4% of males died from age 65 on. For females, the pattern was different: 10% died between ages 25 and 29, 16.3% between ages 45 and 49 and 38.5% from age 65 on. The basic pattern is of a peak at a young age, the young male peak being earlier than the young female peak (the usual interpretation of this pattern is of young male accidents versus female maternal mortality). Then 68.9% of males die from age 40 and 69.9% of females. Since the split at age 39/40 does not lead to a significant difference between males and females in terms of individual sample sizes (even at the .05 level, as noted above), we will analyze dental pathology in two age groups, up to age 39 and 40 and over. The age class split is therefore 1-5 and 6-13. By age 40 the cultural, dietary and biological (effects of pregnancy and lactation) differences between the sexes will be well established.

In the data set, the overall male/female difference on caries (Table 1.3) is significant (P of χ^2 = **0.00152**), but it fails to reach the .05 level of significance for the over 40 age group (P of χ^2 = 0.061). However, in younger adults there is a difference (male caries incidence 8.3%, female 16.8% (Table 1.7: P of χ^2 = **0.00071**). Since the difference in the occurrence of root fragments (perhaps indicative of gross caries) is completely non-significant between males and females under 40, we can deduce that young females experience a higher incidence of carious disease than do males.

Comparing the younger adults, it is clear that the majority of caries in females are interproximal and buccal. In young males there are more teeth with either multiple or gross caries (i.e., extensive lesions with an indeterminable starting point or points) than in young females (37.9% of all caries in young males as against 25% of all caries in young females). Examining the teeth of those under 40 and comparing those with either no caries or single occlusal caries versus those with interproximal or buccal caries, we find a significant difference (P of χ^2 = **< 0.00001**): interproximal caries or buccal caries occur in only 2.1% of young male teeth as against 13.3% of young female teeth that have single caries of clear origin. Lingual caries are very rare: they occur only in combination with other lesions and only in two maxillary first molars of one young male. The ratio of interproximal to occlusal caries in teeth with single caries of clear origin is 0.36 for young male teeth (4/11), but 2.0 for young female teeth (18/9), indicative of dietary differences between males and females (but see Table 2.7 below).

	Carious intact teeth %					
To 39	8.3 (n = 349)	16.8 (n = 358)	13.1 (n = 351)	12.1 (n = 356)	11.9 (n = 352)	13.2 (n = 355)
40+	20.1 (n = 438)	25.7 (n = 346)	22.0 (n = 359	23.1 (n = 425)	20.1 (n = 394)	25.1 (n = 390)
	males	females	maxilla	mandible	right	left
	Antemortem tooth loss (resorbed alveoli) %					
To 39	2.3 (n = 352)	6.3 (n = 397)	4.8 (n = 377)	4.0 (n =372)	4.8 (n = 372)	4 (n = 377)
40+	31.3 (n =801)	56.7 (n =982)	43.2 (n = 835)	47.2 (n = 948)	45.1 (n = 900)	45.5 (n = 883)
	males	females	maxilla	mandible	right	left
	Antemortem tooth loss plus abscessed empty sockets %					
To 39	2.8 (n = 352)	9.6 (n = 397)	8.2 (n = 377)	4.6 (n = 372)	7.0 (n = 372)	5.8 (n = 377)
40+	40.1 (n = 801)	61.0 (n = 982)	52.4 (n = 835)	50.8 (n = 948)	50.9 (n = 900)	52.3 (n = 883)
	males	females	maxilla	mandible	right	left
	All sockets with abscessing (non-empty included) %					
To 39	2.6 (n = 344)	8.8 (n = 385)	7.4 (n = 365)	4.4 (n = 364)	6.9 (n = 361)	4.9 (n = 368)
40+	22.9 (n = 550)	18.8 (n = 425)	24.9 (n = 474)	17.6 (n = 501)	20.2 (n = 494)	22.0 (n = 481)
	males	females	maxilla	mandible	right	left
	Pulp exposure %					
To 39	2.9 (n = 350)	5.5 (n = 365)	4.2 (n = 354)	4.2 (n = 361)	5.0 (n = 357)	3.4 (n = 358)
40+	12.3 (n = 447)	10.6 (n = 358)	11.3 (n = 371)	11.8 (n = 434)	12.2 (n = 403)	10.9 (n = 402)
	males	females	maxilla	mandible	right	left

Table 1.7 Comparison of younger and older males and females on pathology

From Table 1.7, we can immediately see that a great difference exists between younger and older adults, specifically in antemortem tooth loss which jumps by 50% in females. It is also clear that the increase in abscessing with age is greater in males than in females. This could well be only an apparent increase, since differential dental treatment (extraction) in females would lead to healed alveoli in which abscessing would not be evident. It will be important to examine the male/female differences by tooth type, since it may be possible to discern causes of abscessing and pulp exposure. However, looking now at those individuals age 40 and over (Table 1.8), we again see the same pattern of significance only in antemortem tooth loss comparison between the sexes. Examining all teeth for comparison by sex will result in a P of χ^2 = **< 0.00001** when upper and lower dentitions are analyzed, either separately or together, on antemortem tooth loss in those 40 and over (sockets with root fragments count as patent sockets). But differences in abscessing are significant only between the upper and lower jaws, as noted in Table 1.2, and here in Table 1.8 for older adults.

Compare in those 40 and over by:	sex	jaw	side
Antemortem tooth loss versus patent sockets	P of χ^2 **< 0.00001** males 31.3% (n = 801) females 56.7% (n = 982)	ns	ns
Caries absent/present	ns	ns	ns
Pulp exposure	ns	ns	ns
Abscessing in all patent sockets	ns	P of χ^2 **= 0.00507** maxilla 24.9% (n=474) mandible 17.6% (n = 501)	ns

Table 1.8 Tests of pathology in older individuals by sex, jaw and side

Table 1.8 lays out in summary form the comparisons made.

The next task will be to examine the tooth classes with relation to pathology, specifically antemortem tooth loss and root fragments in males and females of 40 years and over. It should be noted that the coding for antemortem tooth loss was done separately, to check for coding accuracy, in the variable "status" and in the variable "socket". There was also coding within "crown" and "root" variables noting antemortem tooth loss in order to ensure that observable/non-observable features were accurately recorded. In Table 1.9 loose teeth are, of course, excluded from the "status" variable in the calculation of socket numbers.

Tooth class in those 40+: all alveolar sites		% antemortem tooth loss	P of χ^2
Anterior	male	19.0 (n = 305)	**< 0.00001**
	female	41.5 (n=369)	
Premolars	male	23.0 (n=204)	**< 0.00001**
	female	50.6 (n=247)	
M1-2 only	male	51.8 (n=199)	**< 0.00001**
	female	78.0 (n=246)	
M3 antemortem loss	male	26.9 (n=93)	0.071
	female	16.7 (n=120)	
M3 antemortem loss plus aetiology unknown antemortem loss	male	46.2 (n=93)	**0.00017**
	female	71.7 (n=120)	

Table 1.9 Tests of antemortem tooth loss in older males and females by tooth class

Table 1.9 shows comparison on antemortem tooth loss for males and females 40 years and over: here the analysis is by tooth classes, perhaps especially helpful in trying better to understand the situation with the third molars. Table 1.9 suggests that the M3 tooth absence of uncertain aetiology should be considered as, in great part, antemortem tooth loss from the same causes as for the more mesial teeth. All but one "unknown cause" tooth absence occurred in M3s (male n = 18; female n = 66). The exception, mentioned before, was an upper left canine in a 40 year old female who had lost three mandibular teeth and also had roots, only, remaining from two other teeth. The loss of a canine may seem unusual but, in fact, 13.3% of upper left canines, and 21.3% upper right canines, were lost antemortem, and the lower left and right canines were lost in 15.8% and 17.1% of alveolar sites respectively (sockets patent and not patent): 75.5% of lost canines were in females.

Antemortem tooth loss tested by jaw led to non-significant results, both in males and females. A similar series of tests as laid out in Table 1.9, again only on individuals age 40 and over, on abscessing, yielded not a single significant result based on tooth classes. However, abscessing in males is significantly different between jaws (P of χ^2 = **0.00555**). In both sexes, abscessing is more common in the maxilla (28.1% for males, 20.9% for females) than in the mandible (only 18.2% in males and 16.7% in females).

The results on pulp exposure were similarly non-significant, apart from one difference between males and females, marginally significant at P of χ^2 = *0.0476*. That result related to pulp exposure in the maxillary teeth with root fragments included: the percentage of males, age 40 and over, with pulp exposure in the maxillary teeth, was 14.3% versus 7.7% for females. The number of teeth observed was 371.

As a summary of data on antemortem tooth loss, Figure 2 shows us that not only is the tooth loss double in females, but the pattern of loss over a lifetime is probably different, insofar as we can judge by the state of dentitions at time of death. In Figure 2 we see that females are likely to die with tooth loss more often than males, especially in the age group 50-60, and that in the age group 70-80 many more females will die with antemortem tooth loss. In fact, in the age group 70-80, 74.7% of all alveolar sites among females will have suffered antemortem tooth loss. In comparison, 43.7% of sockets in that age group of men will have lost teeth antemortem. There can be little doubt that females have more pathology, but especially that antemortem tooth loss in females is accelerated by some factor which is most parsimoniously identified as extraction of pathological teeth. The sample sizes are very different because, of course, the percentage of lost teeth at female alveolar sites (at 44.1%) is nearly double that of male sites.

Figure 2 presents the age distribution of only those alveoli displaying antemortem tooth loss, but a different presentation is possible, and this is provided in Appendix II where the age distribution by sex of antemortem tooth loss frequency across all alveoli is shown.

