# INTERPROXIMAL GROOVES IN PREHISTORIC CALIFORNIA INDIAN POPULATIONS

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## ABSTRACT

Recent investigations have revealed the presence of interproximal groove lesions on the dentitions of several prehistoric California Indians. These lesions are associated with interproximal caries and/or periodontal disease. The grooves are most likely caused by the use of dental probes during life as part of a palliative or therapeutic function. Another possible explanation is the stripping and thinning of sinew through the interproximal spaces of the teeth. Problems arise in the interpretation of this particular lesion because of the relative lack of specimens. In addition, a large majority of individuals who are affected by interproximal caries and/or periodontal disease do not display interproximal grooves. Potential explanations are provided.

## INTRODUCTION

Interproximal grooves are lesions of the teeth occurring in the interproximal spaces of the cervical region (or cementoenamel junction). The grooves are approximately 2.0 mm in diameter (Ubelaker et al. 1969; and this study) with ranges from 0.5 mm to 3.5 mm (Formicola 1988:664). Lengths of the lesions are variable. The groove is depressed or abraded in appearance with a tubular or semi-circular cross-section. The grooves most often affect the cementum or dentin, although the enamel crown is sometimes affected. The depth of the grooves vary, most likely a function of the amount of time the tooth was abraded and the amount of force applied onto the tooth. The grooves sometimes display a polished surface, caused by repeated abrasion. The grooves and polish can be observed both macro- and microscopically.

Berryman et al. (1979), James et al. (1988), Schulz (1989), Ubelaker et al. (1969), and this study have found that interproximal grooves occur primarily in the posterior dentition

(molars and premolars), although some examples can be found in the anterior dentition (incisors and canines) (see Berryman et al. 1979). A slightly higher rate of occurrence in maxillary dentition than in mandibular dentition has been noted (Berryman et al. 1979), although such a correlation could easily be due to sampling error at this early stage because study samples are numerically small.

Previous Discoveries

Ubelaker et al. (1969:145) observed interproximal grooves in individuals from 11 sites ranging in age from 5000 B.C. to historic times (A.D. 1802-1832). Geographically, these 11 different sites are located in South Dakota, Nebraska, Illinois, Kansas, and Kentucky.

In a review of Old World specimens, Formicola (1988:663-663) reported on several specimens from Upper Paleolithic sites at the Grimaldi Caves, Italy, who displayed interproximal grooves. Turner (1988:665) has noted the presence of interproximal grooves on Lower Paleolithic specimens from Uzbekistan in the Soviet Union. Soviet scientists consider these specimens, dated 400,000 - 700,000 years ago, to be either Homo erectus or early H. sapiens (Turner 1988:665). Turner (1988:665) has also noted the presence of interproximal grooves on a Neandertal specimen, Gibraltar I. Puech and Cianfarani (1988:665-668) have noted the presence of interproximal grooves on a H. habilis specimen (L 894-I from Omo), H. erectus specimens from China and Spain, Neandertals from Europe, and H. sapiens sapiens individuals from Europe. Eckhardt and Piermarini (1988) discuss incidences of interproximal grooves in Paleolithic specimens from Omo, Choukoutien, North Africa (Rabat), and Europe, and from Mesolithic and Neolithic specimens in Europe, Africa, the New World, and Australia. In summary, interproximal grooves are found as far back as ca. 2.0 MYA in H. habilis, and have been recorded world-wide.

## RECENTLY DISCOVERED SPECIMENS

A total of six known individuals with interproximal grooves from prehistoric California have been discovered to date (Figure 1). Two individuals were found during a recent survey of over 300 individuals from 27 different archaeological sites distributed throughout California. This skeletal material is located at the Lowie Museum of Anthropology, University of California, Berkeley. These specimens were inspected macroscopically and with a 10x hand lens for interproximal grooves. Additionally, one individual was described by James et al. (1988) and three individuals were described by Schulz (1989). Dental pathologies were also noted. [This survey is by no means a complete one, and much more inspection is required.]


