Dental disease in the 19th century Dutch population of Middenbeemster

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Cover image: the skull of a female 36-49 years of age with artificial glass teeth set in silver (by author)

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Table of contents

Introduction

Teeth are often and sometimes even the only skeletal element that is well preserved. Fortunately for osteoarchaeologists teeth can tell us many things about an individual from the past; diet, oral hygiene, 'stress' subsistence economy, cultural behavior and even occupation can be deduced from dentition. The types of food that come in contact with the mouth determine the micro-organisms that are present in the oral cavity, and the condition of an individual's dentition can reflect the composition of the type of food that has come into contact with those teeth (Roberts and Manchester 2005, 63). Furthermore certain cultural habits can damage teeth, leaving evidence towards what kind of activity could have caused such a lesion. Pipe smoking, especially clay pipe smoking, a common habit among men from the 16th to the 19th century could cause significant lesions to the teeth where the pipe was held in place by biting on it, while the individual could keep on working with both hands (Kvaal and Derry 1996, 28; Duco 1987, 8). Other practices may also be visible on the teeth such as leatherworking, sewing and spinning where the teeth could have been used as tools.

This thesis examines a collection of skeletons from the 19th century, from a rural village in the northern part of the Netherlands called Middenbeemster, in order to see if there is any evidence for a certain diet (for example mainly consisting of grains, meats, starches or lots of sugars) and if there is a difference in diets between men, women and children. It would also be interesting in general to see what kind of dental lesions occurred at this time, and to examine if and how dental problems were treated. Lead, tin and amalgam fillings were already introduced in the early 19th century and could certainly be visible in this skeletal collection (Waldron 2009, 237). This information would also add to our knowledge of the state of oral hygiene in the 19th century in rural villages.

In order to collect this information each individual will be examined in order to assess sex and age before examining the dentition either by the author or by other students from Leiden University. The teeth will be examined and any signs of dental patholoy, any kind of dental work and culturally induced damage to the teeth will be recorded. This data will be put in a database for each tooth in every individual in order to easily access the data in order to better understand the diet, oral hygiene and cultural practices of this time.

In chapter one a short introduction to human dental anatomy and the development of teeth is described before a description of different dental diseases will be presented in chapter two. The history of the village of Middenbeemster and the foods that they would have access to in the 19th century is discussed in chapter three. This is essential to the understanding of the occupations and possible diets of its inhabitants. In chapter four the materials and methods used for the research done in this paper are discussed. The skeletal material is described and the methods for the determination of sex and age and the recording methods for each kind of dental disease are presented. In the fifth chapter the results of the skeletal examinations are presented and in chapter six these will be discussed before reaching the conclusion.

Research questions

The research questions this paper focuses on are as follows:

- What are the patterns of dental disease in the Middenbeemster collection?
  - Are there differences to be seen in dental pathology between men and women?
  - Are clear age-related differences visible?
  - Is the activity related wear related to the occurrence of dental disease?
  - What can we conclude from the inventory of dental disease in relationship to diet?
  - What is the general state of oral hygiene in the Middenbeemster collection?

This information will certainly help us better understand the diet, oral hygiene and cultural practices of the people in rural villages in the Netherlands in the 19th century. Perhaps even more importantly this research also show the use and importance of using proper recording methods such as a custom built database and to gather and record every piece of information separately per individual in order to eliminate the large margins of error that were very common in archaeological research up to the present time.

Chapter 1: An introduction to the anatomy and development of teeth

In order to understand teeth morphology and how exactly teeth are formed a short introduction into this subject is presented in this chapter. Dental terminology is also important to understand in order to comprehend the descriptions of dental disease on individual teeth.

An introduction to teeth

Teeth interact directly with the environment, seizing and chewing food. Incisors bite food into smaller pieces while canines are meant to grasp and capture prey, and premolars and molars grind up the food before swallowing. Incisors are the eight teeth in the front of the upper and lower jaw, two on each side of the jaw. Human canines have also more or less taken over the function of an incisor. Premolars are present next to the incisors, four in each jaw, and two on each side. Finally six molars are normally present in both the upper and lower jaws, although the third molar may not erupt or be congenitally absent (White et al 2012, 102).

Dental terminology

In order to better understand dental terminology used in the following chapters, a short description will be given in this paragraph.

The **mesial** portion of the tooth is the side that is closest to the midline of the dental arcade, where the central incisors contact each other. The **distal** side of the tooth is the opposite surface. **Lingual** usually means the direction towards the tongue, while **labial** is the side towards the lips. This term is usually reserved for the incisors and canines, while **buccal** is used for the premolars and molars. The tooth surfaces of teeth that contact adjacent teeth are called **interproximal** and the chewing surface of the molar is called the **occlusal surface**. The roots of the teeth are located in **sockets** or **alveoli** while being held in place by periodontal ligaments. In order to identify a single tooth five variables should be mentioned: the category of tooth (incisor, canine, premolar or molar), if the tooth is permanent or deciduous (indicated with either capital or lowercase letters), from the upper or lower jaw (indicated in superscript or lower

script), the position within the tooth category (indicated in numbers) and the side (L or R) (White et al 2012, 103).

The development of teeth

Humans normally acquire two sets of teeth in their life. First the deciduous (also called primary or 'milk') teeth erupt that are used during the first few years of life, before they are replaced by the permanent (or secondary) dentition throughout childhood and adolescence. Even before birth germs of the deciduous teeth have already formed in the jaws. When the formation of the crown and a large part of the root is finished, the tooth erupts. When the tooth buds (or germs) are in development inside the jaw, they reside in openings in the alveolar bone called crypts. Inside the crypts the enamel cap of the tooth crowns calcify from the cuspal apices and then root ward. The root apices are the last part of a tooth to develop. The roots of the deciduous teeth are resorbed (by osteoclasts) before the teeth are replaced by the permanent dentition. (White et al 2012, 103, 107).

Ameloblasts form enamel in a process known as amelogenesis. Dental tissue is usually not remodeled during life. Once the teeth and their enamel are formed only changes through physical wear or chemical decay are possible. Cells called odontoblasts form the dentin in a process called dentinogenesis. The primary dentin is deposited during the formation of the tooth and the secondary dentin is formed during the stage of root formation. Wear usually occurs most on the lingual occlusal surfaces (chewing surfaces) of mandibular molars and on the buccal occlusal surfaces of mandibular molars. For anterior teeth wear patterns may vary since these teeth are often used in paramasticatory functions (functions besides biting and chewing) (White et al 2012, 107).

The anatomy of teeth

Figure 1 shows the different elements of a human tooth. The crown is covered with enamel while the roots keep the tooth secured in its socket. Roots can have one or more root cones (discernible by shallow developmental grooves) or partially or completely bifurcated separate (secondary) roots. The external surface of the tooth roots is covered by a layer of cementum, a bone-like tissue. The core of the tooth is formed by dentin (or dentine). This tissue has no vascular supply but receives support from the vascular

system in the pulp and is lined by odontoblasts (dentin-producing cells). The neck of the tooth (or cervix) is the narrow part of the tooth at the intersection of the crown and root. The line that encircles the crown at the cervix is called the cementoenamel (or cervicoenamel) line (or junction)(CEJ). The boundary between the enamel cap and the dentin is called the dentino-enamel junction (DEJ or EDJ) (White et al 2012, 104-105).

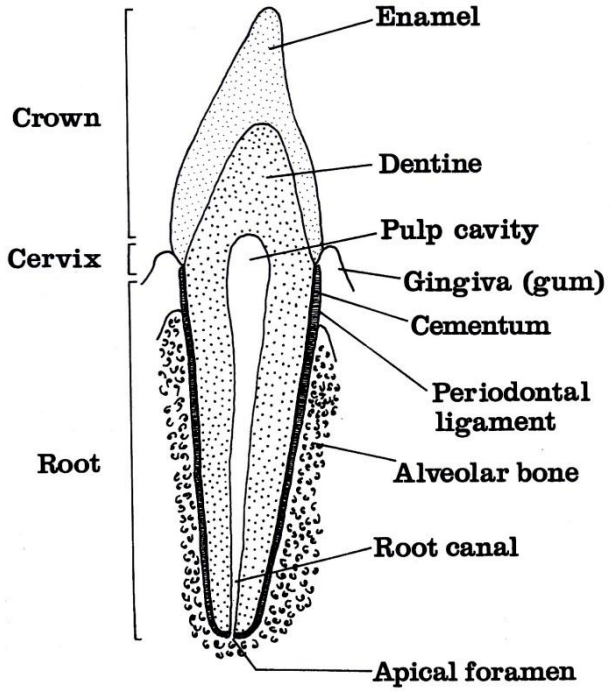


Figure 1: the structure of a tooth (adapted from Mays 1998, 12).

The pulp chamber is the part of the pulp cavity at the crown end of the tooth containing pulp, a soft tissue. The narrow end of the pulp cavity at the root end of the tooth is called the root canal. The opening at the root tip (or apex) through which nerve fibers pass from the alveolar region to the pulp cavity is called the apical foramen. A cusp is an occlusal projection of the crown, its tip is called apex. (White et al 2012, 106).

Chapter 2: Dental disease

Teeth can be affected by a variety of diseases such as infectious disease (caries), a variety of degenerative diseases of the jaws, including ante mortem tooth loss that results from periodontal disease, and recession of the bone of the jaw that becomes more common the older an individual becomes. Developmental problems include enamel hypoplasia and occur when teeth are still developing and a disruption in growth causes a lesion in the tooth. Genetic anomalies can also cause lesions in one or more teeth or a discrepancy in the number of teeth an individual develops. Dental diseases are often also linked; for example plaque deposits on teeth can result in irritation of the soft tissues (gingivitis) and periodontal disease leading to the loss of alveolar bone and ultimately ante mortem tooth loss (Roberts and Manchester 2005, 63-64).

Dental caries

Dental caries is one of the most common forms of dental disease which causes cavities on the tooth surface or neck. This infectious and transmissible disease is the result of the fermentation of food sugars in the diet and caused by the *Lactobacillus acidophilus* and *Streptococcus mutans* bacteria. These bacteria are present in teeth plaque which is usually present on the teeth near the gums, from which they spread to other parts of the teeth (Roberts and Manchester 2005, 65). Starches in the diet may also cause caries but far less often according to Hillson (Hillson 2001, 260).

The bacteria in combination with sucrose produce acids which demineralize the teeth resulting in cavities. Two areas of the teeth are most commonly affected: the crown of the tooth where bacteria can settle in fissures (especially in molars and premolars, see Figure 2) and the roots of the teeth including the cemento-enamel junction if this is exposed due to periodontal disease (Roberts and Manchester 2005, 65). The causes of caries can be divided in several factors: environmental factors (elements in food and water), exogenous factors (diet, oral hygiene) and endogenous factors (the shape and structure of the teeth) (Powell 1985, 317).

However no single factor can be attributed to the development of caries as a study of caries in 12-year-old children in ninety different countries shows. From the results of this research it was concluded that there was no strong relationship between the amount of sugar consumed and the occurrence of caries in westernized countries

(Woodward and Walker, 1994). So one should always be careful to relate a single cause to caries as there might be a variety of factors that could influence its occurrence.