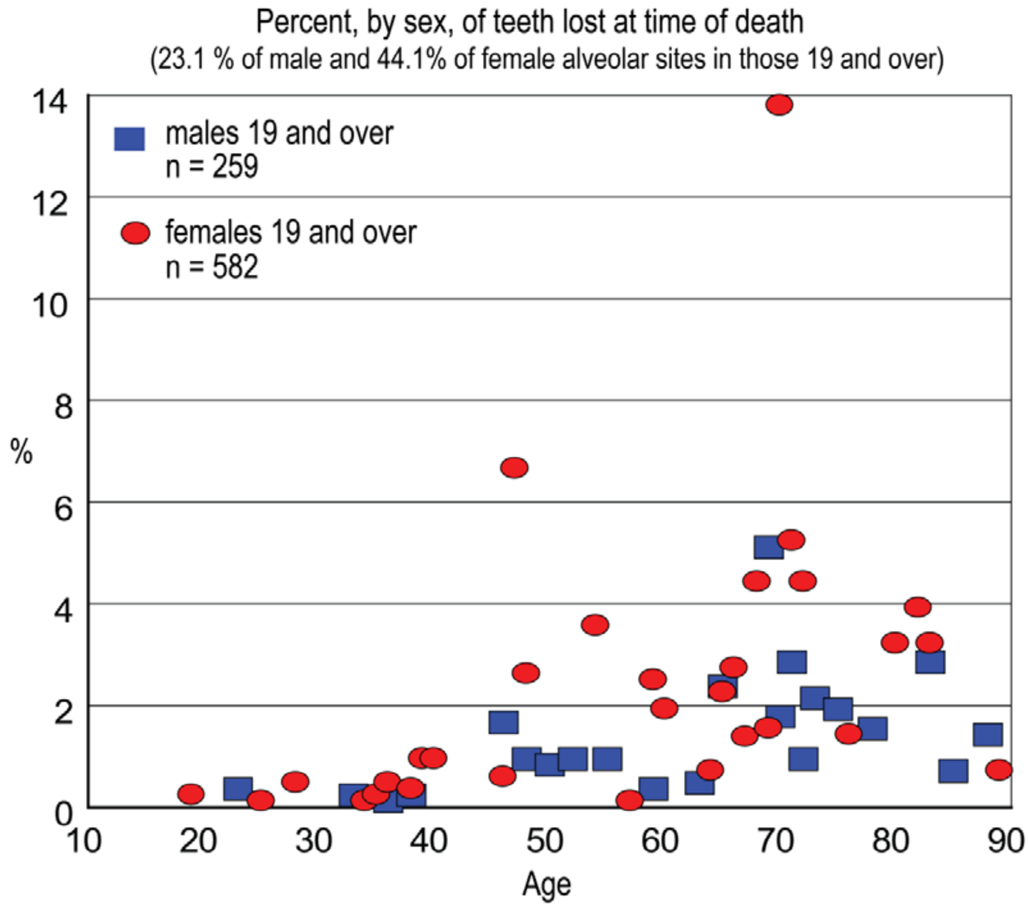


Figure 2 Distribution by age at death of alveoli with antemortem tooth loss

There is a dramatic difference in antemortem tooth loss between males and females. By age 50, cumulatively 14.3% of male teeth have been lost, compared with 25.1% of female teeth. By age 70, 53.3% of male teeth have gone, contrasting with the cumulative percentage of 69.8% of female teeth lost antemortem.

1.6 Focussing on significant results: maxillae in older age grouping

Maxillae 40+		% Pulp exposure roots frags/ intact teeth and root frags	% Abscess present at alveolus/all alveoli	% Complete resorption at alveolus/all alveoli	% teeth carious (root frag included)/all teeth	% of teeth in alveoli which are root frags/intact+roots
males	anterior	12.2	22.7	15.6	10.1	1.2
	pm	14.7	22.3	22.3	29.6	5.8
	M1-2	8.5	18.0	48.3	32.4	3.2
total		222	324	324	177	165
females	anterior	4.4	8.2	40.4	21.3	5.5
	pm	8.2	9.1	56.2	16.7	8.3
	M1-2	10.2	12.9	66.4	37.9	7.7
total		179	420	420	151	135

Table 1.10 Pathology in maxillae in those individuals aged 40 years and above.

The first column of Table 1.10 suggests pipe smoking as a cause of anterior and premolar tooth pulp exposure in males and an accompanying tendency towards abscessing. On the other hand, no such simple solution is provided by the columns recording any interaction between caries (with fragmentary roots considered to be associated with caries) and alveolar resorption. Females have more alveolar resorption, but their caries frequency is greater only in the anterior teeth. Greater attrition in anterior teeth as a result of pipe smoking could explain the lower incidence of anterior caries in males (an interpretation supported by higher rates of pulp exposure and abscessing in males in anterior teeth). Reduction of anterior teeth to root fragments appears to have a complex relationship to caries and other factors.

1.6a Attrition levels: anterior teeth and pipe smoking: anterior teeth only, both jaws, both younger and older adult teeth.

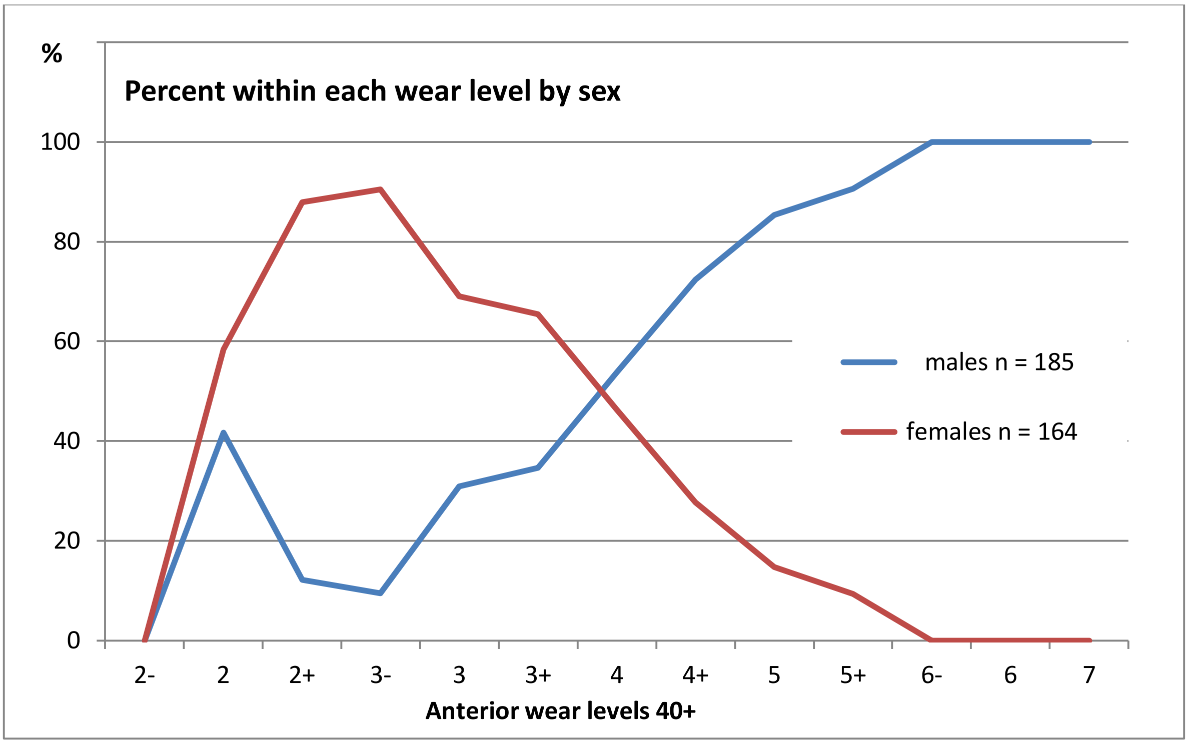


Figure 3 The representation of each sex within each wear level for anterior teeth

In Figure 3 we see the total number of anterior teeth, upper and lower incisors and canines, at each wear level, partitioned into male and female (in the calculation, each wear level totals = 100%, i.e., analysis by wear level by sex). At each lower wear level, the female percentage is higher, but in more advanced wear levels, the representation of males is much greater. The immediate question is whether the sample sizes are comparable, because of antemortem tooth loss rates among females.

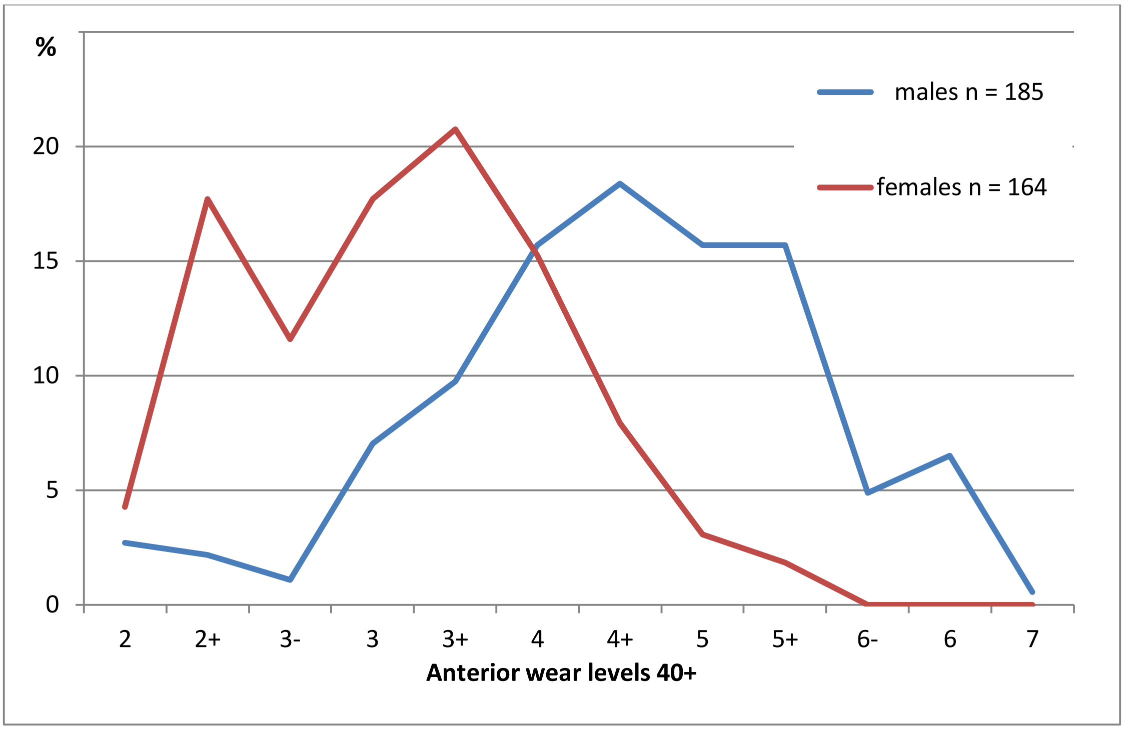


Figure 4 The distribution of anterior teeth wear levels within each sex

In Figure 4, we compare the 185 male anterior teeth and 164 female anterior teeth. Here the total number of each sex represents 100%, i.e. analysis by sex. This confirms the distribution of each set of teeth, male and female, across the relevant anterior dentition attrition levels, that is, the percent distribution of each sex separately across each of the wear levels. It is clear that the female sample is not evenly distributed, but nor is the male. The difference suggests higher levels of anterior attrition established earlier in males. The complete distribution of wear level by age class in each sex is too large a table to reproduce, so we will summarize it by partitioning each sex/wear sample into younger and old (with 39/40 as the split point).