**Figure 1. Location of individuals with interproximal grooves.**

Chronology

CA-Ala-307, also known as "The West Berkeley Site," was a large shellmound site. The site was first excavated in 1902 by a team from the University of California, Berkeley; excavations continued intermittently until 1954 (Moratto 1984:258). CA-Ala-307 is an important site because Wallace and Lathrap (1975:57-59; among others) consider this site to be one of the first "Early Horizon" sites in the San Francisco Bay area with occupation continuing into the early "Middle Horizon." Occupation of CA-Ala-307 began ca. 4000 years ago and continued to approximately 2000 years ago (Moratto 1984:259-261). The Early Horizon deposits are associated with the "Windmiller Pattern," while the early Middle Horizon deposits are associated with the "Berkeley Pattern." Continuities of the deposit are interpreted to represent the evolution of the Windmiller Pattern into the Berkeley Pattern (Moratto 1984:261). Brooks (1975) compared the CA-Ala-307 skeletal remains to those from contemporary sites in the San Francisco Bay region and concluded that a fairly homogeneous population inhabited the area. No unusual pathologies or other unusual observations were made at that time (Brooks 1975:114).

Although the specific location and associations on Santa Catalina Island of 12-1597 are unknown, a radiocarbon date of 3880 years ago (Moratto 1984:149) has been proposed for CA-SCaI-17, "The Little Harbor Site," on the island. Such a date is roughly comparable to the Early Horizon date from CA-Ala-307.

CA-SCl-128 was occupied during terminal Middle Horizon (A.D. 500 - A.D. 700) and Late Horizon, Early Phase I (A.D. 900 - A.D. 1100) periods, and possibly into protohistoric periods (A.D. 1500 - A.D. 1700) (James et al. 1988:111). The cultural deposits at CA-Teh-10 have been dated to a period between A.D. 900 and A.D. 1500 (Schulz 1989:63).

Interproximal Grooves in California

An individual, Catalog #12-84, from CA-Ala-307 (The West Berkeley Site) displays an interproximal groove on the distal side of $LP^3$ (Figures 2 and 3). Individual 12-84 is a male individual with a skeletal age of ca. 55 years (Hrdlicka 1906-1907:Table 1). $LP^3$ is worn moderately on the occlusal surface, scoring 4 on Molnar's 8-point ordinal scale (Molnar 1971:178, Fig. 1). Calculus deposits on $LP^3$ are minimal, while deposits are moderate to extensive on the left and right molars (see Brothwell 1981:155, Fig. 6.14B).

The groove on $LP^3$ is located on the distobuccal quadrant of the cementoenamel junction, running obliquely and inferiorly from the buccal to lingual sides of the lesion. The groove is semi-circular in cross-section. Width of the groove is approximately 2.0 mm at its widest point. Length of the lesion is approximately 4.7 mm. Depth of the groove is approximately 0.7 mm. The groove displays a slightly polished surface.

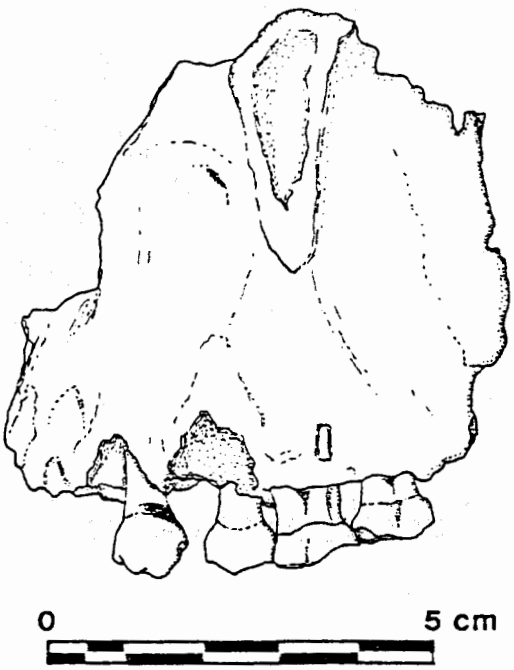


Figure 2. 12-84 lateral view.

