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Osteochondritis Dissecans of skeletal elements of the foot in a 19th century rural farming community from The Netherlands

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ABSTRACT

Osteochondritis Dissecans (OD) is a pathological condition of the subchondral bone and surrounding cartilage of synovial joints, associated with strenuous activity and/or trauma. Reports of OD in archaeological skeletal remains are few and the majority demonstrate low OD prevalence (< 1%). A predominantly 19th century skeletal sample from Middenbeemster, the Netherlands, was assessed for OD. The sample included adult individuals of both sexes. There were no definitive OD lesions in non-pedal elements, yet 12.9% of individuals suffered from pedal OD. Few archaeological and clinical reports specify the prevalence of pedal OD. According to the few that do, the Middenbeemster pedal OD prevalence is distinctly high. Several factors could have contributed to this. First, the rural Beemster community was centered around cattle farming, requiring extensive outside work and animal maintenance; thus, increasing the chances of acute/repetitive trauma in the foot. Second, the footwear worn during that period in the Netherlands was the wooden clog. It is suggested that the hard and inflexible clog, which is poor at absorbing shock and limits the movement of the foot, could have resulted in repetitive microtrauma. These two factors combined may have caused a high frequency of OD.

1. Introduction

1.1. Osteochondritis Dissecans

Osteochondritis Dissecans (OD) is a specific bone lesion correlated by researchers to trauma, either acute or repetitive microtrauma, resulting from vigorous activity (Detterline et al., 2008; Ortner, 2003; Schindler, 2007; Waldron, 2009; Wells, 1974). It affects the subchondral bone and surrounding cartilage of synovial joints. This could lead to the partial or complete detachment of articular cartilage, or both cartilage and subchondral bone, resulting to a loose-body formation within the joint cavity (Schindler, 2007). The fragment detachment area may heal over time, undergoing remodeling with lesion borders becoming sclerotic (Aufderheide and Rodríguez-Martín, 1998). However, when continuous loading is imposed, the healing mechanisms of bone, and thus its remodeling, may decrease leading to bone necrosis (Schindler, 2007). OD frequently occurs in athletes (Aichroth, 1971) and particularly throwing athletes and gymnasts (Baker and Romeo, 2010; Schenk and Goodnight, 1996; Wahegaonkar et al., 2007). In the ideal case of early detection and treatment of the lesion, the repair mechanism, especially in juvenile patients may be entirely successful; yet in most cases it is not (Schindler, 2007). The lesion may eventually be covered by a thin layer of bone, but its surface will remain depressed (Aufderheide and Rodríguez-Martín, 1998; Ortner, 2003).

1.2. Location and classification

OD can develop in any synovial joint. The highest frequency is usually observed in the knee, followed by the elbow, ankle, hip, shoulder, and finally the wrist (Waldron, 2009). Clinical cases document OD lesions on concave bony surfaces such as the posterior surface of the tarsal navicular bone (Bui-Mansfield et al., 2000) and the glenoid cavity (Gogus and Ozturk, 2008). When OD occurs in the foot, the talar dome and the distal end of the first metatarsal are the articular surfaces most frequently affected (Camasta et al., 1993).

In Aichroth's (1971) research of OD in the knee, 69% of the lesions in 105 patients from the Royal National Orthopaedic Hospital occurred on the lateral posterior site of the medial femoral condyle. Thus, this is described as the "classical OD" location. Classification systems for OD lesions located in other joints are scarce, largely because most publications describe single cases (Bauer et al., 1987; Bojanić et al., 2011). Lesions are usually unilateral, but can also occur bilaterally and sometimes in a symmetrical position. Lastly, it is possible for lesions to occur in different joints of the same individual (Detterline et al., 2008; Schindler, 2007).

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1.3. Etiology

The etiology of OD is not fully understood but trauma, either major or repetitive microtrauma, is certainly among the main causes (Schenk and Goodnight, 1996; Schindler, 2007). Other postulated causes include insufficient blood supply of subchondral bone (ischemia, avascular necrosis) (Hughston et al., 1984; Schindler, 2007), and accessory ossification centers within the epiphyses causing abnormal ossification (Schindler, 2007). Heredity may also contribute to OD occurrence since, according to some studies, members of the same family developed the pathology (Andrew et al., 1981; Stougaard, 1964; Tobin, 1957). However, the cause may be due to shared environment (Ponce, 2010). Despite the frequent appearance of OD in athletes, which supports the repetitive trauma etiology, it is agreed by several researchers that a multifactorial etiology is most appropriate (Schenk and Goodnight, 1996; Schindler, 2007).

1.4. OD in clinical research

OD is considered a rare pathology with an occurrence of 15–30 out of 100,000 people (Gogus and Ozturk, 2008). Clinical studies demonstrate that OD can occur at any age (Schenk and Goodnight, 1996). The highest peak occurs in adolescence (Schenk and Goodnight, 1996; Schindler, 2007), with the age ranging from 10 to 25 years according to Aufderheide and Rodríguez-Martín (1998) or 13–21 according to Detterline et al. (2008). OD is usually observed in males more often than females (Aufderheide and Rodríguez-Martín, 1998; Ortner, 2003; Ponce, 2010; Schenk and Goodnight, 1996; Solomon et al., 2010; Waldron, 2009), regardless of the joint involved. This could be due to the fact that men generally engage in more strenuous activities, and tend to be more athletic (Ponce, 2010), which consequently would imply a higher probability of trauma, a factor heavily correlated with OD. In clinical studies, there could be an underestimation of the occurrence of OD because the early stages of the condition can be asymptomatic (Resnick and Goergen, 2002). In addition, Bauer et al. (1987) suggest that OD is underdiagnosed because of visualization difficulties with radiology and due to possible healing.

