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Long-term Patterns of Age-Related Facial Bone Loss in Black Individuals

David Buziashvili, MBS; Jacob I. Tower, MD; Neel R. Sangal, BA; Aakash M. Shah, BS; Boris Paskhover, MD

Supplemental content

IMPORTANCE Facial skeletal changes that occur with aging have critical importance to the aesthetics of the aging face and the field of facial rejuvenation. Patterns of bony change may differ based on race, but existing research is limited primarily to white or unspecified racial populations.

OBJECTIVE To longitudinally document patterns of facial skeletal change among black individuals.

DESIGN, SETTING, AND PARTICIPANTS This retrospective case series study evaluated the medical records of patients treated at an urban tertiary medical center and with at least 2 facial computed tomographic (CT) images obtained at least 6 years apart between 1973 and 2017. All patients were self-identified black adults initially aged 40 to 55 years with no history of facial surgery who required repeated facial CT imaging that included the entire midface and cranium. All data analysis took place between August 1, 2018, and October 31, 2018.

MAIN OUTCOMES AND MEASURES Facial CT scans were analyzed for 2-dimensional measurements to document changes in glabellar angle, bilateral maxillary angles, frontozygomatic junction width, orbital width, and piriform width.

RESULTS A total of 20 patients were included in our analysis (6 men, 14 women). The patients' mean (SD) initial age was 46.8 (5.8) years, with a mean (SD) follow-up of 10.7 (2.9) years. There was a significant increase in mean (SD) piriform aperture width from 3.24 (0.37) cm to 3.31 (0.32) cm ($P = .002$) and mean (SD) female orbital width from 3.77 (0.25) cm to 3.84 (0.19) cm ($P = .04$). There was a significant decrease in mean (SD) frontozygomatic junction width from 5.46 (1.38) mm to 5.24 (1.42) mm ($P < .001$). No significant differences were found in glabellar angles, maxillary angles, or male orbital width between initial and final imaging time points.

CONCLUSIONS AND RELEVANCE This study is the first to our knowledge to document longitudinal bony changes of the face among a population of black individuals. Although significant facial skeletal changes can be observed over an average 10-year period, they are minor in comparison to previously published data among whites. This study suggests that there may be significant differences in facial bony aging between races which may have an impact on the aesthetics of aging and hold implications for facial rejuvenation.

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Author Affiliations: Department of Otolaryngology–Head and Neck Surgery, Rutgers New Jersey Medical School, Newark (Buziashvili, Sangal, Shah, Paskhover); Section of Otolaryngology, Department of Surgery, Yale School of Medicine, New Haven, Connecticut (Tower).

Corresponding Author: Jacob I. Tower, MD, Section of Otolaryngology, Department of Surgery, Yale School of Medicine, 800 Howard Ave, Fourth Floor, ENT Office, New Haven, CT 06519 (jacob.tower@yale.edu).

Facial aging is an intricate process that involves changes to the skin, muscle, fat, and underlying facial skeleton.[1-4] The soft-tissue envelope has been the primary focus of facial rejuvenation procedures. The mainstay treatments of the aging face include rhytidectomy, fat grafting, and injectable fillers, which address soft-tissue changes by repositioning and remodeling the soft-tissue envelope.[5] However, the facial aging process is now understood to also be greatly influenced by bony remodeling.[2,3,6] The facial skeleton creates a scaffold onto which soft tissue is draped, and as facial bony changes occur, the overlying soft tissues undergo morphologic changes, which result in perceived decreases in facial volume and fullness.[1,7]

Facial bone is unique in that it is formed by intramembranous ossification, whereas most of the axial skeleton and long bones develop by endochondral ossification. Despite being regulated by different growth factors, facial bone undergoes a decrease in bone mineral density with age, similar to axial bone.[1] Additionally, the facial skeleton undergoes selective resorption, with certain regions of the face undergoing resorption at faster rates than others.[2] Selective resorption is responsible for the facial skeletal changes that occur during the aging process from infancy through adulthood, eventually resulting in an aged appearance. The proportional changes needed for this transformation are the result of regions of bone resorption adjacent to regions of bone deposition.[2,3] Several regions of notable bone resorption are centered around the nasal, maxillary, and frontal bones. As these bones deteriorate, the craniofacial skeleton undergoes linear and angular changes, which result in rotation and posterior displacement of the midface, and increased aperture of the orbital rim.[6,8,9] Other regions, such as the mandibular angle and zygomatic arch, tend to deteriorate at slower rates or, in some cases, even expand.[2] Facial bone mineral density loss correlates with these morphologic changes, and similar to other bones, this loss is likely dependent on factors that contribute to overall bone health.

