

# SKELETAL AND DENTAL EVIDENCE OF AGING IN CAPTIVE AND WILD AFRICAN APES: A PRELIMINARY REPORT

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## ABSTRACT

A comparative sample of older, mature gorillas and chimpanzees of known life histories was investigated for skeletal and dental conditions associated with aging. Gorillas show several pathological conditions of advanced age, such as skeletal lesions (bony lipping and osteophyte formation) at major synovial and vertebral joints. Gorilla skeletal lesions occur more frequently at hindlimb joints than at forelimb joints and more frequently in the lumbar-sacral region than in the cervical or thoracic regions. Both anterior and posterior dentition exhibit extensive enamel wear (attrition). The chimpanzees (captive and wild), like gorillas, demonstrated dental attrition in nearly every tooth, ranging from small to extensive in size. But, unlike gorillas, skeletal lesions were not as extensive. Comparison of conditions of aging in both wild and captive African apes reveal two distinct patterns. Gorillas show more skeletal lesions throughout the lower limb and pelvic region than do chimpanzees. It is interesting to note that the gorilla pattern parallels that of aged humans. This pattern is not evident in chimpanzees. However, both wild and captive African apes exhibit extensive enamel wear and dental pathologies not unlike human populations before modern dentistry. Comparative studies of captive and wild species can provide another perspective on the aging process from the point of view of the skeleton and dentition throughout life. This information from our closest living relatives, the African apes, can contribute insight into the human aging process.

## INTRODUCTION

The teeth and bones of modern apes are characterized by mammalian and primate traits that provide insight on the effects of aging. With regard to dental anatomy, ape premolars and molars have expanded occlusal surfaces. The enlargement of cheektooth surfaces is a mammalian feature associated with adaptations for grinding and pulping foods. The ape's broad spatulate incisors are an adaptation for biting into thickly skinned fruits and stripping off outer plant coverings. Ape skeletal anatomy exhibits primate limb-use differentiation coupled with pongid increased range of motion at limb joints. The extreme mobility of ape limb joints contrasts with the ape's relatively shortened and inflexible lumbar vertebral region. Finally, compared to most other mammals, adult apes are large in body size and have relatively lengthy lives that can span three to four decades. Therefore, adult ape tooth occlusal surfaces, limb joint surfaces, and vertebral joint surfaces will likely exhibit the long-term effects of use. Such effects, as measured by the degree of enamel attrition and degenerative joint disease, are associated with aging.

A great deal of dental and skeletal research has focused on human archaeological populations (e.g., Armelegos et al., 1972; Bridges, 1994; Greene et al., 1986; Jantz, 1973; Johnston, 1962; Merchant and Ubelaker, 1977; Sheridan et al., 1991; Ubelaker et al., 1995; Van Gerven et al., 1981). In contrast, there have been fewer dental and skeletal studies on wild ape populations (e.g., Jurmain, 1989; Kilgore, 1989; Lovell, 1990; Schultz, 1935, 1939, 1956, 1972; Zihlman et al., 1990). Dental studies of both human archaeological (e.g., Molnar, 1971; Sheridan et al., 1991) and wild ape populations (e.g., Kilgore, 1989; Lovell, 1990; Schultz, 1935) document extensive enamel attrition in adult individuals. Osteological research on archaeological populations details the frequency of osteophyte formation at joint margins and erosion of joint surfaces in human adults associated with degenerative joint diseases of (1) os-

teoarthritis (diarthrodial joints), and (2) osteophytosis (cartilaginous joints) (e.g., Aufderheide and Rodriguez-Martin, 1998; Bridges, 1994; Ortner and Putschar, 1985; Van Gerven et al., 1981). Similar osteological approaches have been applied to studies on adult wild apes (e.g., Jurmain, 1989; Lovell, 1990; Schultz, 1939, 1956, 1972; Zihlman et al., 1990). Like the human studies, the wild ape studies document the presence of skeletal lesions associated with degenerative joint disease but not to the same degree as has been reported for human archaeological populations. Adult ages in the human archaeological and wild ape populations are, however, estimated rather than known.

The incidence of age-associated changes to teeth and bones is expected to increase over the life span of the individual adult. While techniques for approximating adult age grades have been developed for human skeletal studies (e.g., Suchey-Brooks pubic symphysis remodeling), there are no equivalent techniques for distinguishing young adults from old adults in ape skeletal studies. The distinction between adult and juvenile gorilla is based on epiphyseal closure, followed by dental eruption. In contrast, a systematic method of distinguishing younger and older adult ape skeletal specimens has not been developed. This creates challenges for understanding the effects of aging wherein young adults can differ as much as 15 to 20 years from older adults.

In this study this challenge is addressed by analyzing osteological materials from a sample of captive western lowland gorillas (*Gorilla gorilla gorilla*) of known ages (Table 1). The purpose of our research is to determine (1) the degree of dental enamel attrition, (2) the distribution of skeletal lesions (i.e., lipping, erosion) to joint surfaces in forelimbs and hindlimbs (diarthrodial joints), and (3) throughout the spinal column at vertebral centra (cartilaginous joints). Our goal is to define the dental and skeletal effects of aging in male and female western lowland gorillas of known ages.