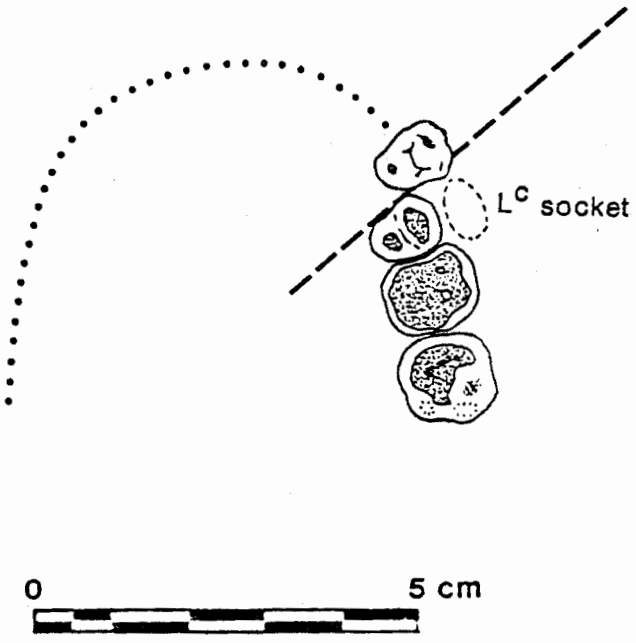


Figure 3. 12-84 occlusal view.

Associated pathologies include: periodontal disease; interproximal caries; and a supernumerary tooth. Periodontal disease is indicated by moderate to extensive alveolar resorption and porosity of the alveolus in the maxilla (Brothwell 1981:155, Fig. 6.14A; Ortner and Putschar 1985:442). $LP^4$ displays an interproximal caries on the mesial side. A supernumerary tooth, lost postmortem, is indicated by a rounded cavity in the palate, just posterior to the incisive foramen in the left maxilla (see also Hrdlicka 1906-1907:Table 3).

In addition, the maxillary left canine ($LC^1$), lost postmortem, was in an abnormal position, buccal to and between $LP^3$ and $LP^4$ (Figure 2). This abnormality is called "transposition," and is sometimes associated with supernumerary teeth in other individuals (Pindborg 1970:68-70). An interproximal contact facet for the $LC^1$ is present on the buccodistal portion of the $LP^3$ crown, inferior to the grooved lesion. $LP^4$ has an interproximal contact facet for the canine on the mesial half of the buccal face of the crown.

One other example, 12-1597, from the Lowie Museum displays a single interproximal groove on the distal cementoenamel junction of $RM_1$ (Figures 4 and 5). This individual is a female with a skeletal age of over 30 years, recovered from the Isthmus, Santa Catalina Island (Lowie Museum of Anthropology, n.d.). No site number was recorded for this individual.

The groove on $RM_1$ is slight and not as well developed as in the previously mentioned example. The surface of the groove is polished, running at a slight angle (oblique) from the mesiobuccal margin of the distal root to the distal interproximal surface. The length of the lesion is 2.3 mm. The width is 1.3 mm and the depth is 0.5 mm. Interproximal caries is present on the distal side of the cementoenamel junction of $RM_1$. $RM_2$ is damaged postmortem (broken enamel crown) and no groove can be observed. Periodontal disease is present in the mandible, indicated by moderate to extensive alveolar resorption. Occlusal wear on $RM_1$ is extensive and scores 7 (Molnar 1971:178, Fig. 1) with a portion of the enamel crown completely worn away on the distal margin. Direction of wear is oblique running linguobuccal. The occlusal surface form is flat. Occlusal wear on $RM_2$ is also extensive and scores 7. Direction of wear and occlusal surface form are similar to $RM_1$.

