Facial Bone Density: Effects of Aging and Impact on Facial Rejuvenation

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Abstract

Background: Facial bone aging has recently been described as primarily resulting from volume loss and morphologic changes to the orbit, midface, and mandible.

Objective: The authors demonstrate how the facial skeleton bone mineral density (BMD) changes with age in both men and women and compare these changes to those of the axial skeleton. They also explore the aesthetic implications of such changes in bone density.

Methods: Dual-energy X-ray absorptiometry (DXA) scans of the facial bones and lumbar spine were obtained from 60 white subjects, 30 women and 30 men. There were 10 men and 10 women in each of 3 age categories: young (20-40 years), middle (41-60 years), and old (61+ years). The following measurements were obtained: lumbar spine BMD (average BMD of L1-L4 vertebrae), maxilla BMD (the average BMD of the right and left maxilla), and mandible BMD (the average BMD of the right and left mandibular rami).

Results: The lumbar spine BMD decreased significantly for both sexes between the middle and old age groups. There was a significant decrease in the maxilla and mandible BMD for both sexes between the young and middle age groups.

Conclusions: Our results suggest that the BMD of the face changes with age, similar to the axial skeleton. This change in BMD may contribute to the appearance of the aging face and potentially affect facial rejuvenation procedures.

Keywords
facial aging, facial bones, bone density, face, facial surgery

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Facial aging is a dynamic process, with changes occurring to the skin, muscle, fat, and underlying facial skeleton. As we have gained a better understanding of the aging process, soft tissue augmentation for volume loss has been added to the treatment plan for many seeking facial rejuvenation.1,2 This volume loss is likely due to soft tissue atrophy in addition to a loss of bony support and projection. Multiple studies have suggested that the bony aging of the face is primarily a process of contraction and morphologic change.3-9

The aging of the bony components of the face is important to understand, as the facial skeleton provides the framework or scaffolding on which the soft tissue envelope drapes. In this study, we will explore how the facial bones age by determining whether the facial bones undergo a change in bone mineral density (BMD) with age, as the axial skeleton does. We will also explore the aesthetic implications of these potential changes.

METHODS

Dual-energy X-ray absorptiometry (DXA) scans of the facial bones and lumbar spine were obtained from 60 white subjects, 30 women and 30 men. Approval was
obtained for this study from the University of Rochester Internal Review Board (IRB), and all patients signed an approved informed consent. There were 10 men and 10 women in each of 3 age categories: young (20-40 years), middle (41-60 years), and old (61+ years). Inclusion criteria required no history of facial or spine fracture and no treatment for osteoporosis in the past. Edentulous patients and smokers were also excluded.

The following measurements were taken for each subject’s scan.

**Lumbar spine:** The lumbar spine BMD (g/cm²) was calculated as the average bone density of L1 to L4 vertebrae (Figure 1).

**Maxilla:** The maxilla BMD (g/cm²) was calculated as the average BMD of the right and left maxilla, as determined by a 3 × 6-mm region of interest (ROI) over the anterior maxilla (Figure 2).

**Mandible:** The mandible BMD (g/cm²) was calculated as the average BMD of the right and left mandibular ramus, as determined by a 2 × 10-mm ROI placed over each mandibular ramus (Figure 3).

All subjects were scanned and analyzed on a Lunar Prodigy DXA scanner (GE Healthcare, Waukesha, Wisconsin). Lumbar spine BMD was analyzed with GE spine analysis software (GE Healthcare, Waukesha, Wisconsin), and the facial bones were scanned using the total body software; custom ROIs were made for the maxilla and mandible. One-
way analysis of variance (ANOVA) and t tests were used to analyze results within each sex across age group. Results were considered significant at a $P$ value less than .05.

**RESULTS**

The mean age in the “young” age group was 29.9 years for men and 27 years for women. The men in our “middle” age group had a mean age of 54.5 years, whereas the women had a mean age of 51 years. The mean age in the “old” age group was 76 years for men and 70 years for women (Table 1).

**Lumbar Spine**

The lumbar spine BMD significantly decreased with age for both our male ($F = 5.012, P = .0077$) and female ($F = 5.047, P < .0001$) study population. Men showed a statistically significant decrease from the middle to old age group ($t = 2.802, P < .05$), as did women ($t = 2.733, P < .001$; Table 2 and Figures 4, 5A,B).

**Face**

**Midface.** The maxilla BMD significantly decreased with age for both our male ($F = 9.283, P < .01$) and female ($F = 6.582, P < .01$) study population. Male subjects demonstrated a statistically significant decrease from the young to middle age group ($t = 3.660, P < .001$), as did women ($t = 2.760, P < .01$; Table 2 and Figures 6A,B, 7).

**Mandible.** The mandible BMD significantly decreased with age for both our male ($F = 5.373, P = .00077$) and female ($F = 9.867, P = .0043$) study population. Men had a statistically significant decrease from the young to middle age group ($t = 3.015, P < .05$), as did women ($t = 2.563, P < .001$; Table 2 and Figures 6A,B, 8).