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**Table 1**  
Western Lowland Gorilla (*Gorilla gorilla gorilla*)  
Dental and Skeletal Sample

Specimens	Age	TBM
Male 1	36 yrs.	172.7 kg.
Male 2	36 yrs.	211.0 kg
Male 3	37 yrs.	148.3 kg.
Female 1	27 yrs.	99.5 kg.
Female 2	23-25 yrs.	—

## MATERIALS AND METHODS

Cranial and skeletal specimens of three adult male (n=3) and two adult females (n=2) captive western lowland gorillas of known ages were analyzed (Table 1). The male subsample has an average age of 36 years and the female subsample has an average age of 25 years. The degree of enamel attrition at each maxillary and mandibular tooth occlusal surface was examined and scored for the number, size, and distribution of exposed dentin patches (following Molnar, 1971). Joint surfaces of the forelimb (shoulder, elbow, wrist), hindlimb (hip, knee, ankle), and vertebral centra (cervical, thoracic, lumbar) were examined and scored for the degree of joint margin lipping and joint surface erosion (following Buikstra and Ubelaker, 1994). Results are reported as a percentage of affected surfaces for the male subsample, the female subsample, and total gorilla sample.

## RESULTS

**Results 1.** The distribution of dental enamel attrition was determined for the male subsample, female subsample, and for the western lowland gorilla sample as a whole (Figure 1). The male western lowland gorilla subsample exhibited slight to extensive enamel attrition in 91.5% of maxillary dentition and 98% of mandibular dentition.

The female western lowland gorilla subsample had slight to moderate enamel attrition in 50% of the maxillary dentition and 54.8% of mandibular dentition. When the male and female subsamples were combined 74.7% of maxillary dentition and 81% of mandibular dentition exhibited enamel attrition.

**Results 2.** The distribution of skeletal lesions in forelimb, hindlimb, and vertebral centra joints was determined for the male subsample, female subsample, and western lowland gorilla sample as a whole (Figure 2). In 8% of forelimb joints, slight marginal lipping is present at joint margins in both sexes. Skeletal lesions were more prevalent at hindlimb joint surfaces. Males had a greater frequency of skeletal lesions in the hindlimb at 67% (moderate lipping and surface erosion) than did females at 25% (slight lipping). The total sample had skeletal lesions in 8% of upper limb joints and in 50% of hindlimb joints. However, among joint types, skeletal lesions were most prevalent and most severe at vertebral centra joints. Males had skeletal lesions in 70% of vertebral centra and females had skeletal lesions in 68%. Thus, skeletal lesions associated with degenerative joint disease were most common at the gorilla spinal column, regardless of sex or age.

**Results 3.** The distribution and severity of skeletal lesions to vertebral joint centra was determined (Figure 3). The distribution and

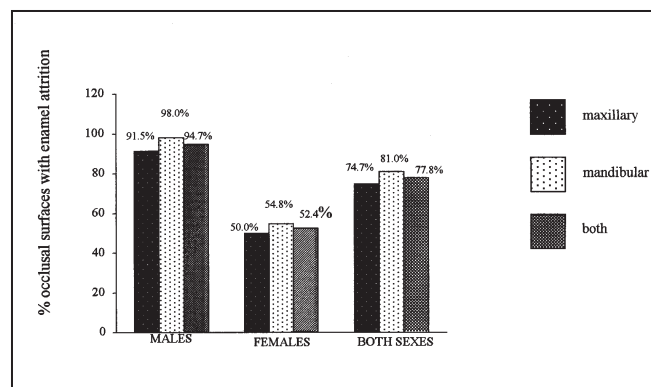


Figure 1. Dental enamel attrition in captive western lowland gorillas.

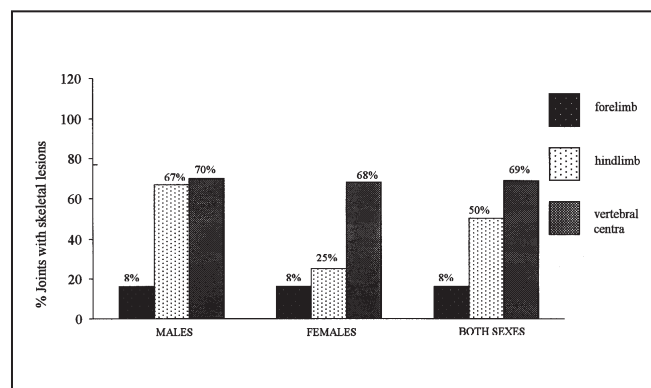


Figure 2. Joints of limbs and vertebral column with skeletal lesions in captive western lowland gorillas.

