RESEARCH ARTICLE

Investigation of Occlusal Wear and Non-Carious Cervical Lesions in Skeletal Remains

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Abstract
The aim of this study is to investigate the relationship between occlusal wear and non-carious cervical lesions in a population that pre-dates modern oral hygiene practices and acidic food consumption by the study of skeletal remains. The cervical region of a tooth is susceptible to developing various types of pathology. One type of lesion is a non-carious cervical lesion. There are believed to be four main potentiating factors in the development of non-carious cervical lesions: mechanical, chemical, occlusal, and multifactorial. Mechanical loss of cervical tooth structure typically results from aggressive tooth brushing. Chemical erosion of cervical tooth structure also leads to the formation of non-carious cervical lesions. Occlusal stresses were first introduced as abfraction lesions, flexure of teeth leading to high stress and fracture at the cervical region. Authors have suggested that non-carious cervical lesions arise primarily in scenarios where multiple precipitating factors are present simultaneously. These factors are generally accepted as the contributors to non-carious cervical lesions. This investigation looks at a large population of skeletal remains.

Introduction
Many clinicians believe that understanding the etiology of dental disease is a critical step to resolving it. [1] Dentistry seeks to understand the process of dental disease in order to provide optimal care for patients. Optimal care requires an understanding of the disease process to provide treatment with outstanding longevity. Restoration of non-carious cervical lesions may provide a restorative challenge for dentists because of continued controversy surrounding their etiology. Dentists attempt to restore these lesions in a variety of ways due to a lack of clear etiology. The original belief surrounding non-carious cervical loss of tooth structure near the cemento-enamel junction was simply limited to mechanical toothbrush abrasion. Further theories include introduction of acidic substances that may contribute to non-carious cervical lesions. The most recent theories include occlusal stresses contributing to an increase of stress at the cervical portion of the tooth. Controversy continues to surround the etiology of non-carious cervical lesions. The cervical region of a tooth is susceptible to developing various types of pathology. One type of lesion is a non-carious cervical lesion. [2] (Figure 1) since an early publication on dentistry by John Hunter in 1778 there has been a mixture of usage and some confusion about the terminology used to describe these lesions. [3] In an attempt to clear up confusion on the subject of non-carious cervical lesions WD Miller categorized non-carious cervical lesions in 1907. [4] The categories created by Miller were wasting, erosion and abrasion. Miller provided the following definitions: “wasting” is used in a collective sense to designate any kind of slow and gradual loss of tooth-substance characterized by a smooth, polished surface, without reference to the cause of such loss; “erosion” refers to the superficial chemical disintegration of tooth-substance; and “abrasion” is a slow and gradual wasting away of tooth tissue by friction. This wedge-shaped defect was described as a wasting away of the tooth at the neck, very often taking a form as though produced by a three cornered file. These definitions are upheld by modern day sources as well [5&6].

In addition to the definitions from Miller, another etiology of the non-carious cervical lesion has since been introduced. In the 1980s, McCoy proposed that the angled notches at the

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cervical portion of the tooth near the cemento-enamel junction were caused by bruxism [7&8]. This suggestion from McCoy was based on engineering articles written by Hood, Selna and Yettram that looked at computer based models to determine clinical outcomes. [9&21] Lee and Eakle further hypothesized that tensile stress from mastication contributed to these lesions by disrupting the chemical bonds of the crystalline structures of enamel and dentin. [12] In 1991 Grippo suggested the use of the term abfraction. [13] Grippo, based on finite element analysis studies, suggested that high stresses from occlusion led to flexure of the cervical portion of the tooth and fracture in the cervical region. However, finite-element analysis has been shown to have potential uncertainty. In the case of abfraction lesions, the resilient support system of the periodontium makes finite element analysis studies very difficult to design and complicates the evaluation of these types of studies. [14] Despite that fact, finite element analysis studies continue to stand behind the abfraction concept. [15] Other types of studies may be important to investigate this topic.

In vivo and in vitro studies have investigated non-carious cervical lesions, as well. An attempt by studying casts of dental students to make in vivo correlations between non-carious cervical lesions has found no correlation. [16] Further in vivo studies have investigated correlation between premature occlusal contacts and non-carious cervical lesions and found no correlation. [17] Even occlusal adjustments have not been found to halt the progress of non-carious cervical lesions. [18] Microscopic analysis has failed to identify any identifiable signs of abfraction-like damage. [19&20] Epidemiological studies have had mixed results in correlating occlusal wear with non-carious cervical lesions. [21&22] Abfraction is only one of the believed causes of non-carious cervical lesions. There are believed to be three main potentiating factors in the development of non-carious cervical lesions: mechanical, chemical, and occlusal. Mechanical loss of cervical tooth structure typically results from aggressive tooth brushing. [23] Chemical erosion of cervical tooth structure also leads to the formation of non-carious cervical lesions. [24] Occlusal stresses were first introduced as abfraction lesions, flexure of teeth leading to high stress and fracture at the cervical region, by Grippo. [25&26] These factors have been investigated by anthropologists in populations in France. In the populations investigated, no correlation was found between occlusal wear patterns and non-carious cervical lesions. [25&26] Mechanical, chemical and occlusal factors are the three factors are generally accepted as the contributors to non-carious cervical lesions.