The individual described in James et al. (1988:43-47), Burial 87-5 from archaeological site CA-SCl-128 (The Holiday Inn Site), displayed interproximal groove lesions on 5 separate teeth. Burial 87-5 was a male individual with a skeletal age of 25-30 years. One interproximal groove was on the distal cementoenamel junction of $LM^2$ and a similar groove on the mesial cementoenamel junction of $LM^3$. Both lesions are in association with interproximal caries. In addition, a periapical abscess is present at $LM^1$. The $RM^3$ displays an interproximal groove of the

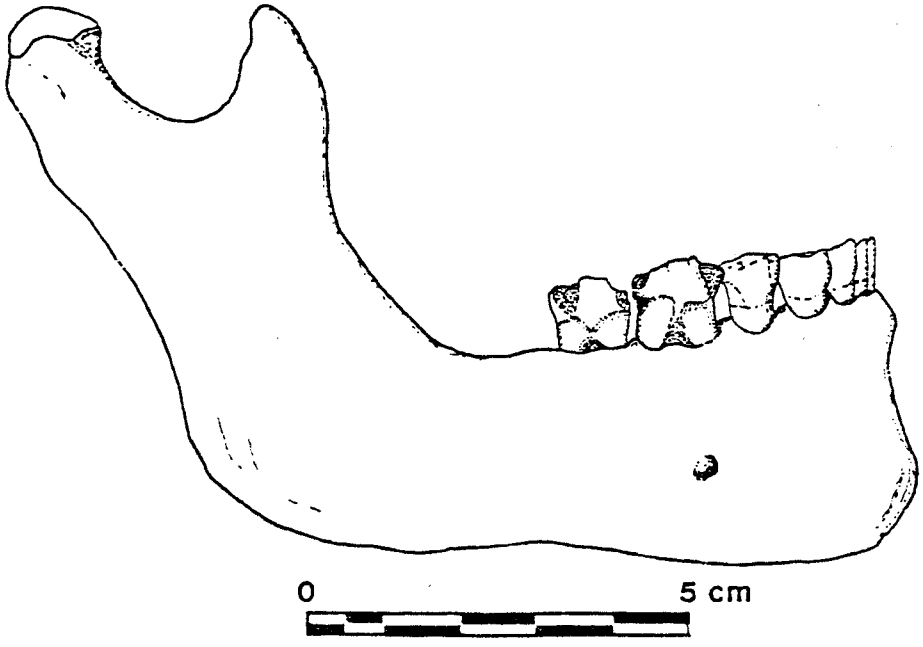


Figure 4. 12-1597 lateral view.

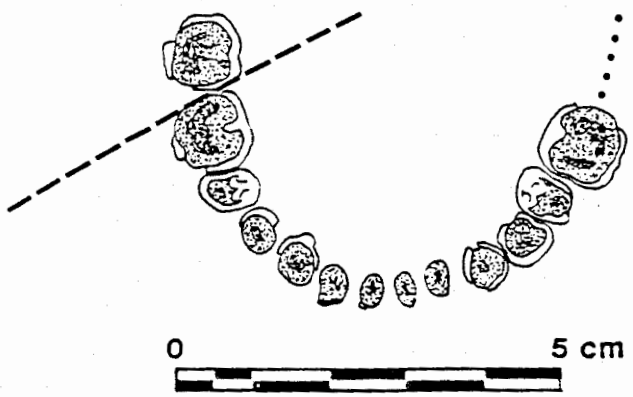


Figure 5. 12-1597 occlusal view.

mesial cementoenamel junction. This tooth was affected by 3 loci of occlusal caries and a periapical abscess at the distobuccal root apex. $RM_1$ displays an interproximal groove on the distal cementoenamel junction in association with an interproximal caries. $RM_1$ displays an interproximal groove on the mesial cementoenamel junction but no interproximal caries. All of the grooves were oblique to the dental arcade.

Schulz (1989) reported interproximal grooves on 3 individuals from archaeological site CA-Teh-10. Burial 19, a 25+ year old female, contained an interproximal groove on the distal side of $LM^2$. This lesion is associated with an interproximal caries. Burial 45, a 35+ year old female, has a single interproximal groove on the distal side of $RP^3$ and two grooves on the mesial side and one on the distal side of $RP^4$. These lesions are associated with periodontal disease. Burial 139, a 30+ year old male, displays an interproximal groove on the mesial side of $LM^3$. Interproximal caries is also present on the mesial face.