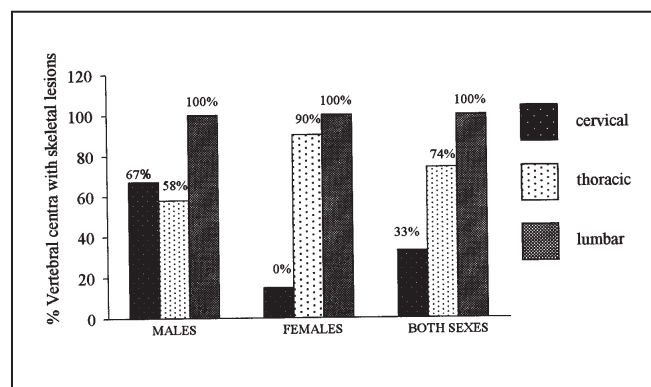


Figure 3. Distribution of skeletal lesions by region to vertebral centra in captive western lowland gorillas.

severity of lesions differed throughout the spinal column (cervical, thoracic, lumbar). In the cervical region, males had moderate lipping and surface erosion in 67% of the centra. In marked contrast, no skeletal lesions were observed in female cervical centra. In thoracic centra, males had slight lipping to severe surface erosion in 58% of the centra. Females, however, had slight lipping to moderate surface erosion in 90% of the thoracic centra. In the lumbar region, both males and females were affected in 100% of the centra. Males exhibited extreme skeletal lesions with complete fusion (ankylosis) of the lumbar bodies anteriorly extending inferiorly to involve the sacrum. Females lacked anterior fusion but exhibited severe lipping and surface erosion in all lumbar centra.

## DISCUSSION

This preliminary study suggests that both age and sex likely play a role in the gorilla pattern of dental and skeletal aging. Because the male subsample is older than the female subsample, if a greater occurrence is observed in the female subsample, then a sex-related pattern is likely; otherwise, the results are indeterminate.

1. Our study indicates that enamel attrition is more extensive in the male subsample than in the female subsample. The subsample results are likely due to subsample age differences. In enamel attrition the captive gorilla patterns of wear are similar to those observed in wild gorillas but with a lessened degree of severity (Nichols, unreported observation). As with wild western lowland gorillas (Kilgore, personal communication), the captive western lowland gorillas in this study exhibit more enamel attrition at the anterior dentition than at the posterior dentition. The differences in degree of enamel wear, with captive gorillas exhibiting less severe wear than wild gorillas, can be attributed to differences in the mechanical and nutrient properties of captive and wild foods and to medical/dental interventions for captive animals. Finally, captive western lowland gorilla maxillary incisors tend to be in malocclusion with lower incisors and there is a diastema between upper lateral incisors and upper canines that is larger than in wild western lowland gorillas (Nichols, 1995). Therefore, the captive gorillas have less crowded anterior teeth that do not come into occlusal contact to the same degree that they do in wild western lowland gorillas.
2. Limb joint skeletal lesions are more frequent in the gorilla hindlimb than in the forelimb. However, males exhibit two and a half times more skeletal pathologies of the hindlimb than do females, and the severity of skeletal lesions is greater in males as well. These skeletal lesions are consistent with human skeletal lesions caused by osteoarthritis. Osteoarthritis is one of several degenerative joint diseases of aging that can result in loss of joint cartilage and development of skeletal lesions at diarthrodial, synovial joints (Aufderheide and Rodriguez-Martin, 1998:93). In human studies, the lower limb is the most frequently reported location of degenerative joint disease (knee joints more so than hip joints, females more so than males) (Aufderheide and Rodriguez-Martin, 1998:94). That the gorillas in our study have a greater prevalence of skeletal lesions at the lower limb joints is not unexpected. African apes exhibit hindlimb dominance during locomotion (Kimura et al., 1979; Reynolds, 1985a, b) and have greater muscle mass (males at 42%, females at 44%) in the hindlimb than forelimb regions (Zihlman and McFarland, in press). The differing gorilla male and female results are likely due to subsample age differences.
3. Skeletal lesions were observed at vertebral centra, which are cartilaginous joints. Again, the gorilla vertebral skeletal lesions are consistent with those described for humans with osteophytosis, another degenerative joint disease (Aufderheide and Rodriguez-Martin, 1998). The distribution of vertebral skeletal lesions differs throughout the gorilla spinal column.

The cervical vertebrae of male gorillas exhibit skeletal lesions, whereas the cervical vertebrae of female gorillas do not (67% in males, 0% in females). Subsample age differences may play a role in these results but the differences can also be attributed to the thicker nuchal area and more massive shoulder region in males (Zihlman and McFarland, in press), as well as male and female differences in

locomotor postures. The male and female patterns of skeletal lesion distribution to the cervical centra are distinct from the skeletal lesion distribution at the thoracic region. Here, the female gorillas have one and a half times more skeletal lesions (90%) than do males (58%). The cervical and thoracic results suggest a sex-related, rather than age-related, pattern of degenerative joint disease at the upper two-thirds of the spinal column. These results contrast with those for the lower spinal column. The 100% distribution of skeletal lesions to the lumbar region in male and female subsamples indicates a common pattern for gorillas. Male and female differences in the severity of these lesions may be attributed to age or sex differences.

The results of this dental and skeletal study of aging in western lowland gorillas are necessarily preliminary. The sample presented here of individuals of known ages and life histories is small. When older females and younger males can be sampled, it will be possible (1) to examine in more detail the course of aging in gorillas, and (2) to establish probable differences in male and female aging patterns.

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