Previous studies have shown decreased rates of bone resorption among the black population compared with the general population.[10] This translates to substantially higher bone mineral density and lower rates of osteoporosis.[11,12] However, studies that have investigated facial skeletal aging have largely ignored race as a possible factor or limited their study populations to white participants.[6,8,13] Most of the existing literature that compares differences in facial aging among different ethnic groups focuses on differences in skin composition rather than skeletal changes. For example, it is known that the epidermal pigment melanin reduces facial aging by protecting against damage from UV radiation.[14,15] With growth in cosmetic procedures among Africans Americans (16%) outpacing growth among whites (8%) as of 2017, understanding how the bony processes underlying facial aging may differ among these populations will be key to counseling patients and creating individualized treatment plans.[16]

Although a general model of facial skeletal aging exists, data are currently lacking regarding the morphologic changes that occur specifically in the black population. Because bone resorption rates vary among different ethnic populations, it is likely that there will be differences in facial skeletal aging. To better identify trends and characteristics of facial bone remodeling, the present study focuses on analyzing age-related facial bone loss among men and women in the black population and its aesthetic implications. To obtain an accurate model of bony change, we use a longitudinal approach that observes the same individuals over time rather than comparing randomly selected individuals from younger and older age groups.

Key Points

Question What are the patterns of bony changes in the aging face experienced by black individuals observed over time?

Findings In this cohort study of 20 black adults observed for an average 10-year period, there was a significant increase in piriform aperture width and female orbital width and a decrease in frontozygomatic junction width. There were no significant changes in maxillary or glabellar angles or male orbital width.

Meaning Although significant longitudinal changes in the facial skeleton can be observed in black individuals, they are less dramatic than those found in previous studies of white individuals, findings that seem to correlate with overall aging trends in bone mineral density.

Methods

A retrospective analysis of patients at an urban treatment facility (University Hospital, Newark, New Jersey) was conducted between 1973 and 2017. The study was approved by the Health Sciences IRB Newark in the Office of Research Regulatory Affairs, Rutgers University, waiving patient written informed consent for deidentified data. The University Hospital Picture Archive and Communication System (PACS) was queried to identify patients who met inclusion criteria of the study. Requirements included initial computed tomography (CT) head angiographic imaging evaluation between ages 40 and 55 years, with repeated CT head image obtained more than 6 years after the first, and both including the midface and cranium. Exclusion criteria included history of facial trauma, surgery, or abnormalities of the bones and soft tissue of the head identified from medical record review and diagnostic codes. Demographic characteristics such as age, self-reported race, and sex were identified from medical record review.

Two-dimensional reconstruction of the CT head images on RadiAnt Digital Imaging and Communications in Medicine (DICOM) (Medixant, Poznan POL) was used to obtain the following measurements: piriform width, right frontozygomatic (FZ) junction width, orbital widths, glabellar angle, and bilateral maxillary angles (eFigure in the Supplement). Measurements were conducted in accordance with existing methodology.[7] The left and right maxillary angles were obtained on parasagittal CT slices at the level of the infraorbital foramen and midorbits, with the angle's vertex at the anterosuperior maxilla, one ray through the midsella, and the other ray extending to the inferior maxilla-alveolar crest junction (**Figure 1**). Glabellar angle was measured in the midsagittal plane with the angle's vertex at the glabella, one ray through the nasofrontal suture, and the other ray parallel to the sella-nasion line (**Figure 2**).