The mechanical factor is known as toothbrush abrasion. Toothbrush abrasion has long been believed to be a major contributing factor to non-carious cervical lesions. [27] Factors related to tooth brushing have been investigated and implicated including type of dentifrice, site of initial toothbrush position, bristle hardness, pressure applied and frequency of tooth brushing. [28&29] Toothbrush abrasion has been identified as a causative agent in cross sectional epidemiological studies as well. [30&31] While toothbrush bristle firmness has been dismissed as a causative factor by some authors, use of dentifrice has been implicated as a responsible factor during an in vitro study. Dzakovitch compared brushing with water only and brushing with dentifrice. [32&33] There is a continued belief that abrasion, particularly from toothbrushes and dentifrice, is a significant contributor to non-carious cervical lesions. Another significant contributor to non-carcious cervical lesions is erosion. Erosion has been defined as the loss of tooth structure due to chemical means. The causative agent of erosion is usually acid especially when the pH drops below the critical pH of 5.5. [34] Exposure to acid can come from industrial causes associated with atmospheric acids, from dietary exposure from foods or from systemic conditions. [35&36] Consumption of acidic foods such as lemons, oranges, and grapefruits can result in pH values as low as 2.0 to 3.5. [37] Systemic conditions such as acid reflux and bulimia may alter the pH levels inside the oral cavity resulting in erosion lesions. Acid erosion is accepted an etiologic factor for non-carious cervical lesions.

The three main factors discussed in the literature as causative agents for non-carious cervical lesions are mechanical by abrasion, chemical by way of acid erosion and occlusal considering occlusal forces leading to stresses at the cervical portion of the tooth. Some authors have even suggested that non-carious cervical lesions arise primarily in scenarios where multiple precipitating factors are present simultaneously. [38] As discussed in the above review all of the three factors have different etiologies, but provide very similar lesions.

Specific Aims

The aim of this study is to investigate the relationship between occlusal wear and non-carious cervical lesions in a population that pre-dates modern oral hygiene practices and acidic food consumption by studying skeletal remains of a pre-modern population.

Hypothesis

H₀ = There is no correlation between occlusal wear and non-carious cervical lesions

H₁ = There is a correlation between occlusal wear and non-carious cervical lesions

Materials and Methods

118 jaws, maxilllas and mandibles, including 1096 teeth were included for examination. These skulls varied in geographic location and time span (Table 1). The skeletal remains originated from sites in Indiana, Michigan and New Mexico spanning 3000 BC to 1400 AD. (Figures 1-4) Any jaws containing primary dentition were excluded from the study. All teeth were examined and scored for amount of occlusal wear (Table 2), and presence or absence of non-carious lesions. The examination was conducted by direct naked eye assessment under excellent lighting conditions. Although sex could not be determined for each jaw studied, it was assumed based on the archaeologic record that both sexes were included. All samples were re-examined at a later time and date to reassure...
the findings. This investigation was deemed to be exempt from regulation by the IRB.

Results

1096 teeth were evaluated in 118 jaws across the sites. The precise age of the specimens was not known, but all studied samples had only permanent dentition. The extent of occlusal wear varied across the sites. 1096 teeth demonstrated an average occlusal wear score of 1.73. Zero non-carious cervical lesions were detected among the teeth studied (Table 3).

Discussion

The most interesting fact in this investigation was the total absence of non-carious cervical lesions. The degree of occlusal wear varied from jaw to jaw. Some jaws showed great levels of occlusal wear and others showed nearly none. There are a few factors that may explain the variance in occlusal wear. Other factors could explain the presence of wear on these samples. The populations themselves differed in amounts of wear. A potential factor may be attributed to lifestyle of the populations. Hunter-gathers tend to have much less occlusal wear than agriculturalists. [39] Grain was not ground as finely as it is today and provided a coarse substance during mastication. [40&41] Due to dietary habits of the populations there is not a distinct way to differentiate between attrition due to mastication and occlusal bruxism other than dietary habit information from anthropologists. Another missing link in this investigation is the exact age of each sample. Increasing age has been shown to be a risk factor for developing non-carious cervical lesions. [42] The samples in this study may have had a shortened life that ended prior to developing non-carious cervical lesions. The lifespan’s of these early populations is known to be shorter than today.