Figure 2: an example of a large occlusal caries located in the mandibular left second molar as well as in the left canine (by author).

Calculus

Calculus is essentially calcified plaque that consists of micro-organisms from the mouth that are embedded in a matrix that is partly composed of the organisms themselves and from proteins in the saliva (Hillson 1986, 284; Lieverse 1999). Calculus is more likely to accumulate on the teeth when the diet is rich in proteins and/or carbohydrates with an alkaline oral environment. Two types of calculus exist: supragingival calculus (above the gum) is the most common form and is thick and grey or brown in color while the less common form appears subgingival (below the gums) on exposed tooth roots, is very hard and green or black in color (Roberts and Manchester 2005, 71-72).

Subgingival calculus only occurs in association with periodontal disease and is a thinner, less obvious layer that covers the surface of the tooth root in a periodontal pocket (see Figure 3). Often an aea of exposed root bare of subgingival calculus is visible around the cervix of the tooth, marking the opening into the pocket where the gingival cuff (border of the gums) rested (Hillson, S. 2008, 312). The teeth most commonly affected by calculus are the teeth closest to the salivary glands. The salivary glands are located on the lingual side of the lower incisors and on the buccal side of the upper molars. The composition of calculus deposits can also be used to attempt to reconstruct

the diet of an individual, but that research is beyond the scope of this paper (Roberts and Manchester 2005, 71-72).

Figure 3: an example of medium subgingival calculus (from Hardy et al, 2009).

Periodontal disease and ante mortem tooth loss

The settlement of calculus deposits in openings between the tooth and the soft tissue and the bone of the jaw results in periodontal pockets which is a major cause of the development of periodontal disease. Periodontal disease seems to have been very common in the past, probably a result from poor oral hygiene in addition to sucrose-rich diets. Periodontal disease is also still common in present times and still a common cause of ante mortem tooth loss (Roberts and Manchester 2005, 73).

Periodontal disease starts with the inflammation of the soft tissues (gingivitis) which is often the result of the accumulation of dental plaque on the teeth, and the bacteria living in the dental plaque then move to the gums where the infection starts (Waldron 2009, 239). From there the infection can pass to the bone (periodontitis) resulting in resorption of the bone and loss of the ligament holding the tooth in place, the distance between the cemento-enamel junction increasing and subsequently loss of the tooth. This dental disorder is mostly diagnosed if 'inflammatory pitting' and new bone formation on the jaw bone around the teeth, but the presence of 'periodontal pockets' and the exposure of tooth roots is certainly a solid diagnosis of the disease (Roberts and Manchester 2005, 73).

Some authors however feel that the exposure of the teeth roots is a reaction of the body to extreme attrition. The problem with diagnosing periodontal disease is that

there is a general lack of a standard for recording and scoring and knowledge of the disease. Davies et al (1969), Brothwell (1981), Levers and Darling (1983), Karn et al (1984) and Lukacs (1989) all classify and describe the disease in a different manner, complicating diagnosis even more (Roberts and Manchester 2005, 74).

Enamel hypoplasia

Enamel hypoplasia occurs when the teeth are still in development and the organism is under sudden or extensive stress. A dental defect can then occur in the form of a line or groove in one or more teeth. This can be the result of a hereditary anomaly, localized trauma or systemic metabolic stress such as nutritional deficiency or an illness. Enamel hypoplasia is generally a non-specific 'indicator of stress' and is currently out of the range of this paper since this is a specialized field all on its own and due to time restrictions and the fact that this paper mainly focuses on diet, oral hygiene and cultural practices instead of malnutrition or disease.

Dental abscesses

If the pulp cavity of a tooth becomes exposed to bacteria, usually as the result of dental caries, attrition or trauma, a dental abscess may develop. However a cavity in the bone around the root of a tooth may not necessarily be an abscess, it may also be a benign cyst (Dias and Tayles 1997). Dental abscesses may also be caused by periodontal disease and the presence of a periodontal pocket which is primarily caused by dental plaque accumulating between the gum and the teeth (Hillson 1986, 306). When bacteria are able to collect in the pulp cavity, inflammation and the accumulation of pus collects, this is called an abscess. It can even spread to the base of the root and from there into surrounding tissues eventually breaking through the surface of the jaw bone, creating a sinus (Hillson 1986, 316). Detecting a dental abscess before this stage is very difficult and requires radiography. Diagnosing a dental abscess can be difficult, but generally the presence of a sinus is accepted as evidence (Roberts and Manchester 2005, 70).

Dental attrition

Dental attrition is the 'natural result of masticatory stress upon the dentition in the course of both alimentary and technological activities' (Powell 1985, 308). It can occur

on the biting or occlusal surfaces of teeth during the chewing of food when the crowns of the teeth grind on each other. Erosion is another kind of wear caused by an acidic polluting environment or high acid-content foods erode the tooth enamel. Abrasion is usually the result of cultural activities and is defined as wear as the result of contact with objects other than the teeth such as a pipe. Attrition also makes the teeth more vulnerable to dental disease such as caries and abscesses. In the past attrition to the teeth could be extensive due to the harder and tougher foods in contrast to the soft and easy to chew foods of today (Roberts and Manchester 2005, 78).

Other diseases that can affect teeth

One of the most common forms of dental deformations due to disease is enamel hypoplasia but some diseases can also affect teeth in a very specific way. Lepromatous leprosy for example can cause the malformation of tooth roots and treponematoses (especially congenital syphilis) affects the development of the teeth causing 'mulberry molars', Moon's molars and 'Hutchinson's incisors'. Moon's molars seem like regular molars except that the cusps of the teeth are very close together (Hillson et al. 1998). In Hutchinson's incisors on of the three cusplets on the incisor edge is poorly developed and a notch occurs. Mulberry molars are the result of a defect in the surrounding tooth structure resulting in the cusps of the first molar being small nodules (Roberts and Manchester 2005, 77-78).

Chapter 3: the history of Middenbeemster

The Beemster is a polder built in the Netherlands in the 17th century (1607-1613) from a drained lake called the Beemster with a total surface area of approximately 40 Km² and it is situated at between 3 and 4.8 meters below sea level. The center is the main town of Middenbeemster surrounded by the villages of Noordbeemster and Westbeemster (see figure 4). The Beemster is bordered by circular ring-dikes of approximately 48.9 kilometers in length. During the 19th and 20th century five forts were built along the western, eastern and southern sides of the Beemster which were part of the 'Stelling van Amsterdam' (a national defense line to protect the country's capital Amsterdam) (de Jong 1998, 11).

Figure 4: a map of the Netherlands with the location of the village Middenbeemster marked in red (source: http://www.gophoto.it/view.php?i=http://www.jufjo.nl/kaartNL2_1600.gif#.UPQvX6PGOF8)

Sustenance and housing

The drained land of the Beemster was originally used for agriculture, mainly grains. A patent dated to 1607 states 'that, for several years, men have planted land here with cole seed, lentil seed and other fruits, as one has been used to do'. As the ages progressed this land was gradually turned into pasture land for cattle, because the soil composition and the groundwater level resulted in bad harvests. By the 17th century the

Beemster was famous for its wool, butter, cheese and bulls. Especially cheese production became very important. Until the 1880's cattle breeding was still the main use for the Beemster (up to 72% of the arable land), until the arrival of steam-driven pumping stations that allowed the Beemster to be pumped dry even deeper, removing more of the water. At this time horticulture suddenly expanded with large tree orchards that can still be seen today (de Jong 1998, 26).

In the 19th century bell-jar farms were built, a design that was popular from about 1600 to 1640 but which regained popularity in the early 1800's. The bell-jar farm has a compact floor plan with a storage area for hay in the middle, under the highest part of the pyramid roof, with the living and working quarters grouped around this central area. The cattle were kept single file against the outer wall. From 1875 up to 1885 this type of farm was frequently built, before the agricultural crisis in 1885, which resulted in the building of only simple farms. Farms at this time were mainly built from wood, since brick buildings would be unstable in the weak sub-soil. In the 20th century bell-jar farms were built once again, with the alteration that living quarters were now detached from the farming section. (de Jong 1998, 37-38)

The church and the graveyard

The reformed church was built in Middenbeemster in 1621-1623 and the church was enlarged in 1625 and between 1661 and 1662 the tower was heightened. Originally five churches were planned in the polder, but the one in Middenbeemster was the only one that was actually built (Griffioen 2011, 11; de Jong 1998, 40). From 1638 to 1829 people were buried at both the church graveyard as well as inside the church. From 1829 onwards people stopped burying the dead inside the church and another new graveyard at another location in Middenbeemster came into use (Griffioen 2011, 11). It is likely that townspeople from the village of Middenbeemster and the surrounding area were buried at the church including men, women and children. Recent research shows that most of the graves can be dated between 1829 and 1866 (personal communication Dr. Hoogland).

Foods from the 19th century at Middenbeemster

In the 19th century keeping cattle and horticulture were the main function of the Beemster region. Therefore it would be expected that people had easy access to dairy

products such as cheese, butter and milk. Fruits from their orchards would also be a common foodstuff every season, and could possibly be potted for winter. It is likely that other traditional Dutch foods were also eaten such as potatoes, several kinds of vegetables (leek, kale, parsnip, onions, et cetera) and meat from cattle. Especially potatoes seemed very popular in the 19th century until a potato blight hit between 1845 and 1847 which destroyed most of the crops (Bieleman 2010).

In the 19th century cane sugar was also cheap and available to everyone after the drop in price in the middle of the 17th century when sugar cane factories were set up in the West Indies. It is estimated that at the end of the 19th century sugar consumption was rated at a little over 900 grams per person per year (Roberts and Manchester 2005, 68-69). Caries could therefore have had a significant impact on the population with these large amounts of sugar ingestion.

Chapter 4: Materials and methods

This chapter discusses the materials that are used for this research and explains the methods that were used to examine the remains and why these were selected.

Materials

The collection used for this thesis is the Beemster collection housed in the Laboratory for Human Osteoarchaeology, Reuvensplaats 3, Leiden, the Netherlands. This collection consists of approximately 450 individuals from a variety of ages and both sexes. Fifty of these individuals were chosen with an approximately even sex distribution. Individuals were only selected if three or less teeth were lost post-mortem, not including the DNA samples. Individuals with more teeth missing could influence the results too much. In most individuals the right mandibular PM2 and M2 were taken for DNA sampling, however in some individuals these teeth were not present and other teeth were used for testing. Most of the skeletons were previously examined by Osteoarchaeology (BA or MSc) students for sex and age, while some were examined by the author. The methods used for each skeletal analysis are mentioned below. This collection was chosen since a lot of documentation from the excavation site is known, and it was easily accessible to Osteoarchaeology students.

Details about the Middenbeemster cemetery

Historical documents on the graveyard are available, but making a direct link between an individual and the historical data is difficult. The documentation for example mentions 12 rows of burials while the actual number varies between 12 and 13 indicating that the historical documents may not be accurate. In addition it seems that burials dating before 1829 have been cleared. However currently students and staff are trying to link individuals to the historical records from the location where they were buried. Data about the buried include the date of burial and the name, while a secondary document indicates if a church bell was rung for these individuals possibly relating to a higher status of the deceased. Currently due to time restrictions it is unfortunately not yet possible to relate the individuals that were examined to the

individuals that were recorded in the ledger, making it more difficult to see if status had any influence on oral health.