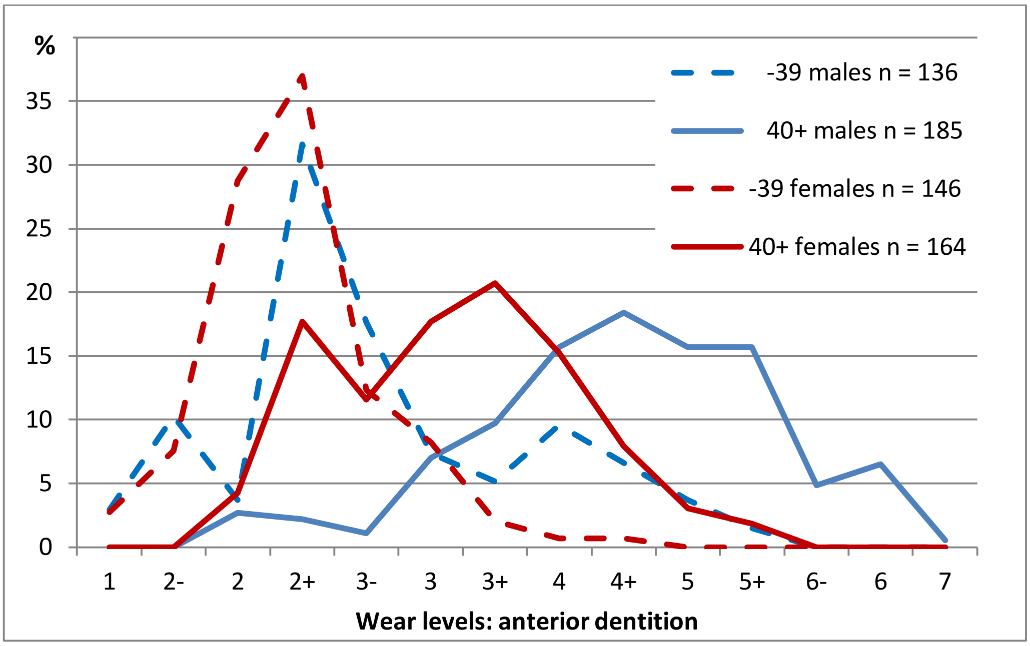


Figure 5 Comparison of anterior wear levels by sex and age groupings

Figure 5 demonstrates anterior tooth wear in 631 teeth (282 in the younger and 349 in the older age category: the age and sex groupings are the units of analysis). The graph shows that, in fact, the percentage distribution of wear across age classes in younger individuals (to age 39) is not markedly different between males and females. This can be further demonstrated by Figure 6 in which the 124 males and 225 females are distributed across their respective wear levels, up to the cut-off point of attrition = 3.

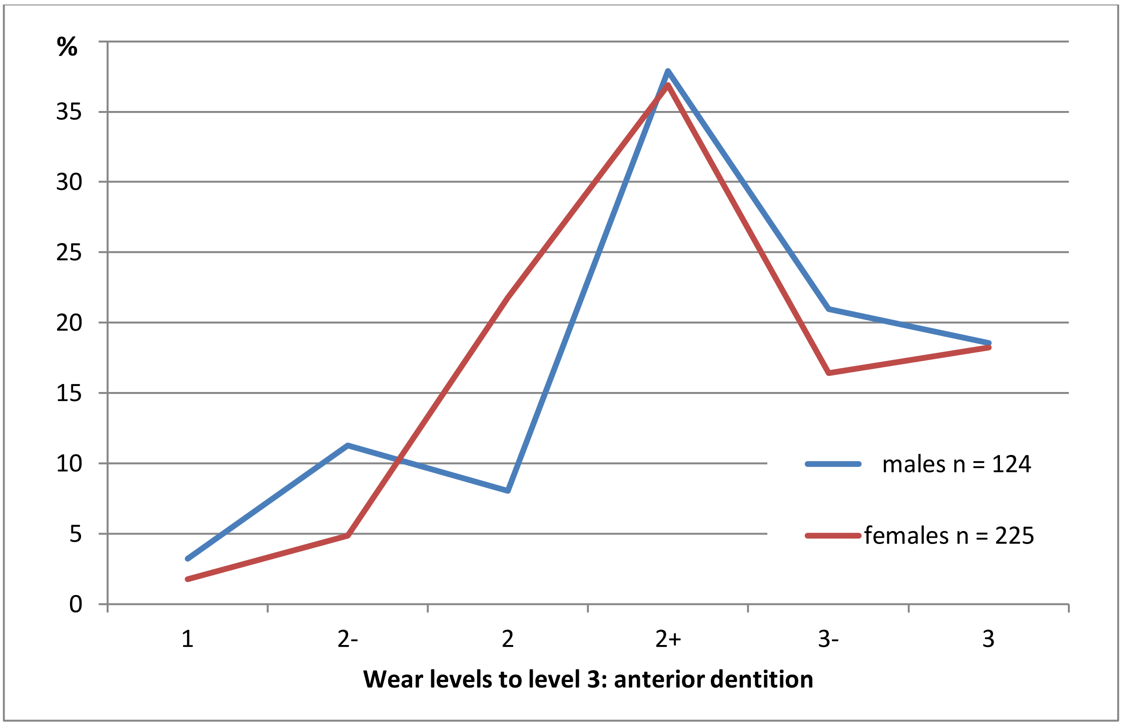


Figure 6 Comparison of early wear levels in the anterior dentition by sex.

It is clear that wear levels diverge only after wear level 3, in terms of percent distribution of males and females across wear levels (summed levels = 100%, i.e., analysis by sex). The oldest males in Figure 6 are in age class 11, and the oldest female is in age class 13. Among males in wear level 3, 56.5% are in the older group (40+), while an equivalent 58.5% of females in wear level 3 are in the older group (40+). For this reason, we can say that there is a good equivalence of males and females with lower levels of attrition in the anterior teeth. Not all males have high attrition in their anterior teeth.

Despite this apparent similar distribution across ages, the anterior tooth sites may not provide reliable information on differential wear by sex.

Overall, there is a much more even distribution of male teeth across wear level and age class, with a large number in the oldest category, whereas there are very few female **teeth** in the oldest age class (because of higher antemortem tooth loss levels), 13 lost of 24 alveolar sites versus only 1 lost of 24 in the male anterior alveoli of age class 13). Age classes 8 and 12 will clearly be discrepant: there are only 6 female anterior alveolar sites in age class 8 (compared with 18 for males) with no wear levels recorded (observation of wear impossible). Only 11/22 male sites in age class 12 have wear levels recorded, but for females the record of possible observations is lower (9/43). The effect on analysis of the relationship of attrition levels to antemortem tooth loss intensifies the discrepancies caused by differing representation in age-at-death classes. Table 1.11 demonstrates that, for females, the number of intact and non-carious teeth is compromised (2/4 female carious teeth have gross lesions, and 1 of 2 male teeth, obviously not observable for attrition).

Anterior maxillary teeth only	Age class 8				Age class 12			
	Intact and loose teeth	Antemortem tooth loss+root frag	Pulp cavity exposed present:absent	Caries *pr/N intact teeth	Intact and loose teeth	Antemortem tooth loss+root frag	Pulp cavity exposed present:absent	Caries pr/N intact teeth
males	10	3+1	1:10	2/11	11	5+0	6:6	0/11
females	0	5+0	0:0	0/0	9	25+2	2:10**	4/11

*pr/N refers to feature present/sample size

**differences in sample sizes can arise when a loose tooth is counted with intact teeth for caries and pulp cavity exposure, but loose teeth cannot be included when considering features dependent upon number of observable alveolar sites. Pulp cavity exposure is observed in *in situ* and loose intact teeth, and in root fragments in alveoli.

Table 1.11 Anterior maxillary pathology in age classes 8 and 12

Despite these concerns, it seems clear that females die with lesser levels of anterior attrition than males, despite surviving at higher rates into old age, so that the female anterior alveolar site sample is larger in age class 12.

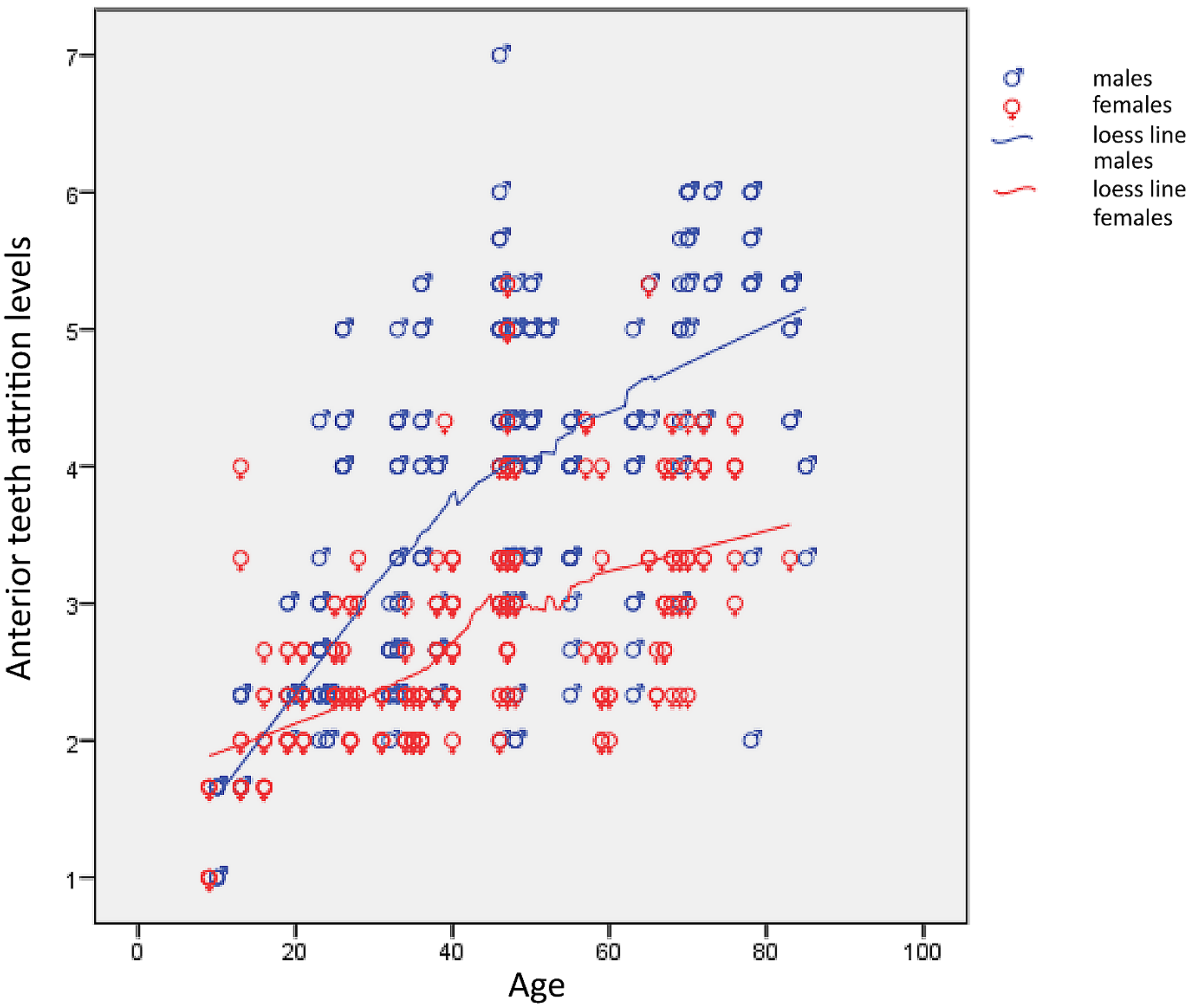


Figure 7 The spread of anterior attrition levels by age in males and females

As a summary of attrition in the anterior teeth in all individuals, Figure 7 provides a scattergram of age (x axis) and attrition (y axis) and includes loess lines (50% of points fitted, Gaussian kernel) giving us a graphic indication of the spread of attrition, which is much broader for males than for females. In other words, some males survive to over 80 with anterior teeth remarkably unworn. The male mentioned previously with attrition at level 7 in his 40s is clearly an outlier, as is the young girl with quite heavy anterior wear.