## DISCUSSION

Interproximal grooves have been attributed to 4 primary causes: use of dental probes (Berryman et al. 1979; Ubelaker et al. 1969); dietary grit (Wallace 1974); erosion (Brothwell 1963); and the stripping of animal sinews (Brown and Molnar 1990).

Dental probes are essentially "tooth picks" of unknown material. Ubelaker et al. (1969) suggested that thin wooden probes caused the grooves, while others have since suggested use of plant fibers or bone tools (see Formicola 1988:664; and references therein). The dental probes, whatever their raw material, apparently served a therapeutic or palliative function, although a hygienic function cannot be ruled out. These probes were repeatedly inserted into the interproximal spaces, abrading the cementum and/or enamel which eventually resulted in a groove. Fine striations within the abraded area can be observed microscopically (Berryman et al. 1979; Wallace 1974; Ubelaker et al. 1969:145). When the probing activity continues over a "long period of time" (this period has not been determined), secondary dentin can form at the affected area (Ubelaker et al. 1969:146).

Both Ubelaker et al. (1969) and Berryman et al. (1979) noted that the interproximal grooves occur most often in the posterior dentition than in the anterior dentition. A larger proportion of affected maxillary dentition than mandibular dentition was also noted, along with a larger proportion of males than females (Berryman et al. 1979:209-211). In California, no such correlation is apparent at this time, since only 6 individuals (3 males and 3 females) are now known. Four individuals (2 males, 2 females) exhibit interproximal grooves in the maxillary dentition. One female exhibits a groove in the mandibular dentition. Finally, 1 male exhibited grooves on both maxillary

and mandibular dentition.

Ubelaker et al. (1969:146-147) make an important distinction between the lesion being caused antemortem rather than postmortem. Secondary dentin formation, polish caused by repeated abrasion, and the positions of the interproximal grooves above the gum line (gum line indicated by calculus deposits or soft tissue deposits/slight discolorations) (Ubelaker et al. 1969:146-147) are cited as proof against postmortem dental mutilation in these cases. Secondary dentin forms as a response to wear or abrasion and is seen most often on the occlusal surfaces of severely worn molar teeth (Ortner and Putschar 1985:438; see also Molnar 1971, 1972).

Wallace (1974) believes that interproximal grooves (which he terms "approximal grooves") are caused by dietary grit. In this model, grit introduced into the oral cavity (mouth) from food is suspended in the saliva. The cervical portion of the tooth, normally covered during life by the gums, is exposed because of periodontal disease which causes alveolar resorption, receding gum line, and exposure of the cementum. During the mouth-cleansing phase of swallowing, grit is forced from the space between the tooth row and cheek, through the interdental or interproximal spaces, and into the oral cavity before being swallowed (Wallace 1974:388-389). Repetition of this action causes fine striations on the cementum and groove, resulting over time in "approximal grooves." Microscopic examination by Wallace (1974) revealed both parallel striations interproximally and intersecting striations on the lingual and buccal surfaces. Wallace (1974:388-389) attributes the pattern of striations to microscopic grit circulating through the oral cavity via saliva. The parallel, interproximal striations represent the primary salivary flow, and the intersecting striations represent grit moving in a "random" pattern during mastication and swallowing.

Brothwell (1963:283-284) believes that interproximal grooves are caused by chemical erosion. He discounts bacterial action and instead cites another study (Zipken and McClure 1940 in Brothwell 1963:284) which suggests a "localized non-acid demineralization due to calcium solubilizing ion such as a citrate" as the primary cause of the grooves. However, Berryman et al. (1979:211) reject the erosion hypothesis because the interproximal grooves are limited to the interproximal surfaces, and because no chalky enamel and no trabeculated dentin are observed in association with the grooves as should be expected in an erosional process. In addition, interproximal grooves are primarily concentrated in the posterior dentition; theoretically, chemical erosion should affect the anterior and posterior dentition equally.

Berryman et al. (1979) concluded that dental probes were the most likely cause of interproximal grooves, while the suction of dietary grit was a possible secondary and contributing factor.