The majority of OD cases reported in clinical literature involve athletes. Examples include Wahegaonkar et al. (2007) and Baker and Romeo (2010) of capitellar OD in baseball players and gymnasts, Koike et al. (2008) of OD in the glenoid cavity of a 22-year-old professional baseball player, and Mahirogullari et al. (2008) of OD in the humeral head of a 15-year-old baseball player. Vanthournout et al. (1991) refer to a 12-year-old tennis player girl, who suffered from OD in the distal end of the humerus. Aichroth's (1971) extensive follow-up research of OD in the knee, demonstrates that more than 60% of the patients' athletic engagement was evaluated from good to excellent and that 46% of them suffered significant trauma on the knee joint. The mean age was 18 years with the full range extending from six to 53 years.

With respect to pedal OD, the clinical literature records that the dome of the talus is most frequently affected, representing 4% of the total general OD cases (Bui-Mansfield et al., 2000; Kadakia and Sarkar, 2007; Santrock et al., 2003; Schuh et al., 2009; Steinhagen et al., 2001). Although trauma is the most likely etiology (Santrock et al., 2003; Steinhagen et al., 2001), Bauer et al. (1987), in their follow-up study on 30 patients, suggest that a circulatory factor could be implicated due to the high prevalence of bilateral lesions (7/30). Publications of OD involving other foot bones are few and they include case reports such as the medial cuneiform (Anderson, 2002), the navicular bone (Beil et al., 2012; Bui-Mansfield et al., 2000; Ozturk et al., 2008), and the 1st metatarsal (MT1) (Bojanić et al., 2011).

1.5. OD as an indicator of past cultural practices

A large post-Medieval (mostly early to mid 19th century) Dutch cemetery in the municipality of Beemster (Fig. 1), is assesed in order to evaluate the relationship between cultural practices and resorptive lesions in the bones of the foot. This may improve our understanding of lesion development that may be tied to physical activity related skeletal trauma. When OD is observed in archaeological skeletal remains, it could be indicative of equivalent types of strenuous activity. For example, Wells (1974) analyzed ancient skeletal material from the British Isles and reports a higher frequency of OD in Romano-British and Anglo-Saxon samples, compared to those of the Bronze Age period. Wells hypothesized that as the areas which the former groups inhabited were rather inhospitable and had to be cleared for agriculture, it lead to trauma-related OD development owing to usage of poor footwear and inefficient equipment. Wells (1974) then postulated that the low frequency of OD in the Bronze Age samples suggests pastoralism as the dominant way of life.

1.6. The Beemster site

The Beemster polder, a piece of land reclaimed from the North Sea and a World Heritage Site announced by UNESCO in 1999, was inhabited by small, rural communities which focused heavily upon dairy farming and less on market and subsistence gardening (De Jong et al., 1998; Falger et al., 2012). The Beemster landscape, is characterized by a central village, the Middenbeemster, and its small conglomerates/hamlets West-, Noord- and Zuidbeemster. Prior to the late 19th century, a lot of walking was required from the farmsteads to the central village where school, markets and other central facilities were located, as well as for the workers living in the village to deliver services back to the farmsteads. In the Netherlands, agricultural industrialization did not occur until the latter half of the nineteenth century, thus mostly after the time-period of the Middenbeemster cemetary sample (Drukker and Tassenaar, 1997; Van Zander, 1996). Historical data and osteoarchaeological research indicate that people engaged in high levels of strenuous manual labour (Gerard et al., 2002; Lindeboom et al., 2012; Palmer, 2012; Saers, 2012).

1.7. Goals of current study

Archaeology is always looking for new and better ways to reconstruct past human behaviour, and the occurrence of pathological lesions in the foot may be a valuable indicator of activity, trauma, and as will be presented, footwear, in this case the wooden clogs, '*klompen*', commonly worn in the Netherlands in the Medieval and post-Medieval periods. The main aim of this study is the examination of a high prevalence of foot lesions in a post-Medieval population from the Beemster polder of the Netherlands, in order to illuminate aspects of past activity and behaviour.

2. Materials and methods

2.1. Analyzed sample

Middenbeemster is one of the villages of the municipality of Beemster, in the province of Noord-Holland. Inhabitants from the whole of Beemster were interred in the Middenbeemster cemetery of the Keyser church from AD 1623–1866. From the last period of cemetery use, between 1829 CE and 1866 (Falger et al., 2012), archival documents including, death records, are available for many of the skeletons. The excavated skeletal sample came mostly from that latter time period. Most graves contained complete, or nearly complete, and well preserved skeletal remains. Males and females are equally represented and individuals of all ages (fetal to > 90 years) were buried in the cemetery (Lemmers et al., 2013).

One hundred and forty skeletons comprised of 63 males, 69 females, and eight unsexed older subadults, were examined for the presence of foot lesions. The sample was divided into four age-at-death groups; subadults (13–17 years), young adults (18–34 years; which can be