We should also note that if there is pipe smoking, it does not affect one or the other side of the anterior dentition differentially. Summarizing the enquiry into this, we can note that among male intact anterior teeth, 39% of teeth on the right fall below the 3+ wear level, and 38.3% on the left. Those teeth with wear levels of 3+ and more make up 61% of the right anterior teeth, and 61.7% on the left. Analysis separately of those above and below our age split of 39/40 similarly gives no definitive evidence of consistent greater wear on the right or the left.

We cannot take the attrition levels for granted in comparison with other samples, however: pipe smoking will increase attrition, high levels of dental pathology, loss and extraction will affect wear on antimeres. For example 10.1% of males (n = 189) as against 23.3% (n = 176) of females have caries in their anterior teeth, root fragments included. That is a significant difference (P of χ^2 = **0.00065**), already suggesting that females were eating more cariogenic, less abrasive food, and would be avoiding foods requiring heavy mastication.

As yet, we have not concentrated on abscessing in anterior teeth to see the relation of abscessing to sex. In males there is consistently high abscessing in anterior teeth from age 40+ on, and the difference from females is significant. The difference for cheek teeth is non-significant. Since abscessing shows a significant difference by jaw (Tables 1.2 and 1.8), we will now focus on anterior maxillary teeth in the older age group.

Anterior maxillary teeth in age group 40+	% abscessing in all patent alveoli	% pulp exposure including root fragments	% abscessing in sockets either empty or with root fragment	% complete resorption
males	26.9 (n = 119)	14.6 (n = 89)	50.0 (n = 38)	15.6 (n = 141)
females	14.2 (n = 106)	5.0 (n = 80)	40.5 (n = 37)	41.1 (n = 180)
P of χ^2	**0.01900**	*0.0382**	0.411	**<.00001**

*marginally significant

Table 1.12 Testing pathology in maxillary anterior teeth by sex

Can the higher rate of abscessing in maxillary anterior teeth in males (Table 1.12) be associated with the higher male wear levels? Caries differences are still present among older individuals, 10.1% for males versus 21.3% for females, but the significance level does not reach 0.05, because the sample sizes are now only 89 and 80 respectively for maxillary anterior teeth. Was it because of attrition that the researchers recorded a higher rate of pulp exposure in the anterior upper teeth of older males? But the researchers did not record a greater presence of root fragments in the anterior maxillary teeth of males who died over age 40 (there is a root fragment only for the right lateral incisor of a 50 year old male, with abscessing and pulp exposure, his adjoining central incisor completely gone from an abscessed socket). There are four females with root fragments in this anterior maxillary category, all with abscessing. The youngest of these females with root fragments is a 69 year old with only five intact maxillary teeth, and five of her seven observable maxillary alveoli have abscesses: her wear levels are low, between 2+ and 4+, no doubt because of lack of occluding teeth and a diet of soft food.

While there is the suggestion that pulp exposure was a result of attrition, it is possible that pathology is responsible for the observation that significantly more female than male anterior maxillary alveoli were recorded as completely resorbed. Again, analysis is made difficult by antemortem tooth loss, but the wear/pulp exposure finding is relevant. Looking at maxillary anterior teeth in males of 40+ with wear levels of 3 or greater, 14.6% of these males had pulp exposure (n = 82). None of the 75 females had pulp exposure. Indeed, only two females reached the wear level at which pulp exposure began to be recorded for males (5+, according to the schema followed, which refers to teeth that still have a narrow complete rim of enamel on the occlusal surface, see LINK Figure 1). Pulp exposure is linked to male anterior attrition (and probably to abscessing) and reference to Figure 7 will confirm that female teeth did not survive intact to that level of attrition.

1.7 Examination of empty sockets, all tooth classes, both jaws, both age groups

Examining, in the total sample (i.e., all tooth classes), the presence of periapical abscessing (defined except for two cases as an open lesion in the alveolus, as noted previously), we find that maxillary empty sockets are overrepresented, but there is no consistency regarding which side has more empty sockets with periapical abscessing. Cheek teeth, i.e., premolars and molars, have a higher incidence of abscessing at the empty socket sites, apart from second premolars (P4s). But there is little consistency: a better approach is to consider all sockets with indications of periapical abscessing, those that are empty, and those that retain intact teeth or roots.

In the total sample, alveolar sites that retain a root fragment are very much more likely to be mandibular and most likely to be P3 to M1, especially on the right side. We can be assured that what is coded in this category is not just the result of taphonomical developments, but representative of either attritional or pathological processes. Overall, 25% of sockets in which there is an indication of abscessing have a root remnant. No socket has a root remnant except in the presence of abscessing. There are 62 cases of root remnants, all with abscessing, while abscessing also occurs with 60 intact teeth in alveoli, and in 127 cases of empty sockets. Of 295 empty sockets in the total sample, 43% are associated with abscessing, especially in the first and second molars. At first and second molar sites, 89.1% of all empty sockets are abscessed. In the upper and lower right M1 and the left lower M1 and M2 sites, all empty sockets have abscessing. This suggests that for the cheek teeth, empty sockets do not indicate simple postmortem loss. This suggestion, that empty molars sockets may represent pathological loss, is not unexpected.

We need to examine the relationship of abscessing and empty sockets more closely, because the method of recording specified that only complete resorption of an alveolus would be recorded as antemortem tooth loss: we are therefore unable to understand the nature of "empty sockets" fully. It could be a matter of postmortem tooth loss or it could be a case of premortem tooth loss in which the socket has not completely resorbed.

In Figures 8a and 8b we look at the relationship of abscessing to sockets which were not recorded as having teeth lost antemortem. The figures show 1. the percentage of sockets with an intact tooth and also abscesses; 2. the percentage of empty sockets with abscessing; 3. the percentage of sockets with root fragments for which abscessing is recorded.

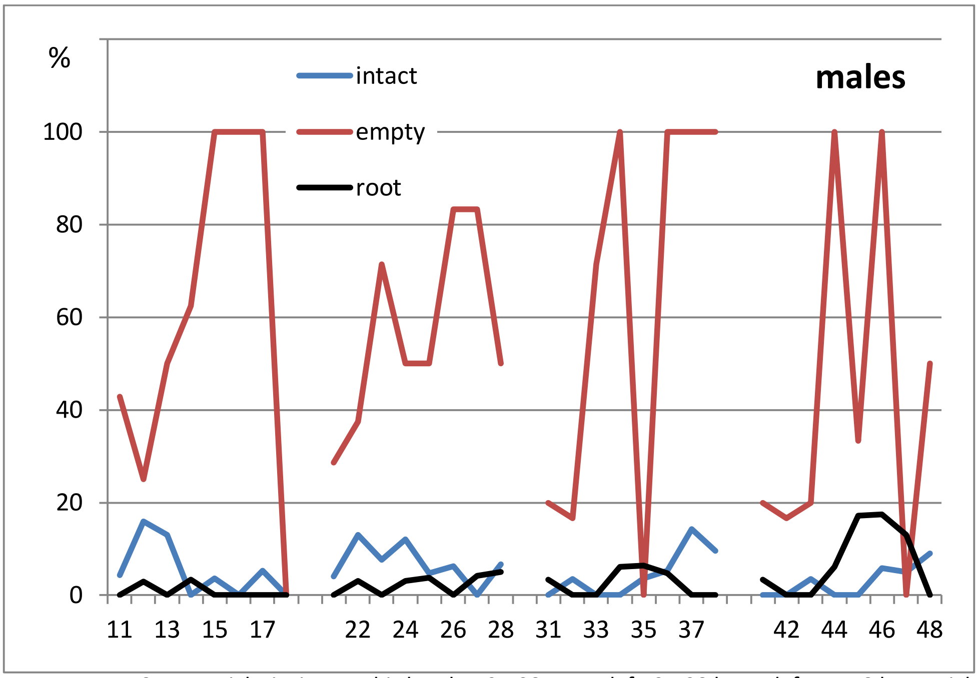
If we analyze including antemortem tooth loss, it seems unlikely that we can use abscessing to help us understand the overall nature of the empty sockets. By excluding antemortem tooth loss rates, we see that empty sockets, particularly in molars, are likely to be ones in which pathology had weakened the integrity of the teeth to a great extent. The analysis is not strong, simply because the sample sizes are very small. Figures 8a and b show abscessed sockets with intact teeth as a percentage of all sockets with intact teeth, and demonstrate that maxillary abscessing in males is more frequent in anterior teeth and the left P3. Note again that the sockets being examined are those with intact teeth, and **not** those with root fragments (i.e. crown destruction). The analysis then follows through with the empty sockets, expressing those with abscesses as a percentage of all empty sockets (e.g., in both males and females every one of the very few empty sockets in teeth 36 and 37 - lower molars – was abscessed, as is shown in Figures 8a and b). Finally, for sockets with root fragments, all were abscessed, and in Figures 8a and 8b the percentage of all patent sockets which have root fragments is shown. In these figures we see the percent frequency of abscessed patent sockets (resorbed excluded). The x axis displays the teeth: upper right, upper left, lower left, lower right, as in Figure 1.

Some idea of sample sizes can be gained from Table 1.15. The higher percentage of empty sockets in which there was abscessing is immediately obvious. We can also see that abscessed empty sockets are more common in males than in females. For the total of 139 male empty sockets, 51.8% are abscessed, whereas only 35.3% of the 156 female empty tooth sockets were abscessed. This is a significant difference (P of χ^2 = **0.00418**), again suggesting that females were more likely to have pathological teeth removed, and that a large number of empty sockets (especially in molars) were empty because of pathology, rather than simply as a result of postmortem taphonomic factors.