Dietary grit is reduced to a secondary role because the morphology of the interproximal grooves does not correspond to that of dietary grit. Berryman et al. (1979), Ubelaker et al. (1969), and this study noted that specimens with interproximal grooves on molar teeth are oblique [angled lingually and distally from the lip region]. A dental probe used antemortem would correspond to the observed groove angles with respect to the position and flexibility of an individual's lips (see Berryman et al. 1979:211, Fig. 2). If dietary grit were the primary cause of interproximal grooves, then one should reasonably expect all of the grooves to be perpendicular to the dental arcade.

A recent article by Brown and Molnar (1990) attributes interproximal grooves to the use of the teeth in stripping animal sinew. Observations were made from cinematic films of Australian Aborigines. In this scenario, sinew is first chewed as an initial preparation. The sinew, which is by now a few millimeters in diameter, is then pulled back and forth between the occluded teeth until the sinew is determined ready for use as cordage for binding (Brown and Molnar 1990:550-551). The interproximal groove is hypothesized to occur when the sinew is drawn through the interdental space rather than between the occlusal surfaces, especially after repeated and long-term activity. Brown and Molnar (1990:551) note that in their Australian sample, periodontal disease and dental caries in association with interproximal grooves is minimal. In contrast, the 6 California specimens all have periodontal disease and/or dental caries associated with the grooves.

A lesion similar to interproximal grooves occurs on the occlusal surfaces of teeth, primarily on the anterior dentition, has been noted by Larsen (1985) and Schulz (1977). They observed grooves on the occlusal surfaces of prehistoric Great Basin individuals (Larsen 1985) and prehistoric California individuals (Schulz 1977) and related the grooves to a specific task activity: processing reeds, cordage, or other material for baskets, nets, etc. The teeth were used as a grasping implement, in effect a "third hand." Such activity has been recorded ethnographically (see Larsen 1985; Schulz 1977; and references therein).

The controversy arises over the explanation as to "why" these grooves were made. My investigations, in agreement with Berryman et al. (1979) and Ubelaker et al. (1969), found that interproximal grooves are associated with interproximal caries and/or periodontal disease. The only exception was individual 12-84, who had dental transposition in addition to interproximal caries and periodontal disease. All of these conditions would be potentially pain-producing. Therefore, the hypothesis that interproximal grooves are caused by dental probes utilized in a therapeutic or palliative function is favored.

However, interproximal grooves are by no means common

lesions. For example, a cursory investigation of 114 individuals from CA-Ala-307, contained in the Lowie Museum collection, revealed a minimum number of 28 adult individuals with teeth. Twenty-five individuals were affected by some form of dental pathology. The most prevalent pathology is periodontal disease, affecting 78.6% (n=22) of the 28 individuals with dentition. Periapical abscesses were present in 60.7% (n=17) of the individuals. Occlusal caries affected 17.9% (n=5) of the individuals, while interproximal caries affected 7.1% (n=2) of the individuals. Antemortem tooth loss affected 60.7% (n=11) of the individuals. Three individuals (10.7%) were unaffected by dental pathology. Only one individual, 12-84, displayed interproximal groove lesions.

In addition, Formicola (1988) and Turner (1988), among others, express dissatisfaction with the dental probe hypothesis for interproximal grooves. They base their conclusions on the fact that many of the specimens they investigated, in particular from Grimaldi Caves, Italy (Formicola 1988:664) and Selungur Cave, Uzbekistan (Turner 1988:665), displayed interproximal grooves without interproximal caries or periodontal disease. Brown and Molnar (1990) are also dissatisfied with the dental probe hypothesis, citing the lack of dental pathologies as evidence against, as well as cinematic evidence in support of their sinew-processing hypothesis.