Methods on skeletal analysis

Sex and age estimations were established for each individual skeleton in order to be able to section the data properly in the results chapter. Sex estimation for adults was based on several cranial and pelvic morphological features such as parietal and frontal bossing, frontal inclination, external occipital protuberance, orbit shape, mastoid process, the sub-pubic angle, arc compose and the greater sciatic notch among others. Age estimations were done using the appearance of the auricular surface (Buckberry and Chamberlain 2002), the texture of the pubic symphysis (Suchey and Brooks 1990), the rate of dental attrition of the molars (Smith 1984), the level of cranial suture closing (Meindl and Lovejoy 1985) and the appearance of sternal rib ends (Iscan and Loth 1986).

Dental disease data collection

All of the teeth were examined macroscopically for signs of caries, dental attrition, calculus and abrasion while both the maxillary and mandibular jaws were visually examined for dental abscesses and periodontal disease. Teeth were identified according to the World Dental Federation notation developed by the Fédération Dentaire Internationale (FDI), also known as the ISO 3950 notation; each tooth is given a number starting from 11 for the right first incisor in the maxillary, 12 for the second incisor and so on, the left half of the dental arcade in the maxillary starts with 21 for the first incisor, the left half of the mandibular with 31 for the first incisor and the right half of the mandibular with 41 for the first incisor.

Each tooth will be recorded as present, missing post mortem, missing ante mortem, unerupted, congenital absence or unerupted/congenital absence if it is unclear whether it has not yet erupted or if it is just congenitally absent in the case of M3. Recording data on caries is partly done according to the system developed by Hillson (2001). It includes classifying the caries into several categories:

- Coronal caries: initiated in the enamel of the crown surface.
    - Occlusal caries: a lesion that was initiated in the fissures, fossae and grooves of the occlusal surfaces of molars and premolars.

- Contact point or approximal smooth surface caries: lesions that are initiated on mesial and distal crown surfaces, just below the contact point between neighboring teeth.
- Other smooth surface carious lesions on the crown: caries that are located anywhere else on the crown sides, but most commonly along the cervix of the crown just above the line of the gingivae.

❖ Root surface caries: caries located on the cement of the root surface when this is exposed (Hillson 2001, 250).

One tooth can be classified with several different types of caries, for example one occlusal caries and one contact point caries. The severity of each caries will then be graded according to grade 1 to 4, partly taken from Hillson (2001, 275).

1. stained area with roughening or slight surface destruction
2. small cavity, no evidence of penetration to the dentine
3. larger cavity, penetrates the dentine
4. large cavity with open pulp chamber or open root canals

Teeth will be recorded as **'missing'** if part of the socket has also broken away and nothing is clear about whether the tooth was missing post mortem or ante mortem. Teeth will be marked with **'lost ante mortem'** if the tooth was clearly lost during life and the bone shows signs of remodeling. If a tooth is lost after death or during excavation or laboratory work and there is no sign of bone remodeling in the tooth socket it will be marked as **'lost post mortem'**. Another possibility is that teeth have never erupted such as in small children or in the case of the third molar.

Attrition and abrasion will be scored according to Smith's (1984) scoring system of stages of wear. 8 stages are defined (see appendix I). Fractures to the teeth as well as pipe notches will be noted as activity related wear (present/absent) for each tooth in order to be able to determine if this was related to caries or other forms of dental disease. A separate checkbox is added to the database in order to indicate if this wear can be related to any kind of dental pathology. For each individual a picture with the dental inventory on it will be provided, where attrition and abrasion (such as pipe notches) can be shaded for a more complete visual presentation of the dentition. Caries will also be marked on this image. These images will then be scanned and added to each individual's record in the database (an example can be seen in appendix II).

Dental abscesses will be recorded according to Hillson (2008). The size of the sinus will not be recorded, but the nature of the canal is recorded as follows:

❖ Through the buccal/labial or lingual plate of the alveolar process.

- Through the angle of the palatine process of the maxilla into the floor of the nose.
- Into the maxillary sinus.
- Onto the buccal or lingual aspect of the mandibular body.

Calculus will be graded according to Brothwell's (1981) three-stage scoring system: slight (only a slight line of calculus), medium (up to 50% of the tooth is covered in calculus) or considerable calculus (more than 50-100% of the tooth is covered in calculus), or will be graded as no calculus present.

Statistical analysis

In archaeology the most common expression of the number of caries to be found in an individual or in a population is to show the number of carious teeth as a percentage of the surviving teeth, or as how many individuals are affected versus the total numbers of individuals. These methods are meant to correct for the number of missing teeth in the skeleton. However these methods have some serious problems. For example the percentage of the surviving teeth method does not take tooth classes into account. Anterior teeth are much more likely to be lost during life, while cheek teeth often have a much higher rate of caries, which causes a large discrepancy in the total numbers. Percentages will also be likely to underestimate caries since most ante mortem tooth loss will probably be due to caries. Also no correction is made for age or sex, while dental disease will occur more often on older skeletons. There is also no way to record two different types of caries in a single or on several teeth, making these percentages essentially useless (Hillson 2001, 256).

Therefore in order to be able to account for the type of tooth, the number of lost teeth, the type of lesion as well as age and sex, each individual skeleton's teeth will be examined tooth by tooth, and will also be recorded in the database tooth by tooth with its accompanying dental disease data. The database is specially designed for this project by the author in Microsoft Access 2007 in order to be able to process the data correctly and extremely accurately. By ordering the data per individual as well as per tooth very specific information will be available, such as how many of the total available molars were affected with caries? Or how many of the women in a certain age category had caries in their third molar? Information will be separated as much as possible in order to run queries to show results that might only come up later, during the investigation when it would be too late to change the recording strategy. When the

necessary queries are run in access they are then transferred to SPSS (version 20) in order to calculate the necessary statistics that Access is unable to do.

Every individual will, according to the methods of sex determination used in the skeletal examination be divided in four age ranges of early young Adult: 18-25, late young adult: 26-35, middle adult: 36-49 and old adult: 50+. The result of the sex determination will be noted as either: M (male) or F (female). Due to the research goals placed in this thesis people that were determined to be I (indeterminate), will be left out of this research.

After inputting the results into the database a series of selection queries will be made in order to select the age and sex from each individual in addition to which tooth was affected and in which rate with caries, calculus, which stage of wear, if there was any activity related wear present on the tooth and if there were any abscesses present. Then these results will be compared between men and women to see if there are any marked differences between the sexes and if any age-related differences are visible. It will also be examined if the activity related wear, if present, was related to any kind of dental disease. Finally it will be examined if there is a relationship between dental disease and diet. If later on individuals can actually be identified through the historical records then this metadata can also be added in order to see if there was a relationship between social class and the state of oral hygiene of the individual.

Chapter 5: Results

In this chapter the results are presented that have been found after the examination of a total of fifty skeletal remains from the Dutch town of Middenbeemster. Twenty-five men and twenty-five women have been examined for caries, calculus, the stage of wear, activity-related wear and the presence of abscesses. The men and women were divided in four age categories: seven women were 18-25 years of age, six women were 26 to 35 years of age, six women were 36-49 years of age and six women were over fifty. The men were divided in exactly the same numbers and age categories with seven in the age of 18-25 and six in the three other age categories. Individuals were only selected if no more than three teeth were lost post-mortem (not including the teeth that were removed for DNA research) since the absence of more teeth could influence the final research results. Only a few exceptions have more than three teeth missing post-mortem if no other specimens were available.

The patterns of dental disease in the Middenbeemster population

The general patterns of dental disease from the Middenbeemster collection seem to show a high prevalence of caries, with individuals often showing several caries in a single tooth. There was also a high number of teeth ante-mortem lost and the men showed a lot of activity-related wear among which many pipe notches. The presence of calculus varied with some individuals heavily affected while others seemed almost free from it. Of course calculus is very delicate and the presents of loose fragments of calculus in the bags where some teeth were kept in suggest that there might have been more calculus present, but that frequent handling of the teeth might have caused it to loosen and fall off.

Ante-mortem tooth loss

The 50 individuals have a total of 1050 teeth present. From the total amount of teeth missing, 403 were ante-mortem lost, 21 were missing (mostly due to the absence of jaw fragments), 24 were post mortem lost, 3 were congenitally absent (mostly second incisors or canines), 25 were unerupted or congenitally absent (in the case of M3) and 74 were taken for DNA research. In total five individuals had lost all of their teeth ante-mortem, two males and three females which were all older than 50. Only three

individuals had one or more abscesses present, one old individual even had three rather large abscesses through the buccal aspect of the mandibular body.

Caries

A total of forty-two out of the fifty individuals showed caries, however some of the older individuals had lost many teeth and a few had even lost all of their teeth ante-mortem, preventing them to have caries. In addition many of the men seemed to have extreme wear to the teeth, possibly wearing away any evidence of caries. In some of the individuals single teeth were very worn away, probably as the result of advanced caries, but sometimes this was very difficult to see, another factor that might underestimate the total amount of caries on the individual's teeth. However total of 280 teeth out of 1050 were affected with caries, and many of the teeth had two or even three caries lesions. The total amount of caries lesions that was present on the teeth is 348. In percentages this means that a total of 26,7 percent of the present teeth were affected with caries, and that every tooth that was affected on average has 1,24 caries present.

Since so many people seem to have had extreme wear on the teeth, it would be interesting to see if this can be related to caries in any way. Perhaps in people with a large average wear number the amount of caries are low which would result in a strong negative correlation. For this statistic the average amount of wear has been calculated for each individual that has at least 16 teeth present to prevent obscured results. When the Spearman rho correlation is run on both the average wear number and the number of caries an individual has the result is a Spearman rho number of -0,074 and a p-value of 0,672, indicating that there is no strong negative correlation between the amount of wear and the amount of caries and that this is also not statistically significant.

Most of the teeth affected with caries are molars, as can be expected. Out of the 280 teeth affected with caries 188 are molars and premolars (67,1%), while 92 of the affected teeth are incisors and canines (32,9%). When only the molars are examined for caries 134 of the molars are affected with one or more caries lesions (47,9%). In total 162 caries are present on the molars (46,6%) out of the total of 348.

Calculus

Calculus deposits were common, but only a few individuals seemed to be severely affected. Many of the teeth were slightly affected, 39 out of 44 people were at least slightly affected, 29 out of 44 individuals had at least one or more teeth medium

affected and 11 out of 44 people had at least one tooth that was severely affected by calculus.

Attrition

Attrition was very common in the 19th century as can be expected and is of course much more advanced in the elderly. Especially the men seem to be exhibiting extreme wear to the teeth, even in younger ages. The average attrition rate for all 44 individuals with more than two teeth was 3,84 across all ages.

Activity-related wear

Activity related wear seems to have been very common in the Middenbeemster population. In total 26 out of the 50 individuals (52%) showed clear signs of activity-related wear that was obviously not the result of mastication. Far the most common was wear related to the smoking of clay pipes which resulted in very clear pipe notches. One theory that would be worth researching is if activity related wear can be related to attrition, since activity related wear results in a higher attrition rate. When the Spearman rho test is executed on the average rate of wear per individual and the total number of teeth affected with activity related wear per individual the resulting correlation coefficient is -0,072 with a p-value of 0,672. This indicates that there is actually no strong correlation between the two values and that this result is also not statistically significant.