Presence of abscessing		Incisors/canines	Premolars	Molars 1 and 2	Molar 3
% of sockets retaining intact teeth	males	5.2 (n = 306)	3.0 (n =99)	5.4 (n = 147)	6.7 (n = 75)
	females	2.1 (n = 281)	4.2 (n =165)	8.7 (n =115)	4.3 (n =46)
% of empty sockets	males	36.4 (n = 77)	61.3 (n = 31)	90.9 (n = 22)	55.6 (n = 9)
	females	17.7 (n =79)	29.3 (n =41)	87.5 (n =24)	66.7 (n =12)

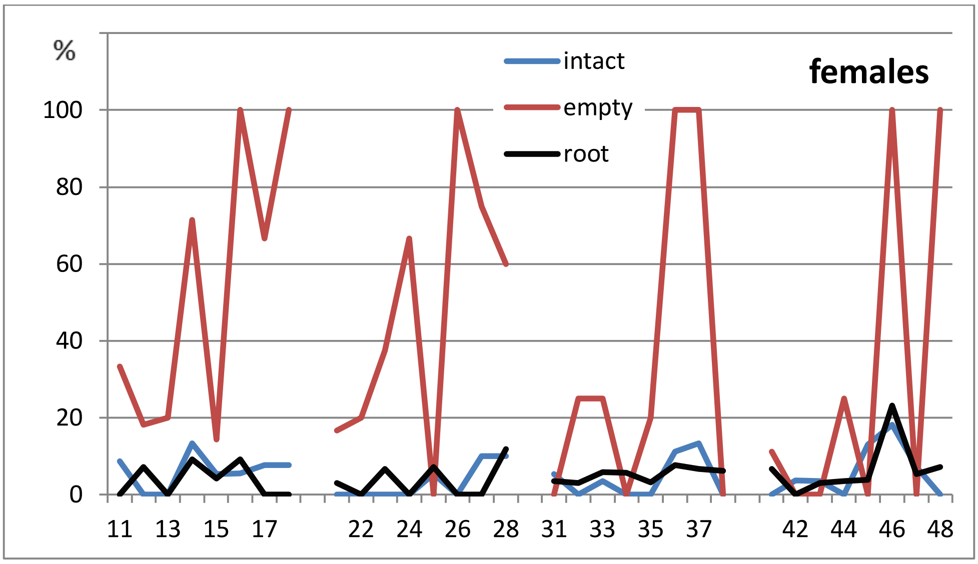
Table 1.15 Abscessing in all sockets, both jaws, both age groups, by sex and tooth classes: Appendix III provides further information and comment on abscessing

Taphonomic factors should be roughly equivalent between the sexes, but from Table 1.15 we can calculate that male empty sockets indicate significantly fewer teeth lost from normal taphonomical processes – without abscessing (see also Table 2.2). This could be explained if male teeth were found to have more robust or curved roots, but reduced integrity of female intact teeth would be a more straightforward explanation.



11-18 upper right incisor to third molar; 21-28 upper left; 31-38 lower left; 41-48 lower right

Figure 8a



11-18 upper right incisor to third molar; 21-28 upper left; 31-38 lower left; 41-48 lower right

Figure 8b

Figure 8 Percentages of abscessing in sockets with an intact tooth; of abscessing in empty sockets (i.e., postmortem tooth loss); of abscessing in sockets with root fragments

Finally, we will return once more to the question of whether anterior maxillary abscessing has any relationship to pipe smoking (Table 1.16). Looking at the evidence from the abscessing variable, we see that there is a slight interaction of abscessing and sex, but that this is overwhelmed by the interaction of complete alveolar resorption and sex. In other words, the antemortem tooth loss in the anterior teeth suggests the possibility of extraction leading to draining and healing of abscesses in maxillae. Since the significance of the difference in tooth loss between the sexes (age 40 and over) in the mandible is even greater (P of χ^2 = **0.00005**), we can conclude that extraction has an effect on the incidence of abscessing in all anterior teeth.

Anterior teeth 40+	alveolar sites assessed for abscessing	% of abscessing in all sockets (complete resorption included as abscessing)	P of χ^2	Comparison of maxillae by sex P of χ^2	% complete resorption	P of χ^2	Comparison of maxillae by sex P of χ^2
males	maxillae (n=141)	22.7	**0.00057**	**0.02288**	15.6	0.159	**0.00295**
	mandibles (n= 164)	8.5			22.0		
females	maxillae (n= 180)	8.3	0.741		41.1	0.813	
	mandible (n= 189)	7.4			42.3		

Table 1.16 Comparison of abscessing in anterior teeth in older adults: the totals include all sockets

Finally, a simpler table (Table 1.17) with raw data will round out the fact evident from the beginning of this analysis, that abscessing in maxillae is of importance. We can now specify that anterior maxillary abscessing in older males is very significant in this sample – as suggested by Figure 8a. Here, we are looking only at the simple distinction between sockets with no abscessing apparent and sockets in which abscessing could be recorded. The table demonstrates that the question of abscessing differences in anterior teeth is firmly linked to the maxillary teeth in males. Association with the pressure trauma and attrition produced by the use of pipes, as well as the effects of tobacco on tissues, might be adduced as contributing to this pathology. Further study of such a problem should consider hypercementosis in the anterior tooth roots.

Abscessing in anterior intact sockets	jaw	absent	present	Jaw within sex comparison P of χ^2	Comparison by sex for maxillary sockets P of χ^2	Comparison by sex for mandibular sockets P of χ^2
Males	maxilla	87	32	**0.00129**	**0.01895**	0.650
	mandible	114	14			
Females	maxilla	91	15	0.779		
	mandible	95	14			

Table 1.17 Presence of abscessing by sex and jaw in anterior sockets of age grouping 40+

We have a secondary source that may help in understanding the relationship of the various factors discussed above.

2: Comparison with second research project on Zwolle dentitions

I was grateful to be given access to work on Zwolle teeth done by Simon Mays, who has published his observations on the relationship of tooth height to wear and of antemortem tooth loss to age *(Journal of Archaeological Scienc*e (2002) 29: 861–871; *American Journal of Physical Anthropology* 2014 153 (4): 643–652). Again these have not been consulted, in order to avoid preconceptions.

The Mays data was also recorded in a way that required an "unpacking of portmanteau codes", not graphic but using symbols such as "."and "*" in association with capital letters and numerals in one cell representing one tooth. Thus, to be certain of the observable sample sizes for each variable, it was necessary to translate the symbols into separate variables for each tooth. Mays had not recorded the Zwolle burial identifying numbers, so identification had to be based on the recorded age and sex. Unfortunately, not all individuals could be identified, so the next step involved checking specific teeth against all possibilities, to ascertain whether ages, especially, had been written down correctly. The method of identification was very time consuming. For example, in the case of a tooth 13 (upper right canine) with a gross caries in a 34 year old male, no match was found. There were indeed two females, 69 and 83 years old, with possible matches for such a feature, but they had both been paired up with Mays identification numbers. All the other right upper canines that had caries recorded in the original research project could be assessed for wear, because the lesions were not occlusal, thus according with the usual condition for canines. Though laborious, my efforts seemed necessary, because I wanted to understand exactly what coding for antemortem tooth loss meant to different researchers. The next step was to pick several features and search, for example, for which female had both upper central incisors with what were coded as caries of the crown walls. Mays had coded a 56 year old female with characteristics including caries, abscessing and postmortem tooth loss for the incisors and the left canine and P3. There was no 56 year old female in the data set used here. Searching on caries in the right central and the left lateral incisor, canine and P3 failed because there were no individuals in the original Zwolle study with this combination of caries, but two individuals had at least three of the features searched for. One was already identified as Mays individual 117, a 28 year old female, another as a 48 year old male (although there were some differences on caries interpretation). Rechecking the Mays file confirmed the 56 year old female record, and no solution was found to this problem. A 46 year old male with six loose carious teeth matched with no individual, but could only have been a 46 year old male who in fact had six loose carious teeth, the majority of the teeth identified differently from the original research.

Because of the number of discrepancies such as these, it was decided to examine antemortem tooth loss simply as recorded by Mays because any attempt to align all individuals' dentitions and identifications of specific teeth or alveolar sites would lead only to guess work.

We can get a general idea of whether the original (to be identified as TC-W) observation on abscessing and antemortem tooth loss is supported by this second set of data. Firstly, abscessing does not occur differentially in males and females (though an exception to this may be empty socket abscessing incidence, see Table 1.15, and with anterior maxillary teeth as seen in Table 1.17). Secondly, antemortem tooth loss is highly sex dependent in frequency. Thus, we again have the suggestion that antemortem tooth loss indicates the extraction of diseased teeth preferentially in females, observing, as before, only adult teeth.

Mays data		sockets with intact tooth	sockets with postmortem tooth loss	antemortem tooth loss
males	no abscess	764	96	332
	abscess	46	32	6
females	no abscess	642	84	631
	abscess	53	29	2
male/female comparison (df = 1)	P of χ^2	0.129	0.906	-
male/female comparison (df = 3)	P of χ^2	0.501		-

Table 2.1 Mays data on abscessing and tooth loss, by sex

Testing the data in Table 2.1 on the sex difference in abscessing associated with sockets retaining intact teeth provides a non-significant result (P of χ^2 = .129). The same test cannot be confidently undertaken for sockets with teeth lost antemortem, because of sample sizes, although there are indications of a difference. Abscessing in sockets with postmortem tooth loss is again completely independent of sex (P of χ^2 = 0.906). In the Mays data set, a quarter of the teeth that were lost postmortem were from abscessed sockets (61/241, with no difference between males and females, Table 2.1).

As stated above and shown here in Table 2.2, the original (TC-W data) finding was very different: of the male empty sockets, 51.8% were abscessed, while 35.3% of the female empty tooth sockets were abscessed (P of χ^2 = **0.00418)**. Abscessed sockets retaining intact teeth also produced differences between the two analyses, but much less dramatic differences and the male/female comparison in the TC-W data demonstrated no difference by sex (P of χ^2 = 0.542). Abscessing, but also postmortem tooth loss, were apparently defined differently in the two studies. The marked difference in the two sets of data can be demonstrated by comparison of the results from two χ^2 at 3df (Tables 2.1, 2.2).

TC-W data		sockets with intact tooth	sockets with postmortem tooth loss
males	no abscess	692	67
	abscess	35	72
females	no abscess	582	101
	abscess	25	55
male/female comparison (df = 1)	P of χ^2	0.542	**0.00418**
male/female comparison (df = 3)	P of χ^2	**0.00310**	

Table 2.2 Original research data on abscessing and tooth socket codes by sex (the data derived from the complete "status" variable for all 2545 alveolar sites). See also Appendix III

It is obvious that the original TC-W research technique of observing abscessing in alveoli from which intact teeth could actually be removed did not lead to an overestimation in the rate of abscessing (compare Table 2.1, intact teeth sockets, males and females, 46/810 = 5.7% and 53/695 = 7.6%, with Table 2.2, intact teeth sockets, males and females, 35/727 = 4.8% and 25/607 = 4.1%). The question was whether the original method might have led to very different (probably higher) rates of abscessing than recorded by other researchers, especially as the technique of tooth removal could not be used in many archaeological samples. Clearly, in this case, the TC-W rate was lower. There was concern that the strict definition of abscessing as the presence of an actual cavity, may also have reduced rates of abscessing, but it is obvious that the empty socket original observations produced markedly higher rates of abscessing than did the removal of intact teeth from sockets for observation. Thus it is clear that tooth removal did not lead to overestimation, and the strict definition did not lead to underestimation with regard to abscessing.