There is no certain knowledge regarding the oral hygiene practices of populations. If the population used toothbrush-like tools, they have not been discovered or recorded in the anthropologic sources. The same is true for toothpaste or equivalent substances. The general belief is that oral hygiene was not practiced. At the very least it was not practiced in the way it is today. The most interesting fact remains that not a single non-carious cervical lesion was found in the

Table 1: Location and dates of populations of skeletal remains.

<table>
<thead>
<tr>
<th>Site</th>
<th>State</th>
<th>Years lived</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloom Mound</td>
<td>New Mexico</td>
<td>1275 AD-1400 AD</td>
</tr>
<tr>
<td>Henderson</td>
<td>New Mexico</td>
<td>1275 AD-1400 AD</td>
</tr>
<tr>
<td>Younge</td>
<td>Michigan</td>
<td>900 AD-1200 AD</td>
</tr>
<tr>
<td>Backlund Mound</td>
<td>Michigan</td>
<td>500 AD-1600 AD</td>
</tr>
<tr>
<td>Andrews</td>
<td>Michigan</td>
<td>3000 BC-300 BC</td>
</tr>
<tr>
<td>Schultz</td>
<td>Michigan</td>
<td>300 BC-400 AD</td>
</tr>
<tr>
<td>Mallon Mound</td>
<td>Michigan</td>
<td>300 BC-400 AD</td>
</tr>
<tr>
<td>Fort Wayne Mounds</td>
<td>Indiana</td>
<td>500 AD-900 AD</td>
</tr>
<tr>
<td>Huron River #2</td>
<td>Michigan</td>
<td>500 AD-900 AD</td>
</tr>
<tr>
<td>Juntenen</td>
<td>Michigan</td>
<td>900 AD-1400 AD</td>
</tr>
</tbody>
</table>

Table 2: Occlusal wear characterization scale.

<table>
<thead>
<tr>
<th>Site</th>
<th>Total Teeth</th>
<th>Total Jaws</th>
<th>Teeth/Jaw</th>
<th>Average Wear</th>
<th>NCCLs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloom Mound</td>
<td>25</td>
<td>2</td>
<td>12.50</td>
<td>2.28</td>
<td>0</td>
</tr>
<tr>
<td>Henderson</td>
<td>159</td>
<td>13</td>
<td>12.23</td>
<td>1.29</td>
<td>0</td>
</tr>
<tr>
<td>Younge</td>
<td>219</td>
<td>29</td>
<td>7.55</td>
<td>1.74</td>
<td>0</td>
</tr>
<tr>
<td>Backlund Mound</td>
<td>88</td>
<td>11</td>
<td>8.00</td>
<td>1.74</td>
<td>0</td>
</tr>
<tr>
<td>Andrews</td>
<td>4</td>
<td>1</td>
<td>4.00</td>
<td>2.75</td>
<td>0</td>
</tr>
<tr>
<td>Schultz</td>
<td>30</td>
<td>3</td>
<td>10.00</td>
<td>1.93</td>
<td>0</td>
</tr>
<tr>
<td>Mallon Mound</td>
<td>150</td>
<td>16</td>
<td>9.38</td>
<td>1.74</td>
<td>0</td>
</tr>
<tr>
<td>Fort Wayne Mounds</td>
<td>154</td>
<td>15</td>
<td>10.27</td>
<td>2.05</td>
<td>0</td>
</tr>
<tr>
<td>Huron River #2</td>
<td>72</td>
<td>10</td>
<td>7.20</td>
<td>1.86</td>
<td>0</td>
</tr>
<tr>
<td>Juntenen</td>
<td>195</td>
<td>18</td>
<td>10.83</td>
<td>1.29</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>1096</td>
<td>118</td>
<td>9.29</td>
<td>1.73</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3: Wear characterization and cervical lesion data.
entire population. Some reports in modern populations have suggested non-caries cervical lesions occurring in 2 to 85% of teeth. The samples investigated here spanned many centuries and different locations of the United States. This opens the door to the possibility that there is some difference in this population from modern populations that is a key factor in the formation of non-caries cervical lesions. Non-caries cervical lesions are common in modern subjects and therefore may require a component of modern practices to exist in teeth. It is possible that acidic dietary practices, modern oral hygiene habits, and modern bruxism differ in such a way that create an environment with potential for non-caries cervical lesions that did not exist in historic populations.

Conclusion

In this investigation of a population without an environment of modern oral hygiene practices, modern acidic diet, and modern bruxism, zero non-caries cervical lesions were present. Based upon previous investigations, a sample this large would be expected to show at least 20 non-caries cervical lesions based upon the minimum 2 percent prevalence, if bruxism were the lone cause of non-caries cervical lesions. The previously proposed etiology for non-caries cervical lesions may need to be reconsidered. The management of non-caries cervical lesions using occlusal adjustments may not be justified without further investigation of aggressive tooth brushing and bruxism. Further studies should be conducted to determine the role of tooth brushing, acidic diet and bruxism in the formation of non-caries cervical lesions in vivo.

References

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