Dental work

There was one remarkable find in the Middenbeemster cemetery, especially since it was a rural cemetery; a woman with false teeth. Both the maxillae and the mandible were both fitted with false teeth, since the women's own teeth were either mostly ante-mortem lost or had rotted away to the roots. The teeth were made from glass and set in a plate that looked like it was made from lead, but after XRF testing it became clear that it was made from silver. Wear on the teeth also make it clear that the sets of teeth were used for actual chewing, and were in use for quite some time before the woman died. It is unfortunate that it is still not possible to link this woman to an individual from the historical ledgers, since such a set of teeth must have been very expensive since it is all made by hand and was made to fit. Therefore she must have had a high status, such as the mayor's wife or a nobleman's wife for example (see Figure 5).

Figure 5: two views of the female aged 36-49 with artificial glass teeth set in silver (by author).

Conclusion

It is to be expected that in the 19th century oral hygiene was not as far evolved as it is today with our regular inspections by the dentist and fluorised water. Caries rates are therefore relatively high with up to 26,7% of all teeth affected with at least 1 caries lesion and that on average every affected tooth had 1,24 caries. Since attrition rates were also surprisingly high a correlation test was done on the relationship between the number of caries per individual and the average attrition rate. It could be expected that these had a strong negative relationship since a high rate of wear could wear away any evidence of caries. However the Spearman rho test indicated that there was no strong correlation to be found whatsoever.

Attrition rates were also quite high, just like the prevalence of calculus which might show that the brushing of or taking good care of teeth was still not a very common practice. Activity-related wear is extremely high for this population, which mostly seems to be the result of pipe smoking, particularly in men. However this does not seem to have had a significant relationship with attrition rates or on dental pathology. Very surprisingly in this rural society one individual was found with actual false teeth made from glass and silver. This must have been the wife of a very rich merchant, mayor or farm owner for her to be able to afford such a handmade piece of art.

Differences in dental pathology between men and women

There are some very clear differences between men and women in visible dental pathology, attrition and abrasion, as can be expected in an era when women still had very different occupations compared to the men. Women were expected to sew, do housework and take care of the children perhaps in addition to helping out in the fields every now and then or helping to process or sell the crops. Men at the time were also avid pipe smokers and with pipes at the time being made from clay, this would wear teeth down considerably. Also not very much is known about women from rural areas being smokers in the 19th century.

For statistical calculations in this paragraph comparisons between men and women will be made on the presence of for example calculus, caries and attrition rates. However the total amount of teeth present between men and women would need to be similar for these statistics to represent the true values. Therefore an independent t-test was done on the number of teeth present in men and women to see if there was a significant difference in the number of teeth available for research. The result of the Levene's test is only presented if included if the comparison is not between 25 men and 25 women which will make this obsolete. In this case the result of the t-test was a t-value of 0,721 and a p-value of 0,474, indicating that there is no significant difference in the amount of teeth still present in the male and female populations that were examined. Therefore in statistics such as the presence of calculus deposits there is no need to first select the individuals with a certain amount of teeth present. Only in the case of average attrition rate differences between the sexes only those individuals with at least 16 teeth present were selected since this could otherwise influence the internal average attrition results. However for more accurate results a second statistic will be

included that does correct for the amount of teeth present in each individuals in order to be certain that this makes no difference in the test results.

Ante-mortem tooth loss

What can be seen from the amount of teeth that are ante-mortem lost is that men over all age categories have 171 teeth that are lost (42,4%) while still alive while women have lost 232 teeth (57,6%) during their lifetime. When put into the independent samples t-test (25 men and 25 women) the result is a t-value of -0,788 and a p-value of 0,435. This indicates that there is no significant difference in ante-mortem teeth loss between men and women. When comparing the means of each group the men have a mean ante-mortem teeth loss number of 6,84 and the women of 9,28 per individual across all ages.

Caries

In caries occurrence there seems to be a large difference between men and women. From the forty-two individuals that showed caries lesions in one or more of their teeth 21 were men and 21 were women, an even divide of 50%. However if the number of caries per individual are taken into account then the numbers are very different. Of the 348 lesions found, 243 belonged to women, a total of 69,8%. This also means that every woman had on average 11,6 caries versus an average of 5 in the male population. This might suggest a difference in sustenance or caring for the teeth. In Forty-four cases women also showed two lesions in a single tooth and in seven cases individuals even presented three caries in a single tooth. In men two lesions in a single tooth were only present in 15 cases and in a single case one tooth had three caries.

If the differences between men and women in caries amount are calculated with statistics then this test can be performed as a regular independent t-test since the Levene's test results are 0,059 (with an F value of 3,775). Since 21 men and 21 women had caries this number could not have been more perfect. For these results the total amount of caries per individual were counted (including if there were several caries present on a single tooth). The result of the t-test is a T-value of -2,694 and a P-value of 0,010 again signifying a significant difference between men and women. This is also not surprising if the mean of number of caries between men and women are compared; 4,95 for men versus 11,48 caries on average for women.

However these results do not consider the actual number of teeth present in each individual, it merely counts how many caries each individual has. Therefore a

percentage value was calculated that shows the percentage of teeth that are affected with caries for each individual. When these numbers are compared between men and women the differences are even greater with a t-value of -3,765 and a p-value of 0,001 and a mean affected percentage of 18,3% for men and 45,1% for women.

If the severity of the caries of men and women is examined on first glance there also seems to be a difference between men and women. In 72 caries spread over 19 different women the severity of the caries was a level 3 (larger cavity that penetrates the dentine) and in the case of 94 caries in 16 individuals the caries was a level 4 (large cavity with open pulp chamber or open root canal). In men 46 caries in 13 individuals were considered a level 3, while only 18 cases in 11 individuals were level 4 caries. Overall this seems like a large difference between both sexes. However if the severity of the caries is examined statistically with an independent samples t-test the means are very close together with a mean of 2,70 for men and 2,97 for women. This only gives a t-value of -1,287 and a p-value of 0,205. This indicates that there is no significant difference in the severity of the caries between men and women. Clearly only the number of caries is different.

Calculus

Calculus distribution differences between men and women are another interesting notion since this could reflect a difference in sustenance or oral health care for example. For these result the total amount of calculus present was counted for each individual, all ranges of severity included (slight, medium, considerable) and then compared between men and women with a standard independent t-test. The results of the t-test give a t-value of 2,035 and a p-value of 0,047. This indicates that there is a significant difference between men and women in the total number of calculus deposits. Men have a mean of 13,6 teeth affected with calculus while women have an average of 8,28 teeth affected with any severity of calculus. When only the teeth with a medium or severe calculus rating are examined the differences between men and women are even larger. The mean in men are 4,2 teeth that are affected with a medium or severe case of calculus while women only have 1,3 teeth affected with this severity of calculus. The t-value for these results is 2,321 with a p-value of 0,025.

However again these results are not corrected for the total amount that are present in each individual. For this reason a percentage amount was calculated for the total amount of teeth present that are affected with calculus. When these data are put

into an independent t-test the result is a t-value of 2,099 and a p-value of 0,042, once more indicating a significant statistical difference between men and women. This is also visible in the mean value for each group, 39% of total present teeth is affected with calculus for women versus 60,5% for men.

Attrition

In comparing attrition rates between men and women, a clear difference can be seen. To calculate the differences an average attrition rate was calculated for each individual that had at least 16 teeth present. Scores of 1 were ignored since these were only attributed for teeth that were not present. Teeth that were present were attributed a score of 2 or higher. For statistics an independent t-test was not possible due to the fact that only 37 of the 50 individuals had at least 16 teeth present, 20 of which were male and 17 were female. Due to this fact the Levene's test gave a result of 0.015 (with an F of 6,477), which is evidence that the data is not normally distributed between the men and women. However if the result is taken from the field 'Equal variances not assumed' then we end up with a t-value of 2,745 and a p-value of 0,010 which means that there is a significant difference between men and women. The men furthermore have a mean of 4,16 while the women have a mean attrition rate of 2,90, a clear difference. When the Mann Whitney U test is done which compares not normally distributed data a result of 0,012 is obtained, again showing that there is indeed a significant difference and that men generally show a higher rate of attrition than women.

When all present teeth are taken into account, not only of the individuals that have 16 teeth or more present 22 males and 22 females were compared in an independent t-test, the males had a mean attrition rate of 4,31 and the women of 3,37 with a t-value of 1,995 and a p-value of 0,053. This indicated that statistically no difference between men and women can be discerned; however this number is so close to 0,049 which would show a statistical difference that this might be disputed. When the Mann Whitney U test is once again performed this results in a p-value of 0,051.

Activity-related wear

One clear form of activity related wear that shows a clear difference between men and women is the appearance of pipe notches in teeth. Almost all of the men seem to show some form of wear due to the smoking of pipes and remarkable enough, three women also showed several pipe notches proving that a small percentage of women were also

avid smokers (see Figure 6). From the total amount of men that had enough teeth present in order to be able to show pipe notches (22) only two individuals showed no clear signs of activity related wear due to smoking. One was a young adult aged between 18-25 and the other a middle adult aged between 36 and 49. In conclusion 90,9% of the men seemed to be avid smokers versus 15% of the women (3 out of 20 individuals with more than 16 teeth present).

Figure 6: an example of a female with visible pipe notches (by author).

When statistics are used to analyze the total amount of wear present on each individual's entire dentition it is not surprising that we would see a large difference between men and women. For these calculations each tooth has been marked as either showing activity-related wear or not showing activity related wear. In some cases however teeth might have had one pipe notch on either side of the tooth but it was determined that having one or two pipe notches on one tooth would not influence these results significantly so these were omitted.

The independent samples t-test resulted in a t-value of 5,444 and a p-value of 0,000 showing an extremely high difference between the presences of activity related wear between men and women, which is not at all surprising. The men have a mean presence rate of 8,56 while the women on average only have 1,12 teeth with wear on it.

However these results do not correct for the amount of teeth that are still present in each individual. Several teeth that would have showed activity-related wear might have been lost, or the few remaining teeth may all show some sort of wear which would not show in the statistics. Therefore a second calculation has been made with a calculated percentage value of the number of teeth that are present and that are affected with wear. When an independent t-test is performed on these numbers the mean of the percentage of total present teeth that are affected with some sort of activity related wear is 40% for the men and only 6% for the women with a t-value of 5,851 and a p-value of 0,000 (Levene's test F-value is 0,051).

Conclusion

This paragraph has given some surprising results to the differences in dental health between men and women. There appeared to be no significant difference in the amount of teeth that were ante-mortem loss, but there was a significant difference in the amount of caries in men's and women's teeth. In total 69,8% of the caries that were found in all of the individuals belonged to women with a total p-value of 0,010. There was however no large difference in the average severity of the caries that was present. Another significant difference between men and women was the rate and amount of calculus present on the teeth. In men this was significantly higher than in women. The men had a mean of 13,6 teeth affected with calculus while women only had an average of 8,28 per individual. The statistics also showed an even greater difference in the rate of calculus found in men and women with the men showing far more 'medium' and 'considerable' amounts of calculus on the teeth than women.