Was antemortem tooth loss underreported by the original methodology? Table 1.2 provided the TC-W information that 22.5% of 1153 male sites had antemortem tooth loss, and 42.2% of 1379 female sites had antemortem tooth loss. Based on Table 2.1, 29.4% of 1148 male sites and 47.7% of 1328 female sites had antemortem tooth loss, according to the Mays data. The differences, by sex or in total, are very significant, so we need to understand this.

Figures 9a, 9b, 9c and 9d represent an attempt to deal with the complexities of this difference. In the figures, the totals are derived ONLY from the number of sockets with antemortem tooth loss (i.e., resorbed sockets) or postmortem tooth loss (i.e., empty sockets). The attempt here is to understand the pattern of occurrence in males and females and in each jaw, as well as to see whether there are consistent differences or similarities in the observations of the two research data sets (remembering that the two sets are not exactly the same in terms of sample numbers and identification as to alveolar sites and sex).

Female maxillae (Figure 9a) provide a neat pattern: antemortem tooth loss and empty sockets mirror each other because the two variable percentages total 100%. We can see clearly where the two data sets diverge in the interpretation of the alveolar condition. The divergence is most extreme at the right premolars, the left canine and the left first molar. The tendency is obviously for the Mays data more often to record teeth as lost antemortem than postmortem. In the case of female mandibles (Figure 9c) there is clearly more convergence of interpretation of socket condition, except in the case of canines, but only on the right (compare also the difference between left and right maxillary canines in Figure 9a).

Male maxillae (Figure 9b) present a completely different picture from the female maxillae, although the same tendency is apparent, that the Mays data more often records antemortem tooth loss than an “empty socket”. The difference of left from right in the male maxillae is also notable. It is clear that there is some factor altering the relationships in anterior maxillary dentitions in males, and this can be discerned also in the mandibles to some extent. The examination of two sets of data certainly demonstrates differences in interpretation and identification, but it shows that there are, without a doubt, some differences between males and females affecting male anterior teeth. With regard to female cheek teeth, we see overwhelming agreement between researchers that antemortem tooth loss affects females more broadly across tooth classes than males. Cultural intervention is a possible explanation for this.

The following figures compare the two data sets on antemortem tooth loss and empty sockets.

The object of the comparisons illustrated by Figure 9a-d between the Mays (M) data and the Constandse-Westermann (C-W) data is not so much to highlight differences in interpretation as to confirm the evidence provided by the initial research.

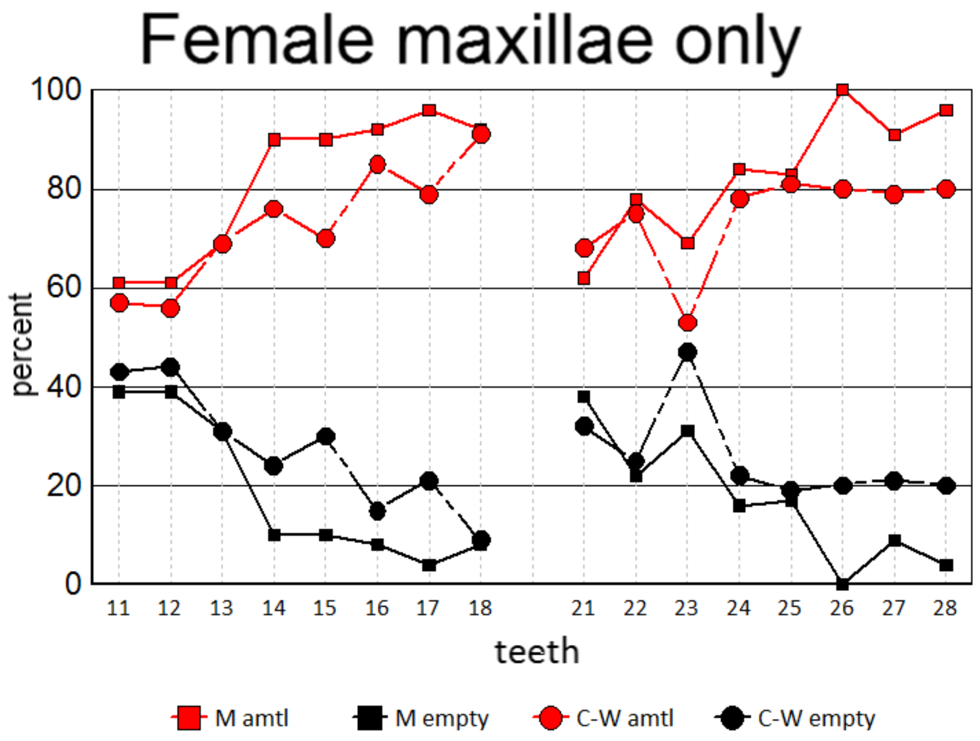


Figure 9a

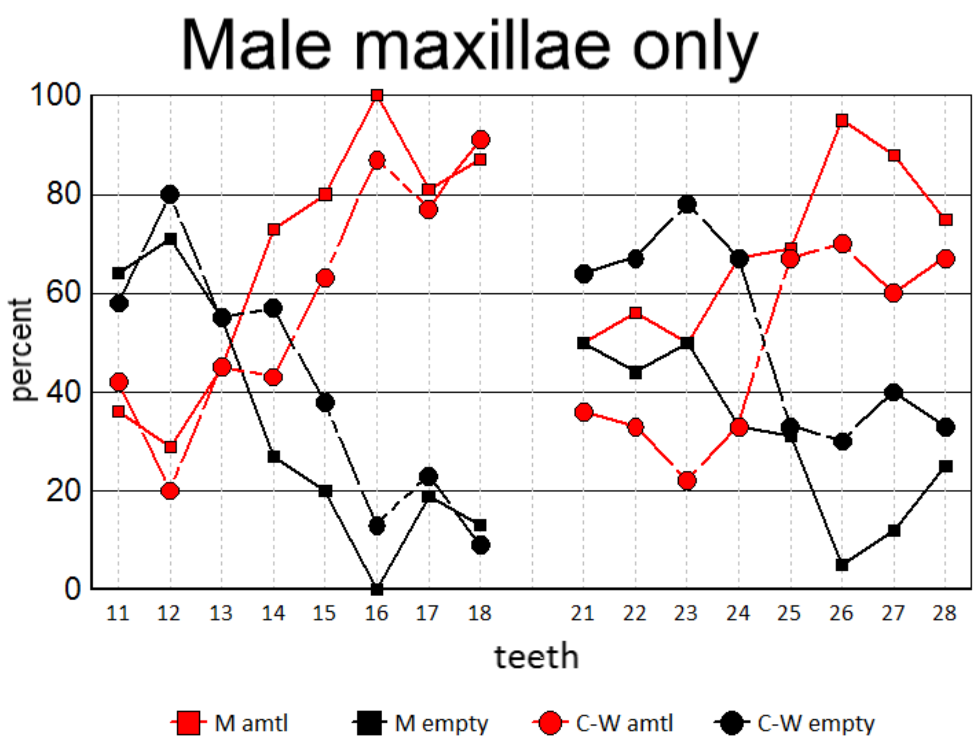


Figure 9b

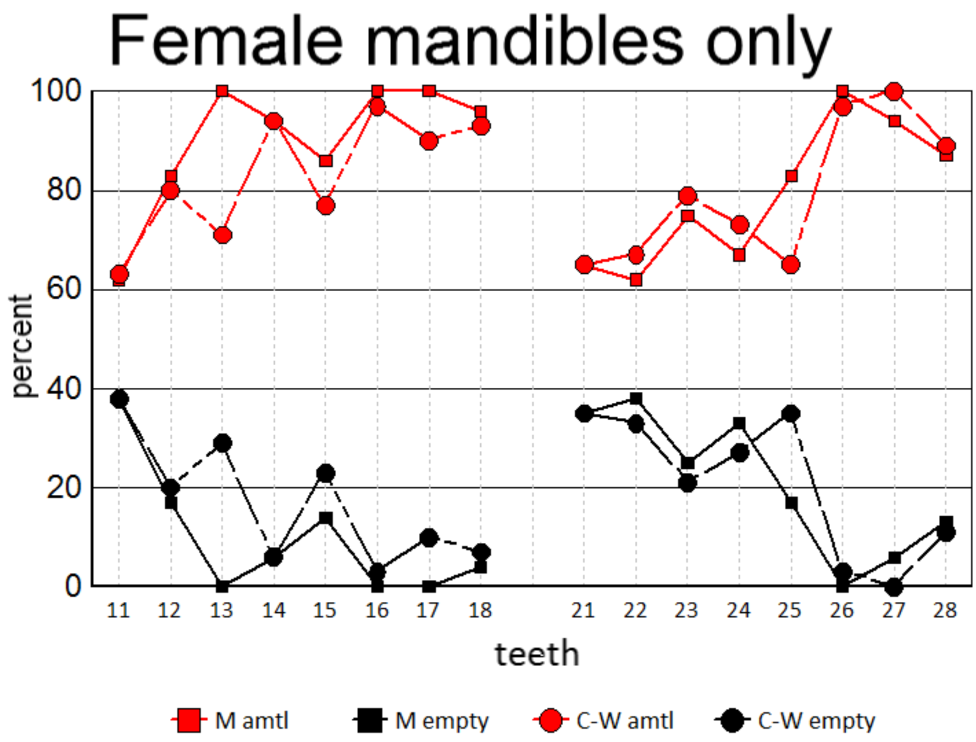
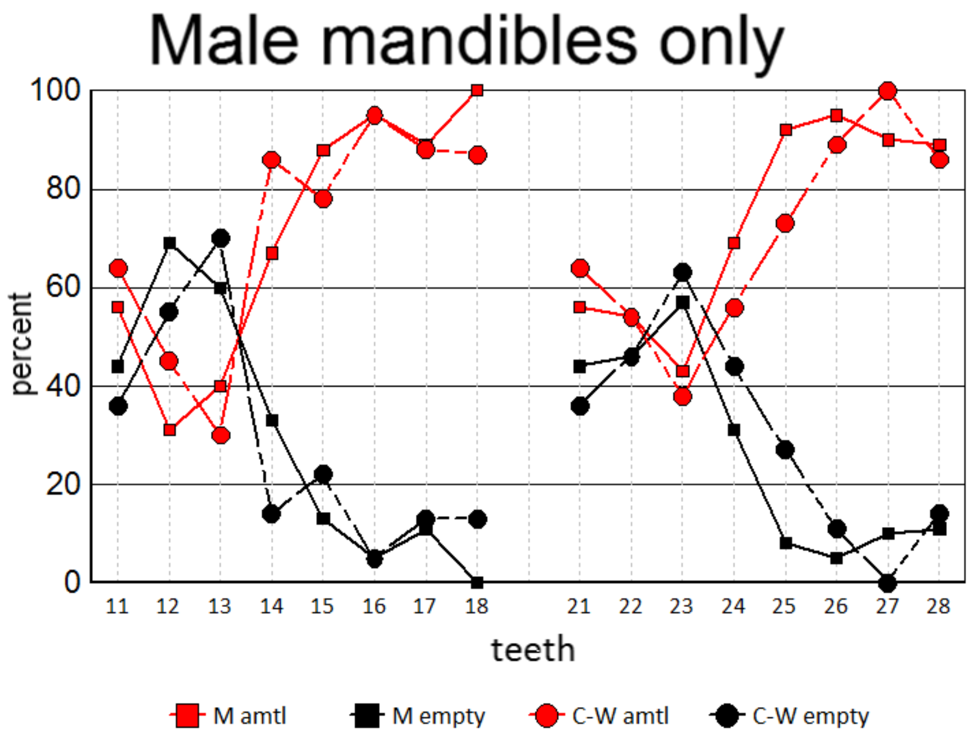