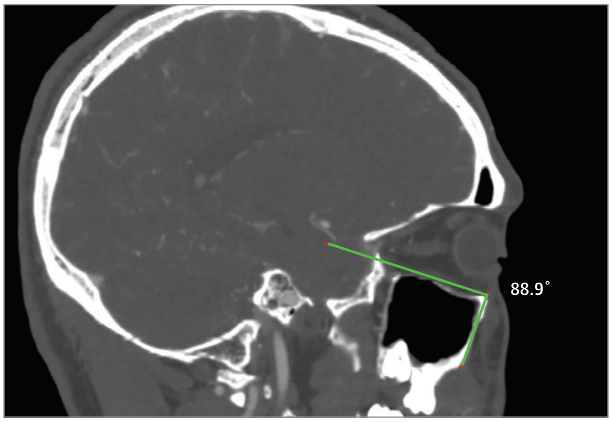

Figure 1. Left and Right Maxillary Angles Were Obtained on Parasagittal Computed Tomographic Slices at the Level of the Infraorbital Foramen and Midorbits

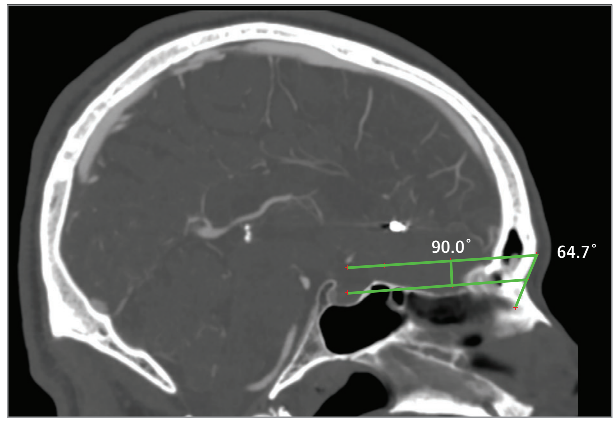

Figure 2. Glabellar Angle on Computed Tomography

The piriform width was measured on coronal section and defined as the widest transverse width of the piriform aperture. The right FZ junction was identified on coronal CT section and measured at its widest point; its lateral "notch" was used as an anatomic landmark along which a horizontal line was drawn medially through the width of the bone. To measure the right orbital width, the infraorbital suture line was identified on a superficial coronal section, and a transverse line from the suture line through the orbital midline was constructed to a superomedial bony orbital landmark.

Data were collected using Microsoft Excel, version 16.0. Statistical analysis was conducted using Statistical Program for the Social Sciences, version 24.0 (IBM Inc). Descriptive statistics were performed, and paired 2-tailed *t* tests were used to assess for statistical significance. $P < .05$ was considered statistically significant.

Results

A total of 20 patients meeting inclusion criteria were identified. There were 6 men and 14 women included in the study. The mean (SD) age at initial CT head imaging was 46.8 (5.8) years, and at second evaluation it was 57.5 (6.7) years. A mean (SD) of 10.7 (2.9) years elapsed between initial and final CT evaluation. There were no significant differences between male and female patients with regard to mean piriform width, FZ junction width, glabellar angle, or maxillary angles at initial or final CT head imaging (**Table 1**).

Longitudinal changes in the facial skeleton of the 20 patients are detailed in **Table 2**. There was a decrease in mean (SD) FZ junction width from 5.46 (1.38) to 5.24 (1.42) mm, which was significant ($P < .001$). There was an increase in mean orbital width from 3.82 (0.25) to 3.89 (0.20) cm, which was not significant. However, when stratified by sex, women experienced a mean (SD) orbital width change from 3.77 (0.25) to 3.84 (0.19) cm, which was significant ($P = .04$). Male patients' orbital width changed from 3.96 to 4.02 cm, which was not significant ($P = .35$). There was an increase in mean (SD) piriform width from 3.24 (0.37) to 3.31 (0.32) cm, which was also significant ($P = .002$). The mean (SD) right maxillary angle decreased from 84.77° (10.60°) to 84.09° (10.35°), and the mean (SD) left maxillary angle decreased from 83.55° (9.56°) to 83.19° (11.07°); however, neither change was significant ($P = .33$ and $P = .74$, respectively). There was a decrease in mean (SD) glabellar angle from 72.26° (9.08°) to 71.58° (8.66°), which was also not significant ($P = .61$). Maxillary angle data were obtained from only 15 of the 20 patients, and glabellar angle data were obtained from only 14 of the 20 patients owing to 1 or more cephalometric landmarks not being visualizable on at least 1 CT scan. There were no significant differences in rates of bony change between the male and female population subsets (**Table 3**).