In mean attrition rates that were calculated for each individual there was also a significant difference between men and women with the men having a mean rate of 4,16 while the women had a mean attrition rate of 2,90. The result of the Mann Whitney U test confirmed this with a p-value of 0,012. Unsurprisingly the largest difference between men and women was in the presence of activity-related wear. Men seemed to have been avid pipe smokers and even though a few of the teeth affected by wear were not the result of pipe smoking this still resulted in a high significant difference. This is reflected in a p-value of 0,000 of the independent samples t-test and a mean amount of teeth affected with activity related wear of 8,56 for men while the women on average only had 1,12 teeth affected.

Age related differences in dental pathology

When age is included in statistical analysis it is clear that some results will not be representative of the total number of caries or amounts of calculus for example since each advancing age group will be missing a larger amount of teeth. Most of the results have not been corrected to only include the individuals with a certain amount of teeth present since too few individuals would be left in each group to have meaningful results. The old adult group for example would almost disappear while the young adults would be overrepresented.

Ante-mortem tooth loss

It is of course not surprising to expect that ante-mortem tooth loss increases with age an when a standard ANOVA test is run on the number of teeth lost ante-mortem it is not surprising that it returns a p-value of 0,000. When a Tukey Post-Hoc test is run it is also not surprising to see a p-value of 0,024 between the early young adults and the late young adults, although this does prove that there was already a significant amount of Ante-mortem tooth loss in the group from 26-35 years of age. The p-value for the late young adults and the middle adults is 0,048, which again shows an increase in loss of teeth ante-mortem. And finally the p-value for middle adults related to old adults is 0,001 again indicating a large increase in AML (ante-mortem tooth loss). On average the group of old adults only had 6,75 teeth left per individual, however three individuals still had almost all of their teeth while five others had lost all of their teeth ante-mortem. This age category is also only defined as 50+ since making more exact age estimates are extremely difficult, especially for ages over 60. It is therefore possible that individuals up to 100+ were included so this age group will be considered with care.

If a Kruskal-Wallis test is performed to correct for the different size of each age group (early young adults N=14 versus N=12 in the other groups) the result is a p-value of 0,000 once more signifying a significant difference between at least two of the age groups.

Caries

It would be expected that the amount of caries decreases with age since as became clear in the section above individuals lose a significant amount of teeth as they get older. When the One-Way Anova test is run it is therefore not surprising to see no

significant differences between any of the groups with an F-value of 1,349 and a p-value of 0,273. However if the mean amounts of caries are examined per age group it is surprising to see that the late young adult group has much more caries than any of the others. The average number of caries for the early young adults is 7,17, for the late young adults it is 12,25, for the middle adults it is 6,25 and for the old adults 6,17. Statistically however it seems that this difference is not large enough to show up in the ANOVA test. When the Kruskal-Wallis test is performed to correct for the small group of old adults (6 individuals versus 12 in the other age groups) there is however a significant difference visible between the age groups with a p-value of 0,000. There does not seem to be a difference between the early young adults and late young adults (mean rank of 28,83 and 28,79) but there does seem to be a significant difference between the late young adults and the middle adults with a mean rank of only 10,92 and the old adults with a mean rank of 13,42.

When the average numbers of teeth that are affected with caries are calculated for each individual and these numbers are put into the One-Way Anova test the resulting F-value is 0,851 and the p-value is 0,475. This once more signifies that there are no large differences in the number of teeth that are affected with caries for each age group. Only the early young adult group has a mean average of 21,8% of the teeth affected with caries, while the other three groups stay between 31,7 and 38,6%. If the Kruskal-Wallis test is performed that compares the median in order to correct for the old adult group only consisting of six individuals with surviving teeth the result is a p-value of 0,534 again indicating that there is no significant difference between the age groups at all.

Calculus

Calculus deposits are expected to have a significant difference between early young adults and one of the older groups and of old adults with the younger groups since in the early young adults calculus has not had much time to form while the old adults have already lost a lot of teeth so their calculus rates should be lower. This does seem the case when the total number of teeth affected by calculus in each age category are calculated using One-Way ANOVA. The ANOVA test does show a significant difference between one or more of the categories with an F-value of 3,429 and a p-value of 0,025. In order to see where the statistical differences are a Tukey post-hoc test was done. This resulted in a statistical difference between late young adults and old adults which is as

predicted. The old adults only have a mean of 5,33 teeth affected with calculus while the late young adults have a mean of 16,67 teeth affected. As expected the early young adults have a mean of 9,5 teeth affected and in the middle adults 12,42 teeth have calculus deposits. When the Kruskal-Wallis test is performed to correct for the low amount of old adults that have teeth remaining the result is a p-value of 0,012 again indicating a significant difference between the age groups. Once more the old adults are the group where the least amount of teeth are affected with calculus with a mean of 15,71 versus 23,96 for the early young adults, 34,79 for the late young adults and 27,79 for the middle adults.

When the number of teeth present in each individual are taken into account and the total percentage of teeth affected with calculus is calculated then the results are slightly different. When the One-Way ANOVA test was run this resulted in an F-value of 1,294 and a p-value of 0,289. This number does not show any statistical difference between any of the age groups in contrast to the earlier test. The average mean for the early young adults is 35%, for late young adult it is 61,1%, for middle adults 54,7% and for old adults 49,6%. However since the size of each age group is not even an additional Kruskal Wallis test was performed. This resulted in a p-value of 0,278, again showing no significant difference between any of the age groups.

Attrition

For the comparison of the total attrition rate for every tooth present for each individual the average attrition rate was calculated according to the teeth that are present. In total 44 individuals that still had enough teeth (>2) were compared. As expected 1 middle adult and five old adults were missing all of their teeth so attrition rates for these individuals could not be calculated. When a One-Way Anova statistic is run on these data the significance between at least two groups is considerable with an F-value of 15,968 and a p-value of 0,000. When a Tukey post-hoc test is run to see exactly where these significant differences are located something surprising is visible. One would expect the older adults (at least those with remaining teeth) would show the highest rate of attrition with the younger adults showing lower average attrition rates. However while the early young adults have a mean attrition rate of 2,29 and differ significantly from the late young adults with a mean of 3,78 and a p-value of 0,009 and the late young adults also differ significantly from the middle adults with a p-value of 0,024, the middle adults instead of the old adults seem to be showing the highest average rate of

attrition with a mean of 5,20. It is not surprising that they do not differ significantly from the old adult group with a p-value of 0,942 and a mean of 4,89.

When a Kruskal-Wallis test is performed to correct for the uneven age groups the result is a p-value of 0,000 once more signifying that there is indeed a statistically significant difference between one or more age groups. Here the difference is between the early young adults (mean rank of 8,57, N=14) and late young adults (mean rank of 24,5, N=12). The older adults seem to differ less from each other with a mean rank of 32,82 (N=11) for the middle adults and a mean rank of 30,71 (N=7) for the old adults.

When only the individuals with 16 teeth or more are compared with a One-Way Anova test again the result is an F-value of 12,519 with a p-value of 0,000. Here the means are slightly different with an average attrition rate of 2,29 for the early young adults, 3,79 for the late young adults, 4,99 for the middle adults and 5,03 for the old adults. This seems like a much more logical result than the test done on all of the present teeth. However the only significant differences between age groups are between the early young adults and late young adults. The result of the Kruskal-Wallis test is a p-value of 0,051 which would indicate that there is no statistical difference between the age groups, but only just. This is probably due to the old age group only having a small number of individuals.

Activity-related wear

It would be interesting to see if the older adults have more signs of activity-related wear than the younger groups. This would seem logical since teeth do not remodel and any kind of wear that was acquired in younger years would still show as they grew older. However these values need to be adapted to the amount of teeth that are still present for each individual or else individuals with only a few teeth would get a low total amount of teeth affected with wear while 100% of the remaining teeth could be affected. Therefore the total remaining numbers of teeth that were actually affected were calculated in a percentage and this is used in the One-Way Anova test accompanied with a Tukey post-hoc statistical analysis.

The results of these test are as follows: the early young adults on average have 13,7% of their teeth affected by activity related wear, the late young adults have a mean of 29,7% of their total present teeth affected, the middle adults have a mean of 24,1% and the old adults have a mean of 25,8%. The One-Way Anova test does not find the differences between any of the age groups statistically significant with an F-value of

0,898 and a p-value of 0,450. Again the group of Old adults may not be representative since only 7 old adults have not lost all of their teeth ante-mortem. When a Kruskal Wallis test is done to examine not normally distributed data the means do differ slightly to correct for the uneven groups but the z-value is 0,629, again confirming that there is no statistical difference between any of the groups.

Conclusion

It would be expected that as individuals get older they would have higher rates of ante-mortem tooth loss, caries, calculus and attrition. However this does not always seem to be the case. If the rates of ante-mortem tooth loss are compared then unsurprisingly there is a significant statistical difference between each age group and the following one. The early young adults, late young adults, middle adults and old adults all differ significantly from each other. One would also expect the rate of caries to increase as individuals get older, however statistically no significant differences could be found between any of the age groups in either total amounts of caries per individual or in the average percentage that was affected for each individual. The only statistical difference that could be found between any of the groups was the result of the Kruskal-Wallis test on total amount of caries present per individual. This did show a statistical difference between late young adults and middle adults which would not be suprising.

In total amounts of calculus present for each person the only statistical difference that can be found is between late young adults and old adults. However the numbers do rise from the early young adults (mean of 9,5 total teeth affected) to the late young adults (mean of 16,67) and the middle adults (mean of 12,42) and as expected fall again towards the old adults (5,33 teeth affected on average). When a Kruskal-Wallis test is done to correct for the uneven size of each age group again a significant difference between the age groups is shown with a p-value of 0,012. Strangely enough when a correction is made for the total amount of remaining teeth that have been affected with calculus the One-Way Anova test results in a p-value of 0,289 indicating no significant difference between age groups. The Kruskal-Wallis test results also indicate no difference between any of the groups with a p-value of 0,278.

When attrition rates are compared throughout each age group it is not surprising to see a rise from the early young adults with a mean attrition rate of 2,29 to the late young adults with a mean of 3,78 and the middle adults with 5,2. The only strange result is that the older adults have a lesser mean attrition rate than the middle

adults; 4,89. All age groups differ statistically from each other except for the middle and old adults since the difference between the two is so small.

Activity related wear would also be expected to increase when individuals get older, however the One-Way Anova and the Kruskal-Wallis test both find no significant difference between any of the age groups. However the early young adults do show a little less activity related wear than any of the older groups with a mean value of 13,7% of the present teeth affected versus 29,7%, 24,1% and 25,8%.

Chapter 6: Discussion

In this chapter the results presented in the previous chapter will first be discussed before the research questions presented in the introduction will be attempted to be answered to see if any new information can be extracted from this research, and if the numbers that have been calculated so far seem correct or if there could have been any factors that could have influenced the statistical results. Furthermore it will be examined if it is possible to evaluate the general state of oral health for the Middenbeemster population and if any more interesting results can be concluded from the differences of types and rates of dental pathologies between men and women as well as several different age groups and the relationship of the found dental pathologies to diet and activity-related wear.