Figure 9c



11-18 upper right incisor to third molar; 21-28 upper left; 31-38 lower left; 41-48 lower right

Figure 9d

Figure 9 Comparison by jaw and sex between two sets of Zwolle research data on sockets with antemortem tooth loss (amtl, resorbed sockets) or postmortem tooth loss (empty sockets)

Antemortem tooth loss (AMTL) seems to mean, for both research teams, that abscessing can no longer be observed (but see Table 2.1), whereas postmortem tooth loss (PMTL) could have more than one interpretation: 1. a tooth in an abscessed socket was lost premortem but the alveolus did not have time to heal before death, or 2. a tooth in an abscessed socket was no longer firmly placed and was thus lost after death because of the condition of the alveolus. Either way, this is a very different situation from 3. the loosening and loss from the alveoli of teeth (especially single rooted teeth) as a normal taphonomic process.

Examining only the upper premolars, sexes pooled, we can see that abscessing was observed much more frequently in the TC-W data set for alveolar sites lacking teeth, even fragmentary teeth — apart from one tooth in which a retained root fragment had been recorded as lost by Mays (Table 2.3), perhaps a curation loss.

Since the root morphology of maxillary premolars in this population is unknown, all we can say is that the, usually, single rooted second premolar may be shed postmortem slightly more often than the, to varying degrees, bifurcated root of the first premolar. Table 1.4 does not support that interpretation. Without more detailed coding on the state of the empty alveoli, we cannot resolve this conundrum.

We would suggest that the long term experience and extended research of Pot (LINK) on historical dental collections provides confidence in the observation that many of the empty sockets were those of diseased teeth: at least half of the empty sockets in males were abscessed (Table 2.2) presenting the possibility of extraction of teeth from abscessed alveolar sockets in females.

tooth	Mays			TC-W		
	AMTL+ABSC	PMTL+ABSC	total	AMTL+ABSC	PMTL+ABSC	Total**
14	0	33.3% (n=6)	40	0	66.7% (n=15)	43
15	3.7%* (n=27)	25.0% (n=4)	37	0	40.0% (n=10)	31
24	0	37.5% (n=8)	31	0	58.3% (n=12)	36
25	0	44.4% (n=9)	40	0	25.0% (n=8)	33

* TC-W coding was of root fragment, pulp exposed, socket abscessed.
** eight “abscessed, root fragment only” alveoli have been removed from these totals.

Table 2.3 Comparison of two sets of data on Zwolle premolars for tooth loss and abscessing

We can suggest that some of the TC-W empty sockets were possibly correctly interpreted as the result of antemortem tooth loss by Mays, but that it is also very likely that teeth which had completely lost integrity were shed after death: that is, root fragments were in fact lost postmortem. In this sense, the original research protocol was thus more conservative.

There is one other area in which we might get clarification of the Zwolle dental pathology from the Mays analysis – in the types of caries. We cannot compare the two sets of data directly because of the difficulties of identification of individual dentitions, and because there are differences in recorded tooth identifications.

Besides these basic problems, we can expect that there will be differences resulting from variations in ways of observing and coding. For example, in the original records it was clear which of the intact tooth crowns could be examined with confidence for carious lesion locations (analysis by crown surface, though not undertaken here, would be possible), whereas the Mays coding method specified only that a carious lesion of a certain type was observed. A further difference was that cemento-enamel junction (CEJ) and root caries were not reported separately in the original data set. Had the Mays identification of individuals been completely recorded (i.e. by grave), a closer comparison would have been useful, because there can be no doubt that inter-observer differences of carious lesions occur widely in dental anthropological studies.

However, the total results may provide some extra information, when we restrict ourselves to the cheek teeth, since they provide more varied types of lesions. There are differences in sample sizes, especially in the mandibles, since we cannot exclude individuals from the Mays data set without guesswork. The percentages give a general idea of the differences in caries rates (Table 2.4): the differences are not marked.

% incidence of caries	Males TC-W	Females TC-W	Males SM	Females SM
Upper premolars	17.0 (n = 100)	17.3 (n =81)	17.4 (n =109)	19.5 (n = 82)
Lower premolars	14.8 (n =115)	15.3 (n = 111)	16.9 (n =136)	14.8 (n = 115)
Upper molars	21.6 (n =116)	28.4 (n =102)	26.8 (n = 123)	29.7 (n = 111)
Lower molars	29.2 (n =130)	33.3 (n =87)	33.6 (n =149)	36.4 (n =96)

Table 2.4 Comparison of two sets of data on Zwolle cheek teeth on caries rates by sex

Since the sample sizes are most nearly equivalent for the female upper premolars, it is worthwhile to examine the caries coding for those teeth (Table 2.5). While comparison of the two research results on caries in female upper premolars does not provide a significant difference (P of χ^2 = 0.714), it certainly suggests that inter-observer differences can be marked with relation to caries, although the identity (here sex) of the Mays recorded individuals may open to question.

upper premolars: females	Types of caries in upper premolars									
	occlusal	gross	mesial	distal	CEJ	root	wall	buccal	lingual	multiple
SM	0	9	-	-	3	0	4	-	-	-
TC-W	1	5	2	1	-	-	-	3	0	2

Table 2.5 Coding of caries in upper premolars of females, comparison of data sets

It is a reasonable interpretation that "occlusal" can often differ between researchers examining molars: the pinhole (pit and fissure) lesions on occlusal surfaces are always a question. As defined for the TC-W data set, caries was recorded only when the lesion permitted the entrance of a probe (LINK see section 4C). Premolars only are examined in Table 2.5, so that we can expect a lower rate of occlusal caries to be observed than would be the case for molars.

The definition of "gross" may also differ. For the TC-W data set the definition used here was code = 10: the tooth crown having been completely removed, only root remnants remained in the socket, the pulp cavity was exposed and the alveolus had a periapical abscess. There were 62 cases of this code, the youngest in a 16 year old and the oldest in an 88 year old. Many individuals had multiple teeth in this state (the 62 teeth without intact crowns belonged to 32 individuals). The 16 year old female had both lower first molars reduced to root fragments; a 70 year old male had six root fragments only in alveoli -- both lower central incisors, the right lower second premolar and the second and third molars and left lower premolar. Teeth in which the crown walls as well as the occlusal surface retain some integrity, but in which the origin of the lesion cannot be determined, seem not to be accommodated in the original coding, unless multiple caries recorded as both occlusal and mesial, distal, buccal or lingual cover that, an advantage of the detailed graphical coding method. There are 46 teeth with multiple lesions recorded, 19 of them male (from 15 individuals) and there are 11 female individuals with, among them, 27 multiple caries teeth. A 47 year old woman has 13 teeth with multiple caries recorded, in each case mesial, mostly both mesial and distal, but in some cases with three surfaces involved, mesial, distal and buccal (none occlusal).

Of the TC-W total male and female tooth sample with multiple caries, there are 17 cases in which occlusal lesions are associated with some wall lesions: these may well be recorded as "gross" by other researchers. However, a better test of "gross" is to note which of these multiple lesion teeth did not have wear recorded: only ten had no record of wear, four of them belonging to the one 47 year old female mentioned above. It is clear that not all occlusal caries obviated a recording of wear (Table 2.6): 16 male teeth with wear recorded had single occlusal caries, but none beyond 3- in the TC-W system of attrition levels, LINK. In addition, 18 male teeth had multiple caries, eight of which were occlusal. Again, all eight were within the 2- to 3- range of attrition levels. Similarly, 12 female teeth had single occlusal lesions, only two beyond wear level 3-. Four female teeth had occlusal caries in association with other lesions, and also wear recorded, from 2- to 2+ (the total number of female teeth with multiple caries and a record of wear was again 18). From this we can tell that some of the occlusal lesions were small.

Intact crown in situ and loose TC-W data	Occlusal caries with wear recorded	Multiple caries including occlusal with wear recorded	Total teeth with caries and wear recorded	Total intact crown in situ and loose teeth
males	16	8	85/747	759
females	12	4	98/653	670
Minimum wear level	1	2-	1	
Maximum wear level	4	3-	6-	

Table 2.6 Original data set: wear level records for teeth with occlusal caries

More problematic is the way in which interproximal (IP) caries are recorded in any study. These IP lesions may begin in the area of the facets, or they may begin at the CEJ. It is a question at what point it becomes impossible to discern the differences between the two: it is also a difficult location to observe accurately (in archaeological samples particularly, LINK and LINK). Furthermore, the original observations did not record discoloration of the enamel as caries (LINK section 4C). Since such discoloration is often seen in the interproximal enamel, this could reduce the rate of IP caries recorded for the TC-W data set, in comparison with other researchers – again, a lesion had to allow a probe to pass into it to be recorded as caries.

Table 2.5 records two female upper premolars with multiple caries: in each case (a 27 year old and a 36 year old) there was both a mesial and a distal caries. Thus the mesial and distal caries frequencies are actually 4 and 3, according to the graphical record.

As it happens, the 47 year old woman mentioned above as having 13 carious teeth can be identified in the Mays data record— although there are differences in the recording of tooth identities which makes comparison of some variables impossible. It is helpful that we can recognize that all 12 of the caries Mays defined as “side of crown” are lesions on mesial, distal or both mesial and distal locations (based on the more detailed graphical method of recording). Despite difficulties in tooth identification, it does seem that the Mays “gross” refers to “root fragment in socket” and that in one case an abscessed socket is recognized in both studies of this one dentition as the result of postmortem tooth loss. In other cases, however, Mays recorded an empty socket as antemortem tooth loss without abscessing, while the original record of these was of abscessed sockets. Far from a concern that the original method of recording would underestimate abscessing in the Zwolle teeth, in this individual four abscesses were noted in the Mays record, but eight were observed by the original researchers. There were also eight cases of complete alveolar resorption: since two of the ten Mays cases of antemortem tooth loss referred to abscessed empty sockets, it appears very likely that the original researchers provided good data for assessing the amount of pathology in the sample.