Unfortunately, the use of dental probes are not as yet well documented ethnographically. Nevertheless, one can imagine that rather vigorous activity must be required in order to create the grooves. However, studies on living people are not available in order to determine the amount of time, amount of pressure, or any other variables required to create the groove. In addition, individual variability should be taken into account in terms of the relative strength of one's dental tissues (enamel, cementum, and dentin) and resistance to attrition, one's resistance to pain, and perhaps more esoterically, one's personal preferences as to physical and/or psychological pleasure (i.e., the person enjoyed tooth picking to such a degree that grooves were caused) (see Formicola 1988).

## SUMMARY AND CONCLUSIONS

Interproximal grooves have been identified in prehistoric California Indian specimens since 1988. The individual from CA-Ala-307 was located in deposits dated from 4000 to 2000 YA (Early Horizon to early Middle Horizon). If this example is associated with the Early Horizon component, then it would be the oldest known specimen from California with interproximal grooves. This individual, 12-84, displayed interproximal grooves in association with periodontal disease, interproximal caries, dental transposition, and hyperodontia. Two others, 12-1597 from Santa Catalina Island and Burial 87-5 from CA-SCl-128, displayed

interproximal grooves associated with interproximal caries. Two individuals (Burials 19 and 139) from CA-Teh-10 had interproximal grooves associated with interproximal caries; the third (Burial 45) had interproximal grooves associated with periodontal disease (Schulz 1989:63-65). Additionally, the individuals investigated by Berryman et al. (1979) and Ubelaker et al. (1969) had interproximal grooves associated with interproximal caries and/or periodontal disease.

A related question to the objections raised by Formicola (1988) and Turner (1988): Why are interproximal grooves infrequent in occurrence, especially in individuals with interproximal caries, periodontal disease, or some other pain-causing dental pathology? I propose several possible answers to this question:

Non-recognition: Previous researchers have not recognized or observed the presence of interproximal groove lesions. Future investigators should be more aware of any anomalies which can be observed and described, especially in specimens that will be reburied.

Sampling error: Because this investigation has reviewed only a small portion of the Lowie Museum collection, specimens containing interproximal grooves could await discovery. This explanation also applies to all other collections of human skeletal material.

Severe dental attrition: As previously mentioned, dental attrition was often extensive in prehistoric California Indian populations, and no doubt in other hunter-gatherer populations. Occlusal wear to Grade 8 in Molnar's (1971:178, Fig. 1) scale indicates that the tooth is worn down to the roots. Such a condition could potentially remove an interproximal groove lesion.

Cultural factors: Behavior must also play a part in explaining interproximal grooves. Berryman et al. (1979) and Formicola (1988) noted that more males than females exhibited interproximal grooves, suggesting perhaps a male-oriented activity. No such association can be made for the California specimens at this time because of the small sample size (minimum number of 6 individuals: 3 male and 3 female). As a cultural activity, "tooth picking" could have served a hygienic function; in individuals who had pain-producing dental pathologies, "tooth picking" could have further served as a therapeutic/palliative function. Already mentioned was the possibility of intentional dental modification in individuals without associated dental pathology, or possibly the processing of sinew with the teeth. Ethnographic observations can further illuminate this hypothesis.

I propose that the occurrence of interproximal grooves in the individuals discussed above are consistent and valid with the

use of dental probes serving a therapeutic/palliative function. However, Brown and Molnar (1990) propose the most convincing alternative argument, that of processing sinew with the teeth. However, in this scenario, it would seem that grooves should occur on both the occlusal and interproximal surfaces. The interproximal grooves produced by this activity would also tend to be concentrated in the maxillary dentition because it is mechanically simpler and more efficient to pull objects downwards from the mouth with the hands. Further investigation of the cinematic evidence should prove enlightening. For the present, the Brown and Molnar (1990) explanation appears to be valid for their Australian sample, but not necessarily so for the California examples and those cited by Berryman et al. (1979) and Ubelaker et al. (1969). Brown and Molnar (1990:549) and others have suggested that all interproximal grooves have a common etiology. Needless to say, further research is required before interproximal grooves can be explained to everyone's satisfaction. Future investigators should be alert for not only interproximal grooves but all pathological and abnormal conditions. Complete description and accurate diagnosis of these conditions are vital components to human osteological studies.

## NOTES

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