The patterns of dental disease in the Middenbeemster collection

The fifty individuals that have been examined for this research consisted of twenty-five men and twenty-five women that were equally divided in four different age groups: early young adults that were 18-25 years of age, late young adults 26-35 years of age, middle adults 36-49 years of age and old adults that were 50 years of age and older. These individuals had a total of 1050 teeth present from the total amount of 1600 which would have been present if all individuals still had all of their teeth including the M3. A total of 403 teeth were lost ante-mortem which is 25,2% of the total amount of teeth. This seems relatively normal since this includes individuals of all ages and the older individuals would have lost more teeth than the younger individuals. The rate of dental abscesses seems relatively low with only four individuals out of 50 affected (8%).

The amount of individuals affected with caries was very high with forty-two out of forty-four individuals that had more than two teeth present affected (95,5%) and a total of 280 out of 1050 teeth affected with one or more caries lesions (26,7%). Strangely enough many teeth were affected with more than one caries lesion. A total of 348 lesions on 280 teeth results in an average of 1,24 lesions for each affected tooth. Also only 47,9% of the affected teeth are molars, if premolars are included then this number is 67,2%. This results in a total of 32,9% of the total amount of teeth affected to be incisors and canines, which seems unusual.

Calculus rates were also very high with thirty-nine out of forty-four individuals at least slightly affected, twenty-nine out of forty-four individuals had at least one or more teeth medium affected and eleven out of forty-four people had at least one tooth that was severely affected by calculus. Attrition rates were also relatively high with an average overall attrition rate of 3,84. Activity related-wear was also common in this population with twenty-six out of forty-four individuals (59,1%) affected with some sort of wear that could not be attributed to attrition due to mastication. Most of this wear is the result of the smoking of clay pipes that results in the forming of pipe notches in the teeth. Strangely enough in this rural society an individual was found with false teeth in both the upper and the lower jaws. This was determined to be a woman 36 to 49 years in age. The pair of false teeth was constructed from glass and set in a silver plate.

Differences in dental pathology between men and women

Ante-mortem tooth loss

As became clear in the results chapter there appeared to be some very clear differences between men and women and some differences that were not so clear or from which the results differed in different tests. Also small differences might not be visible in statistical results, but might still suggest that there is a slight difference between the genders. There is for example no statistical difference in the amount of total ante-mortem tooth loss between men and women, but when the total amount lost is put in percentages, men have lost 42,4% and women have lost 57,6% out of 403 teeth that were ante-mortem lost. Also when the means are compared men have a mean ante-mortem tooth loss number of 6,84 and the women of 9,28 which does show that women lost slightly more teeth ante mortem than men did.

Caries

The statistics do support the results that were calculated in percentages except in the case of the severity of the caries that seems to be much more advanced in women. In the standard t-test where the total amount of caries are taken for each individual and then compared between men and women this resulted in a p-value of 0,010. A second test was done in order to exclude the amount of teeth that were lost with the total amount of teeth affected (in %) per individual, even though a statistical test was performed on the total amount of teeth present in men and women which did not show

a significant difference. The second t-test on total percentages resulted in a t-test p-value of 0,001, indicating an even larger difference between the sexes. The only variable that could have influenced these numbers would be the teeth that have been so worn down that caries present on these teeth could no longer be seen. Since men have greater rates of attrition than women do, this could have been an influence on the results, but unfortunately this cannot be confirmed or disproven. However a correlation test done between the total amount of caries per individual and the average attrition rate did not show a positive correlation. Therefore for now it will be assumed that women indeed had more caries than men did.

Calculus

For calculus rates teeth were given a rating of no calculus present, slight calculus (only a narrow line present on the tooth), medium calculus (approximately 50% of the tooth covered in calculus) or considerable calculus (more than 50% of the tooth covered in calculus). Then the total amount of teeth that were affected with any amount of calculus were compared between men and women. This showed a statistical significant difference between rates, with men showing considerably more calculus deposits than women. Again a second test was performed in order to exclude the possibility that the amount of teeth lost would influence results. These numbers calculated the total amount of teeth affected with calculus in a percentage number. Again the statistical calculations confirmed a significant difference between men and women. However in some cases it was clear that the calculus deposits had let go of some teeth, since many of the teeth were loose in bags, with some bits and pieces of calculus that were obviously once present on the teeth. Therefore it is probable that in some skeletons calculus rates were underestimated due to the handling of the teeth and the fragility of the (often large) deposits.

Attrition

Attrition was rated for each tooth in each individual as a 1 (no attrition present), which was only given to teeth that were not present since every individual was at least 18 years old and there was no tooth present that showed no attrition at all, to a maximum of 8, which would mean that only the roots were left in the tooth socket. The complete reference schedule can be seen as Appendix 1 below. After scoring the average attrition rate for each individual these scores were compared between men and women. To

exclude any wrong results several tests were performed, first an average attrition rate was performed on individuals that had at least 16 teeth present. However this included 17 females and 20 males which resulted in a result of the levene's test of 0.015, an uneven result for statistics. If however an independent t-test is performed and the score from 'Equal variances not assumed' is taken this results in a p-value of 0,010 indeed showing a statistical difference between the two groups.

A Mann Whitney U test was also done in order to see if this would give the same result. This resulted in a p-value of 0,012, not showing much difference from the first test. If these tests are done on all individuals irrelevant of how many teeth were present this results in a p-value of 0,053 in a standard t-test. When the Mann Whitney U test is once again performed this results in a p-value of 0,051. Both values show that there is no statistical difference between men and women; however these values are so close to the 0,049 point which does imply a statistical difference that it is questionable if this could be assumed to be true. In the Mann Whitney U test women show a mean rank of 18,73 and men of 26,27 which does imply at least a slight difference between the two groups. Also since in this test even individuals with only two teeth were included perhaps showing an average that is not representative it would be more logical to find the first test between individuals with at least 16 teeth present to be more trustworthy and concluding that there was indeed a large difference between men and women with men on average having a larger average attrition number than women, with a mean of 4,16 in the standard t-test while women had a mean of 2,90.

This greater rate of attrition in men could be attributed to the fact that all men with teeth present (with 2 exceptions) were avid pipe smokers and the smoking of these pipes resulted in significant wear to their teeth. This wear however was usually restricted to 6-8 teeth which would receive a higher attrition rating. However in order to see if pipe smoking and a high attrition rate were related a correlation test was performed on the average attrition rate and the total number of teeth affected with activity-related wear. The result showed no correlation at all. This concludes that men probably ate foods that were more abrasive or that they had more activity-related wear which looks similar to wear that is the result of mastication since teeth were often worn down across the entire surface (of course with the exception of teeth with pipe notches).

Activity-related wear

As has already been discussed men showed much more pipe notches than women (90,9% versus 15%) as well as other types of activity related wear. Statistics are not even necessary when such a large difference is shown between sexes and the t-test result is not surprising a p-value of 0,000 with a mean of 8,56 teeth affected for men and only 1,12 teeth for women. These results do not need much discussion; however it does show that women did not do much with their teeth even in women's jobs such as cooking, spinning and sowing. Men's jobs would of course include working with materials that would wear teeth much faster than wool or plant material such as leather or wood. It is surprising however that three women were also pipe smokers. Only 15% of all women seemed to have smoked pipes on a regular basis and it is a shame that currently it is still very difficult to be able to link burials to the historical ledgers that are available and that could have shown what kind of status these women might have had. All that can be discerned is that the three women were of very different ages when they died, one was an early young adult, one a late young adult and one a middle adult.

Age related differences in dental pathology

Ante-mortem tooth loss

It would be as expected that individuals lose more tooth ante-mortem as they get older. However in present times it is unusual to lose teeth before reaching 50, this was of course not the case in the 19th century. But it was not certain if a statistical difference could be seen between the two youngest age groups, the early young adults 18-25 years of age and the late young adults 26-35 years of age. When the total amounts of teeth lost ante-mortem are compared statistically with a One-way ANOVA test it is not surprising to receive a resulting p-value of 0,000. The Tukey Post-Hoc test that is then performed however does result in statistical differences between all age groups, including the two youngest. Therefore it is clear that even in the ages between 26 and 35 there was already a significant amount of ante-mortem tooth loss for the Post-Hoc test to show a statistical difference. Also not surprising is that the biggest statistical difference can be seen between the middle adults and old adults with a p-value of 0,001 indicating that there was more than a significant amount of tooth loss from 36 years of age onwards.

Caries

Information on the amount of caries when individuals get older is interesting since people will probably have more caries in older ages, but they will also lose teeth or have them pulled if they get too severely affected. Can this be seen in statistics? The One-Way ANOVA test resulted in a p-value of 0,273 indicating no significant difference in the average amount of caries between age groups. The mean values however do show a slightly higher number of caries in the late young adult group. When a Kruskal-Wallis test is done to correct for the few old adults with remaining teeth a p-value of 0,000 is the result, which indicates a large difference between at least two of the age groups. The means indicate that the early young adults and late young adults both have about the same amount of caries; however the middle adults and old adults seem to have a much lower mean rank.

When these tests are done again with a correction for the total amount of teeth present and the percentage of teeth affected with caries are calculated the One-Way ANOVA test again shows no statistical difference. If the Kruskal-Wallis test is done to correct for the uneven age groups it also shows no statistical difference between the groups. The only thing that can be concluded from the means is that the early young adults on average have slightly less caries than late young adults who seem to have been affected with caries most (although not enough to show a statistical difference) and then a reduction in middle adults and old adults which is probably the result of ante-mortem tooth loos either due to natural causes or due to their removing of the teeth causing them pain. The statistics done on the percentage of teeth affected with caries are also probably the most reliable since absent teeth could also have caries. It is however impossible to guess how many of the missing teeth are missing due to caries or due to periodontal disease or perhaps a tooth could have been knocked out during a fight. Statistics could be calculated using missing values, but this result would probably be untrustworthy due to all the missing variables.

Calculus

When the total amount of teeth affected with calculus are calculated it would be expected that rates would get lower in the old adult group who only have relatively few teeth left in contrast to the younger groups. The result of the One-Way ANOVA test did show a significant difference between at least two of the age groups. The Tukey test however only showed a statistical difference between the late young adults and old

adults. As expected the early young adults only have a mean of 9,5 teeth affected with calculus while the late young adults have a mean of 16,67, the middle adults of 12,42 and the old adults of 5,33.

However when the total amount of present teeth are taken into account and the number of present teeth that are affected are calculated in a percentage number and these numbers are compared the Anova test does not show any statistical difference. The Kruskall-Wallis test also does not show a significant difference with these numbers. The means however do suggest a similar divide as stated above with the late young adults having the largest amount of calculus. With these calculated numbers this seems like a strange result as the middle and old adults would be expected to have the most teeth that are still present to be affected with calculus. It is of course possible that in late young adults the amounts of calculus were still building up but were lost when they got older due to attrition and activity related wear.