We can also suggest that interproximal caries in the original data set will include lesions at the cemento-enamel junction. With this in mind, we can again look at the TC-W set of data on interproximal (IP) versus occlusal and buccal caries. In the following table, teeth with multiple caries are counted as either having IP or not having IP caries.

	Types of caries	to 39	40 and over	Between ages P of χ^2	Between sexes to 39 P of χ^2	Between sexes 40+ P of χ^2
males	IP	7	53	**< 0.00001**	0.196	0.057
	Occlusal+buccal	19	10			
females	IP	21	44	**0.00294**		
	Occlusal+buccal	29	19			

Table 2.7 Original data set (TC-W) using the full sample of 1491 teeth with observable carious lesions.

Table 2.7 demonstrates that there are no significant differences between the sexes within the two age groupings: the simple comparison by sex, ignoring age group, is also not significant (P of χ^2 = 0.151), despite the fact that IP caries in males represent 67.5% of all caries (60/89), compared with only 57.5% (65/113) in females. Nevertheless, a test of the overall data presented in Table 2.7, encompassing the interaction of sex, age and caries type, indicates a significant difference in the male/female distribution of caries type with age (P of χ^2 = **0.01856**, df = 3). On the basis of this data, interproximal caries rates do not appear to give a simple indication of a different (more cariogenic diet?) in females. Perhaps a dietary change with age among males, as well as cultural differences in the treatment of pathological teeth between males and females, make simple conclusions about male-female contrasts in the ratio of interproximal to caries difficult to sustain.

From this brief enquiry into the differences between two sets of observation of the same sample, we again derive evidence, though limited, that female pathology was greater than male (at least as regards molars, see Table 2.4).

Conclusions

The present study has focused on identifying which pathological features in dentitions are significantly different, that is, differences that occur by jaw, side, tooth group and sex. Major differences are discerned only between males and females, and in abscessing only, between jaws.

Questions immediately arose that needed answering. Was there anterior attrition in males that suggested pipe smoking? Was that a habit among all males, or only some? Is there evidence for any females smoking? It is, in fact, true that males reach higher levels of anterior tooth wear at a younger age than females, but male attrition is actually variable and there is no definitive difference by side. Thus not all males smoked pipes, and all smokers did not preferentially hold a pipe in one side of the mouth, for example, the right. While anterior attrition is advanced in males (Figure 5), this could relate to dietary (tearing off of tougher food) and other factors, for example, using teeth for activities other than holding pipes.

On the other hand, there is a significant difference between males and females in terms of anterior maxillary pathology: abscessing, reduction to roots and pulp exposure. Table 1.10 showed that in older males, the maxillary sites for anterior teeth and premolars are markedly more abscessed than for females. With regard to whether there are significant differences in pathology by jaw or side, it is relevant that the only difference is that the maxilla displays significantly more abscessing than the mandible. Male maxillary abscessing at anterior tooth sites is significantly greater than that of females in the older age category, but the conclusion is reached that evidence for abscessing in females is altered by dental extraction: abscesses would drain and be healed and the alveolar margin would be remodeled and smoothed. This interpretation is supported by the fact that antemortem tooth loss in anterior teeth of mandibles in older females is highly significantly different (P of χ^2 = **0.00005**) from that in males. From this we can deduce that pipe smoking is not the major, certainly not the only, determinant of the condition of male dentitions in comparison with female dentitions.

The next question is whether we can suggest dietary differences between males and females, and whether this led to greater rates of removal of diseased teeth in females.

Dietary difference between males and females is most obvious in those under 40, since the difference is best seen when based on intact teeth in which carious lesions can be observed, particularly on interproximal lesions, which suggest a softer, more cariogenic diet in females. Some questions regarding interproximal (IP) lesions at the cemento-enamel junction (CEJ) arise because the original coding did not specify a differentiation between crown and CEJ. Limited comparison with a second set of observations on the same sample gives the clue that the mesial and distal caries included CEJ caries. Looking at young adults and focusing only on IP versus occlusal caries gave the impression of a strong difference in caries location, suggestive of dietary differences, but overall, the difference was not significant (sample sizes are small: Table 2.7). However, we do see a marked change over a lifetime, especially in male teeth, suggesting an increasingly soft and cariogenic diet as dental health deteriorates.

In general (but see LINK), there is an inverse relationship between attrition and caries. This seems to hold for the Zwolle dentitions. Higher anterior attrition in males is established, though not for **all** males. Some males have attrition levels matching female anterior attrition. Overall, however, female anterior dental attrition is lower, perhaps leading to the higher caries rate (Table 1.5).

In females, caries incidence is high and there is a higher rate of antemortem tooth loss overall, not just in the anterior teeth. This loss is very marked especially after age 40: Figure 2 shows this clearly, and demonstrates that males are much less likely to die with tooth loss, even in old age. The interaction of lower caries rates and lower incidences of alveolar resorption as against the high abscessing and pulp exposure rates in males is completely reversed in females. The proposal put forward here is that teeth in sockets that are abscessed, and with the type of gross caries that lead to the exposure of the pulp cavity and abscessed empty sockets (Table 2.2), are extracted preferentially in females, leading to statistically different conditions in males and females. In addition, data such as that presented in Figures 9a-d clarifies the marked difference in male and female tooth loss patterns. Studies on antemortem tooth loss and attrition cannot provide comparative data for any dental samples apart from those samples which are strictly comparable in male and female diets and treatment of pathology. The observations analyzed here give an excellent picture of the state of Zwolle teeth during the period of the burials, but the data are not representative of other times, other dietary regimes, or other interventions in cases of dental pathology. The data reflect dietary and cultural differences between males and females, as well as broad variation within the sexes by age. The picture is complex and interesting, and interpretation can rely on no simple explanation.

Finally, it will be evident from several comments made throughout this paper that the excellent recording method developed by Tjeerd Pot allows other researchers to follow through with analyses of his observations: variables can be coded according to different methods of analysis. Researchers may develop further variables, for example, analysis by crown surface, rather than by tooth, and this could be undertaken with confidence. The legacy of the work by Tjeerd Pot is an important resource in dental anthropology.

ACKNOWLEDGEMENTS

Trinette Constandse-Westermann provided me with the opportunity to analyze the Zwolle data and made a considerable effort to ensure that I had all the relevant materials, especially the original hand written data recording sheets, from which I worked. I am very grateful to her for letting me see such interesting data, as well as for her careful reading of this text. Simon Mays kindly passed on to me his Zwolle dental data files.

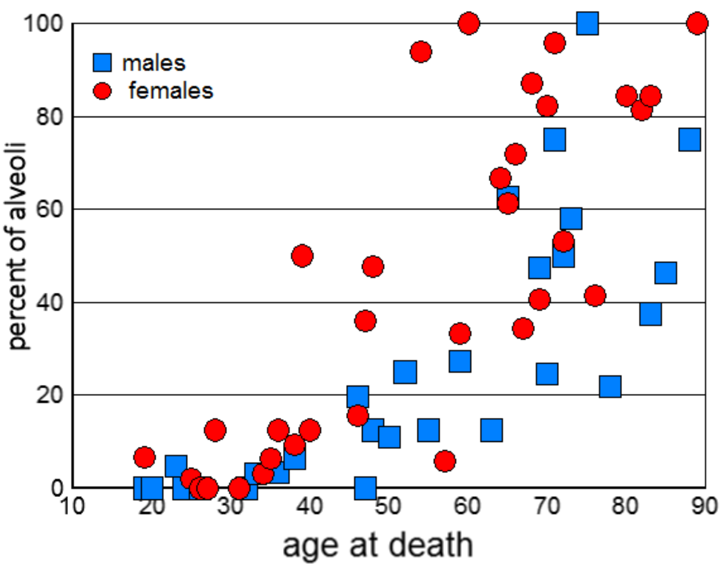
APPENDIX I: Information on loose teeth.

loose teeth	jaw	age	males	females
anterior	maxilla	-39	4	6
		40+	7	7
	mandible	-39	4	6
		40+	2	11
premolars	maxilla	-39	1	3
		40+	3	6
	mandible	-39	0	4
		40+	0	4
M1-M2	maxilla	-39	6	4
		40+	3	3
	mandible	-39	2	3
		40+	0	4
M3	maxilla	-39	1	2
		40+	2	0
	mandible	-39	0	0
		40+	0	1

With a loose tooth, the alveolar region is unobservable as a result of poor preservation, not pathology: of the 99 loose teeth, 85 (86%) are not carious. Eight of the caries are interproximal. Only two teeth have pulp exposure (one with an occlusal lesion and one with multiple caries).

Comparing frequencies of loose teeth by sex and age class (P of χ^2 = 0.464, 1df), provides no suggestion that bone loss in post-menopausal females should be explored further with regard to loose teeth. As reported above, it is of interest that there is a significant difference between the sexes: only 22.8% of male loose teeth are mandibular, whereas the female value for mandibular loose teeth is 51.7%. However, there is no difference between the sexes in the frequency of anterior teeth (P of χ^2 = .872).

Appendix II: the age distribution of antemortem tooth loss across all alveoli by sex



The presentation here differs from Figure 2 because Appendix II shows the age distribution of antemortem tooth loss across all alveoli (totalling 259 of 1120 male alveoli and 582 of 1331 female alveoli), in adults over age 18. Figure 2 shows the distribution by age at death of only those alveoli in which antemortem tooth loss was observed.

Appendix III: Comment on Section 1.7 and Table 2.2

The interpretation of the Zwolle data on sex differences in pathology required detailed original recording of observations and careful analysis of those observations. However, the complex discussion on the interrelation of abscessing with other factors in Section 1.7 should not distract from the probable relevance of male pipe-smoking as a contributing factor.

Alveolar sockets with intact teeth, sockets with root fragments and empty sockets are all included in the following table. Alveolar resorption would be likely to preclude reliable observation of abscessing in a socket and indeed, the coding protocol used would not have encompassed observable abscessing associated with complete resorption.

The frequency of abscessing in male anterior teeth (irrespective of jaw and age differences) is significantly greater than for females.

Tooth class		Abscessing present	Abscessing absent	P of χ^2
Anterior	males	48	339	**0.00465**
	females	32	342	
Premolars	males	39	205	0.417
	females	29	189	
Molars 1 and 2	males	37	141	0.223
	females	39	108	
Third molars	males	11	74	0.250
	females	14	57	
All	males	135	759	0.549
	females	114	696	