**DISCUSSION**

The bony components of the face are important for the overall 3-dimensional contour of the face, as they provide the framework on which the soft tissue envelope drapes. If this framework experiences a morphologic change with age, the overlying soft tissues will subsequently project differently. Facial bony aging has been characterized in recent studies by volume loss and morphologic change. This loss of facial bone volume may be related to a...
decrease in BMD, similar to what is seen in the axial skeleton.

It is widely accepted that BMD decreases with age in the axial skeleton due to a variety of factors such as nutrition, hormonal changes, medications, lifestyle changes, and medical comorbidities. The mean BMD used to make the diagnosis of osteoporosis by the World Health Organization decreases with age. For example, the mean for total hip density for white women at 25 years of age is 950 g/cm²; for white women at 85 years of age, the expected mean is a drop to just below 700 g/cm². The potential effect of aging on the BMD of the facial skeleton, however, has received little attention.

The bones of the face are formed by intramembranous ossification without cartilaginous precursors, which differs from the rest of the axial skeleton and long bones. Thus, the growth and bony resorption of the face may be regulated by different factors. This has led many to believe that the facial bones and long bones age differently. Deguchi et al, however, analyzed this question by studying 134 subjects in 3 separate age categories based on mandibular cortex erosions and the lab values of serum bone-specific alkaline phosphatase (S-BAP) and urinary N-telopeptide cross-links of type 1 collagen (U-NTX). He found that mandibular inferior cortical erosion on radiographs was associated with increased levels of S-BAP and U-NTX and that there was a strong association between mandible and general bone metabolism.

The earliest suggestion of an association between osteoporosis and facial bone loss was made in 1960. It is well known that subjects with tooth loss undergo significant alveolar bone loss, but decreased mandibular bone density has also been found in multiple studies independent of dental status. D’Amelio et al analyzed the mandibles of 15 men (ages 34-85 years) and 16 women (ages 23-82 years) with an X-ray densitometer. He found a significant bone density decrease in the ramus for both sexes with increasing age. A study of 18 postmenopausal women over 2 years showed more bone loss in the mandible by DXA compared with the femur trochanter and phalanges. Thinning of the mandibular cortices of <3 mm has also been associated with low skeletal bone mass.

In this study, we hoped to expand upon the previous research by including both sexes and by analyzing the largest number of subjects to date.

Various imaging modalities are utilized to measure BMD. In this study, we used DXA imaging, as it has been shown to best predict patients who are at risk of osteoporosis. This has led the United States Preventative Services Task...
Force and the National Osteoporosis Foundation to recommend the use of DXA, which has become the gold standard for the diagnosis of osteoporosis. We did not calculate a T or Z score (comparison of the individual’s bone mineral density to the 30-year-old or age-specific mean) for our research subjects, as we were not diagnosing osteoporosis and were only comparing the BMD across age.

The lumbar spine BMD in our study subjects significantly decreased with age for both sexes. This suggests that our study population results correlate with the known decrease in lumbar spine BMD within the general population and that our population was an accurate sampling of the general population. The maxilla and mandible BMD decreased with age for both sexes as well. This result suggests that the facial bones may undergo a decrease in BMD similar to the axial skeleton. This loss of density may contribute to the decreased facial bone volume and projection seen with aging. These changes in facial bone volume and density may happen at the same time and do not necessarily have a cause-and-effect relationship. Our results suggest that the axial and facial skeleton undergoes similar decreases in BMD with age and that facial bone aging may be linked to the same metabolic factors that cause osteoporosis in the axial skeleton.

The decrease in BMD of the facial bones with age may also have an impact on facial rejuvenation. As we have come to better understand the changes in facial aging, it has become more evident that the most effective approach toward facial rejuvenation should include restoring volume and contour, in addition to reducing the skin envelope. Soft tissue fillers and fat can be used successfully to restore volume loss and, when injected more deeply, result in the restoration of supportive structures and the skeletal foundation.18 Skeletal augmentation, using implants made of porous polyethylene or silicone, is also an effective method to reverse age-related changes of the facial skeleton in patients with intact occlusion.19 Screw fixation is usually recommended for porous polyethylene implants, and most implants have been shown to cause some element of bony remodeling.19 Patients with facial bones that are thinned and less dense may not be the best candidates for such a procedure, as it may predispose them to fracture. The type of volume augmentation should be tailored to each patient to rejuvenate the face and minimize potential complications. A better understanding of facial bone strength and support will further our understanding of facial aging and the future possibilities for facial rejuvenation.

CONCLUSIONS

The facial skeleton undergoes a decrease in bone mineral density with age, similar to the axial skeleton. This bone density loss correlates with the morphologic changes and overall decrease in volume with increasing age documented in previous studies. These changes result in decreased support and projection of the soft tissue envelope. This, in addition to the decrease in facial fat, creates the typical appearance of the aged face.

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