Attrition

Attrition was calculated from all teeth that were present in individuals that had more than two teeth and statistically calculated through One-Way Anova. This resulted in a p-value of 0,000 indicating a significant difference between at least one of the age groups. The early young adults, late young adults and middle adults all differ significantly from each other which is not surprising since attrition would be expected to increase with age. Only the old adults did not seem to differ much from the middle adults. In this test the middle adults instead of the old adults seemed to have a slightly higher attrition rate. However when the individuals with at least 16 teeth present are compared through One-Way Anova the results are slightly different. Here the means do seem to increase with age with a mean for the early young adults of 2,29, 3,79 for the late young adults, 4,99 for the middle adults and 5,03 for the old adults.

However only the early young adults and late young adults seem to be statistically different from each other. Also the Kruskal-Wallis test results in a p-value of 0,051. This is however not really surprising since this number is very close to 0,049 which does indicate a statistical difference between age groups. In this case the second result with only those individuals included which had at least 16 teeth present seems like the most logical. However the number of middle adults and old adults does decrease since only a few from these age groups would have sufficient teeth to be

included in the statistic. Luckily the differences are not so great that this really matters and in general attrition rates do seem to increase with age.

Activity-related wear

Activity related wear was scored as either present or absent for each tooth, since statistically it would not make much of a difference if a tooth had one pipe notch or two since the tooth next to it would also be affected. Therefore it was deemed irrelevant to score a tooth with more than one type of wear per tooth. In order for missing teeth to be excluded the total remaining numbers of teeth that were actually affected were calculated in a percentage and this was used in the One-Way Anova test accompanied with a Tukey post-hoc statistical analysis in order to see the exact difference between each group. As expected the early young adults have the lowest percentage of teeth affected with a mean of 13,7%. The older groups do not differ from each other in a significant number with 29,7% for the late young adults, 24,1 for the middle adults and 25,8 for the old adults. The One-Way Anova as well as the Kruskal-Wallis test do not find the differences between any of the groups statistically significant.

However one would still expect that activity related wear would increase with age, one solution for this is that teeth that were affected with activity related wear were more likely to be lost ante-mortem (or were removed by someone due to pain complaints) than other teeth that were not affected. This could result in a lower total number of teeth affected with activity-related wear.

Activity related wear and its relationship to pathology

Activity-related wear is remarkably common in this collection and consist mainly of pipe-notches in both men and women. Two individuals also showed a different kind of wear where the labial side of the maxillary incisors and the buccal side of the mandibular incisors were involved as if an item, for example fabric or rope, was held between the front teeth and was slid downward. However in none of the cases activity related wear was the cause for any kind of dental disease. It might have even obscured caries lesions since the wear might have worn the tooth away so far that the lesion was no longer visible. However the wear that was caused by for example pipes does not seem to have had an influence on the presence of caries or abscesses.

In the chapter about general patterns on dental pathology it also raised the question if activity related wear may then perhaps be related to attrition since the pipe notches created with pipe smoking would certainly increase the attrition rate for each individual. When a Pearson's correlation test is done on the total amount of caries present, the total amount of wear present and the average total attrition (over all present teeth) the result is surprising. The Pearson Correlation shows a correlation coefficient of 0,342 with a p-value of 0,015 between the total number of caries present and the total amount of wear present indicating a slight correlation between the two. The total amount of caries and the average total attrition gives a correlation coefficient of -0,312 with a p-value of 0,039 indicating a slight negative correlation. The total amount of wear versus the average total attrition results in a correlation coefficient of 0,387 and a p-value of 0,010, once more indicating a slight correlation.

This does show that a high rate of attrition has a negative influence on the number of caries, which seems logical since attrition could wear away any evidence of caries. It also shows that there is a slight correlation between the number of caries and amount of wear which shows that individuals with high total numbers of wear also on average have more caries. Of course this does not prove that wear causes caries but it shows that there is a slight relationship between the two. When the total amount of wear and the average total attrition are compared a slight correlation also seems to exist showing that individuals with high rates of wear do receive a higher rate of attrition, another logical conclusion.

Therefore the conclusion is that activity related wear as well as attrition have a slight influence on pathology shown here as caries although this correlation can also be coincidence since the correlation rate is not very high. The two might still be unrelated.

The inventory of dental disease in relationship to diet

Making a relationship between the presence of certain kinds of dental disease and a certain type of diet or the consumption of certain types of foodstuffs are always difficult. However some statistically significant results do show some strong differences between men and women. Women for example on average had relatively low attrition rates (measured from the total amount of teeth present in individuals with >2 teeth) with a mean of 2,19 for early young adults, 3,39 for late young adults, 4,51 for middle adults and 3,98 for old adults. Men however had a mean attrition rate of 2,40 for early young adults, 4,19 for late young adults, 5,77 for middle adults and 6,11 for old adults,

much higher rates than those of women. In the paragraph about difference between men and women above it was also shown that there is indeed a statistical difference between the two groups (even when all teeth.

This difference between attrition rates can of course partly be explained with the large number of teeth in men that were affected with activity-related wear which would increase the attrition rate slightly (even though often only 6-8 teeth were affected). And as was explained in the previous paragraph there does seem to be a slight correlation between attrition rates and activity-related wear but this does not explain such a large difference between men and women. Furthermore often the entire dentition seemed to be worn down evenly across all teeth which would seem the result of mastication. It is therefore possible that men consumed more foodstuffs that contained abrasive materials such as sand. Perhaps in the 19th century bread still contained a large concentration of sand, which men could easily take with them to the fields to eat as lunch and women could eat other products instead of bread while they stayed at home with the children.

This would also explain the relatively large amounts of calculus deposits on the teeth of men, which differed statistically from the calculus deposits on women's teeth. The carbohydrates in bread are a cause for the buildup of calculus; however smoking may also have an influence, which almost all of the men did. It is therefore not certain if this would be the main cause, but it could certainly be an influence, like the consumption of sugar.

Another large difference between men and women was the large amount of caries present in women. Statistically there was a large difference between men and women in caries amounts while the number of teeth present in men and women were relatively the same so this could not have been explained by a larger amount of teeth lost ante-mortem in men. The most logical explanation for this seems to be a larger intake of sugary foods in women, since sugar is the main cause for caries. Perhaps women were fond of sweets and in this rural area fruit was probably also eaten, especially in season and perhaps preserved in jars for the winter or processed as jams. Just like today most men were probably not especially fond of sweet foods preferring meats and cheeses for lunch and dinner.

The general state of oral hygiene in the Middenbeemster collection

What is clear from the results is that people suffered the most from caries lesions in their teeth with forty-two out of 44 individuals and a total of 26,7% of all present teeth affected. Calculus rates were also high with 39 out of 44 individuals at least slightly affected and a total of 546 out of the 1050 present teeth affected with any kind of severity. Ante-mortem tooth loss was also high with a total of 403 teeth lost from a total of 1600 resulting in 25,2% of all teeth lost. Attrition was also high with an average of 3,84 and activity related wear among all individuals with more than 2 teeth was up to 59,1%.

But what does all this information actually say about the general state of oral health in this population? It is clear that people loved to smoke clay pipes and ate a lot of sugary as well as starchy foods which is visible from the high amounts of caries and calculus deposits found in the people from Middenbeemster. Exactly how much time people spent taking care cleaning or brushing their teeth and visiting the individual or doctor that also worked as a 'dentist' probably primarily pulling teeth will probably remain unclear. However the statistics do support that caries lesions as well as teeth affected with activity-related wear are reduced in middle and old adults, which might suggest that people would get them removed when they were worn away so much that they hurt. However there were also plenty of skeletons with small pieces of teeth or even only roots left, which was probably the result of extensive caries or attrition and they obviously did not have these teeth removed. What is clear is that people knew that smoking clay pipes would damage the appearance of their teeth and from the high amount of individuals with pipe notches that were found (20 men and three women) people obviously did not care what their teeth would look like or that it might result in caries and high rates of attrition.

Cleaning the teeth must also not have been a regular task or the calculus deposits and the occurrence of caries would not have been so often and so severe. There seems to be one exception to this however, one middle female adult obviously had the funds as well as the desire to replace her missing teeth with some beautiful glass teeth set in silver. These teeth would of course be functional, since she would be able to eat 'regular' foods again but certainly it would have a visual appeal as well. Since this would have to be a wealthy woman it is possible that only the wealthier women cared or were able to afford to care about the appearance of their teeth. It would therefore be interesting to see if the females with pipe notches were wealthy or poor individuals in order to determine if wealthy women cared more and better for their teeth.

The only thing that would further this research would be to compare the results from this site to a similar rural site from the same period of time. However these sites are rarely examined since it is often thought that the 19th century was not a very interesting age to examine, limiting the amount of data that can be compared to this cemetery.

Conclusion

For this research a collection of fifty skeletons from the Netherlands was used, from the town of Middenbeemster. Middenbeemster is a village in the middle of a drained polder called the Beemster and was originally built in the 17th century. Middenbeemster is surrounded by the villages Noordbeemster and Westbeemster and is located in the northern part of the Netherlands. Middenbeemster in the 19th century was a rural village where cattle breeding and horticulture were the main practices, and the village was famous for its wool, butter, cheese and bulls. The collection of burials came from the new cemetery next to the church that was in use from 1829 to about 1866.

The Beemster collection consists of approximately 450 individuals from a variety of ages and sexes. For this research a selection was made of 50 individuals with an even sex and age distribution and which had no more than three teeth lost (ante-mortem lost teeth and teeth taken for DNA not included, also in some cases such as in the case of old adult females only a few individuals were available). Individuals were divided in four age groups: early young adults that were 18-25 years of age, late young adults that were 26-35 years of age, middle adults 36-49 years of age and old adults 50+ years of age.

From the total amount of 1600 teeth 25,2% was lost ante mortem across all ages which seems like a relatively normal amount. Caries was common among the population with forty-two out of forty-four individuals affected with at least one caries and a total of 280 out of 1050 present teeth affected with one or more caries lesions (26,7%). On average every affected tooth had 1,24 lesions present and a relatively high amount of incisors and canines were affected with caries (32,9% from the total amount of caries). Thirty-nine out of forty-four individuals that still had teeth present were also at least slightly affected with calculus deposits. Twenty-nine out of forty-four individuals had at least one tooth that had medium calculus deposits and eleven out of forty-four people had at least one tooth that was affected considerably with calculus. However only four individuals (8%) were affected with one or more dental abscesses, which seems like a relatively low number for such a large group.

Attrition rates in this population were high with an average attrition rate of 3,84 across all ages. Activity-related wear was present in twenty-six out of forty-four individuals (59,1%) which was mostly caused by pipe smoking resulting in pipe notches. Amazingly no evidence of any sort of dental work was found among these skeletons except for one woman that was thirty-six to forty-nine years of age when she died. She

was actually fitted with a pair of false teeth in her maxilla as well as in her mandible made from glass teeth that were set in silver. Unfortunately it is still unknown who this woman might have been so it is not yet possible to see if this was a woman with a high status.

When differences between dental pathology in men and women are compared some very surprising results are presented. Ante-mortem tooth loss amounts do not differ statistically with women losing slightly more teeth ante-mortem, however the amount of caries present seem much higher in women than in men. When a t-test was performed this showed a significant difference between the two groups with 69,8% of all of the caries lesions present in women. There was no significant difference in the severity of the lesions however. One explanation for this could be that men had relatively high attrition rates, which would wear away the caries, leaving no evidence of former lesions.

Calculus rates in contrast seem to be much higher in men than in women. Both the numbers calculated for the total amount of calculus and the amount that was calculated according to the total amount of teeth present show a significant difference between men and women with 39% of the total amount of teeth affected in women and 60,5% of total teeth affected in men. Attrition rates in also seem to be much higher in men than in women. If only the individuals with 16 teeth or more are examined then the men have a mean attrition rate of 4,16 while the women have an average rate of 2,90. In the One-Way ANOVA this also resulted in a statistical significant difference between the sexes.

It is no surprise that with clay pipe smoking being extremely popular in the 19th century that men had much more activity-related wear than women and that most activity-related wear consisted of pipe notches. However three of the women also showed pipe notches, indicating that in some women this was also practiced and accepted. In total 90,9% of the men showed any kind of activity-related wear versus only 15% of the women. Of course statistically this also shows a significant difference when put into an independent samples t-test.

When ante-mortem tooth loss, amounts of caries, calculus and the rate of attrition and activity-related wear are compared to each age group some interesting facts can be concluded. Not surprising the amount of ante mortem tooth loss increases in statistically significant steps from early young adults, late young adults, middle adults and old adults. However this does imply that even in the age of twenty-six to thirty-five years of age, ante-mortem tooth loss was significant. In numbers of caries one would

expect the number of caries to increase with age. Although this is the case from early young adults to late young adults (average percentage affected of 21,8% and 31,7%), none of the age groups seem to differ from each other significantly with affected amounts around 30% of all teeth present. Calculus deposits also do not seem to differ significantly between any of the age groups when the total amount of teeth present that are affected with calculus are calculated in percentages. Early young adults do already have an affected rate of around 35% of their teeth which rises slightly in late young adults and then lowers again towards the two older adult groups. Of course calculus amounts might be underestimated due to affected teeth falling out or due to the loss of calculus post-mortem due to handling of the teeth.

The attrition rate that is calculated for individuals that have 16 teeth or more present seems to be the most representative with average attrition rates rising from an average of 2,29 for the early young adults to 3,79 to the late young adults, 4,99 for the middle adults and 5,03 for the old adults. The only real statistical difference can be seen between early young adults and late young adults however. The rate of activity related wear would be expected to rise in old adults but with a mean affected percentage of 13,7% in early young adults and around the 25 to 29 percent in the other age groups this does not seem like the case. One cause for this might be that teeth heavily affected with wear were more likely to fall out in middle and old adults therefore underrepresenting the total amount of teeth affected.

At first it did not seem like activity-related wear and dental pathology were related, since in only one case it seemed like a carious lesion resulted from the wear of a tooth. However when statistics are consulted it seems like there is a slight relationship between the number of caries and the amount of wear present, a slight negative relationship between the rate of attrition and the total amount of caries present and again a slight positive relationship between the total attrition and the amount of wear (correlation coefficient of around 0,350 and -0,312).

In relationship to diet it seems since women have a larger amount of caries present in their dentition that they would consume larger amounts of sugar. Fruits, jams and sugars were very affordable in the 19th century and it is common knowledge that women are fonder of sweet foods than men. Men had more calculus deposits and higher attrition rates, perhaps a result of eating starchy foods that were abrasive such as bread accompanied with meat or cheese. This could also easily be carried to the fields where they might be working.

The general state of oral hygiene is difficult to determine if there is no material from the same period to compare it to but it is clear that caries levels were high, especially in women, while attrition and calculus rates were high in men. Visits to the dentist (or doctor also practicing as a dentist) were obviously not common with so many teeth affected with caries in a very high severity. Cleaning the teeth with for example a toothbrush must also not have been a common practice. The appearance of the teeth probably also did not matter much, or so many men and even some women would not have been smoking clay pipes so often which they knew would damage their teeth. The one exception is of course the pair of beautiful glass teeth that were custom made for the middle aged woman. She obviously had the funds to have these artificial teeth made and seemingly cared about how her teeth would look.

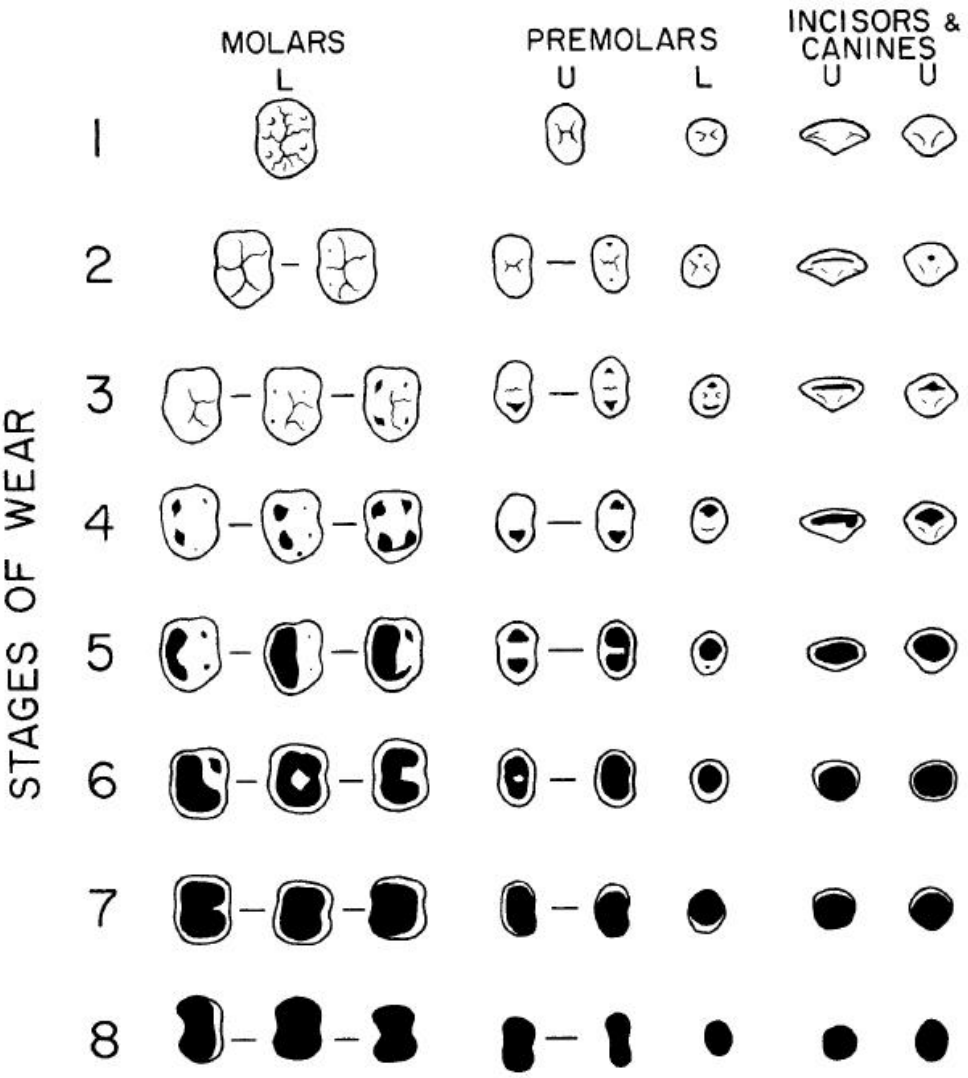
Abstract

This thesis compares the dental pathologies of fifty individuals from a 19th century Dutch rural cemetery divided in even groups of men and women, and four age categories. Between these groups the amounts of ante-mortem tooth loss, caries, calculus, attrition and activity-related wear were examined. The results are that ante-mortem tooth loss was relatively high even under thirty-five years of age, while no significant differences between the sexes were visible. Caries amounts were significantly high among women, but in the comparison between age groups only the early young adults seemed to be affected less than the other three age groups. Calculus deposits were significantly higher among men and went up from the early young adults to the late young adults but then lowered again towards the middle and old adults, probably as a result of ante-mortem tooth loss in these groups. Attrition rates were significantly higher among men and across the age groups a slight increase in attrition rates was visible. Activity-related wear was high in men with more than 90% of all individuals presenting signs of wear, especially due to clay pipe smoking resulting in pipe notches. Three women also showed clear signs of pipe notches due to smoking clay pipes.

In contrast to earlier results there seems to be a slight statistical correlation between the total amount of caries and the amount of wear, a small negative correlation between the amount of caries and the average rate of attrition per individual and a small positive correlation between attrition and activity related wear. The previously discussed data also gives a few clues toward the diet of both men and women. Women were probably more likely to eat sweets and sugary foods than men due to their large amount of caries while men were likely to eat starchy foods such as bread that were also abrasive resulting in higher rates of calculus and attrition. The general state of oral health is difficult to ascertain but it is clear that calculus, caries and attrition rates were high while not so much attention was given to cleaning the teeth or visiting a physician to have sick teeth pulled.

Appendices

Appendix I

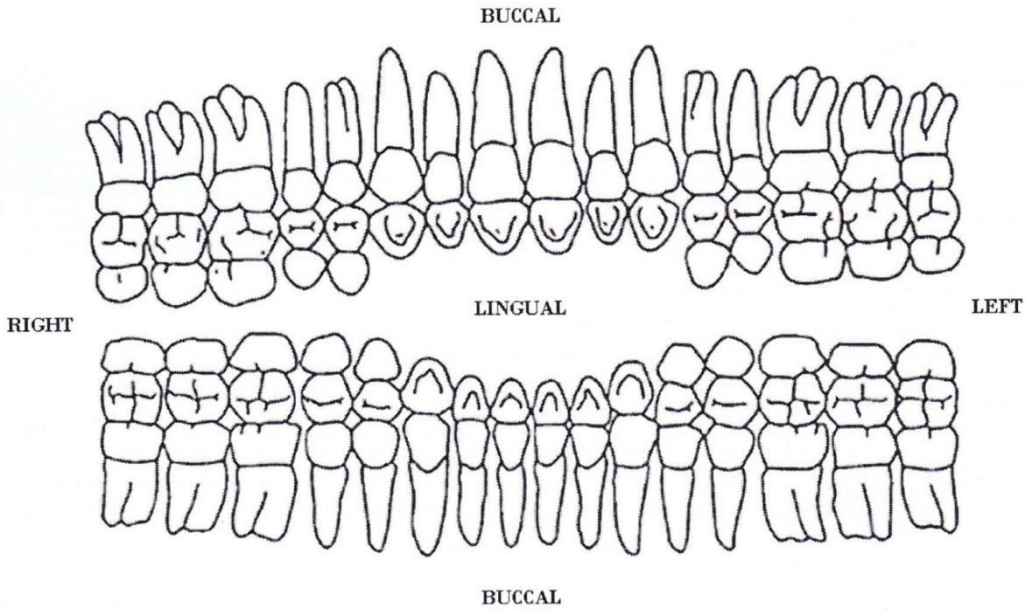


A diagram of crown surfaces with rate of attrition from stage 1 to stage 8 according to Smith (1984, 46). Abbreviations L (lower) and U (upper) designate the arch that was used in the prototype.

Appendix II

Dental Recording Form

Feature number:	
Find number:	
Sex:	
Age:	



An example of the form used to record attrition, abrasion and caries in each individual.

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List of figures