Discussion

Facial aging is a multifactorial process, involving changes to skin, underlying soft tissue, muscle, and bone. Recent research has identified specific sites of bony resorption in the facial skeleton that contribute to aesthetic changes associated with aging. Understanding how these bony changes may differ based on patient characteristics such as sex and race is key to developing a comprehensive model of facial aging and delivering individualized facial rejuvenation treatments. In this longitudinal study of facial skeletal aging in the black population, we found that most bony associations remained relatively stable over time, with select areas of bony remodeling demonstrating change over the ten-year study period.

There are several clinically significant areas of the skull that are known to experience selective resorption.[2] These points include the superomedial and inferolateral aspects of the orbit, the medial suborbital and piriform areas of the maxilla, and the prejowl area of the mandible.[2] In the present study, we noted a significant decrease in FZ junction diameter and a significant widening of the piriform aperture in the black population over a 10-year period. Interestingly, only women had a significant change in orbital width as measured from the inferolateral to superomedial aspect. This measurement was based on the findings of a previous study by Mendelson et al,[2] which noted bony orbital changes in those regions. Men did

Table 1. Analysis of Male vs Female Initial and Final CT Measurements

	Men		Women		
Measurement	Mean (SD)	(95% CI)	Mean (SD)	(95% CI)	*P* Value
Initial					
Angle, degrees					
Glabellar	68.10 (8.63)	(61.19-75.01)	73.93 (9.13)	(69.15-78.71)	.30
Maxillary					
Right	81.80 (7.45)	(75.84-87.76)	85.85 (11.65)	(79.75-91.95)	.53
Left	84.65 (9.52)	(77.03-92.27)	83.15 (10.01)	(77.91-88.39)	.80
Piriform width, cm	3.08 (0.16)	(2.95-3.21)	3.30 (0.40)	(3.09-3.51)	.24
FZ width, mm	5.44 (0.77)	(4.82-6.06)	5.47 (1.60)	(4.63-6.31)	.97
Orbital width, cm	3.96 (0.19)	(3.81-4.11)	3.77 (0.25)	(3.64-3.90)	.02
Final					
Angle, degrees					
Glabellar	66.90 (7.74)	(60.71-73.09)	73.45 (8.64)	(68.92-77.98)	.21
Maxillary					
Right	78.98 (6.68)	(73.63-84.33)	85.95 (11.06)	(80.16-91.74)	.26
Left	82.13 (9.16)	(74.80-89.46)	83.58 (12.07)	(77.26-89.90)	.83
Piriform width, cm	3.16 (0.18)	(3.02-3.30)	3.37 (0.40)	(3.16-3.58)	.19
FZ width, mm	5.20 (0.82)	(4.54-5.86)	5.25 (1.60)	(4.41-6.09)	.94
Orbital width, cm	4.02 (0.18)	(3.88-4.16)	3.84 (0.19)	(3.74-3.94)	.02

Abbreviations: CT, computed tomographic; FZ, frontozygomatic.

Table 2. Changes in Facial Skeleton Over Study Period

Measurement	Initial (SD)	(95% CI)	Final (SD)	(95% CI)	Difference	*P* Value
Angle, degrees						
Glabellar	72.26 (9.08)	(68.28-76.24)	71.58 (8.66)	(67.78-75.38)	−0.68	.61
Maxillary						
Right	84.77 (10.60)	(80.12-89.42)	84.09 (10.35)	(79.55-88.63)	−0.68	.33
Left	83.55 (9.56)	(79.36-87.74)	83.19 (11.07)	(78.34-88.04)	−0.36	.74
FZ width, mm	5.46 (1.38)	(4.86-6.06)	5.24 (1.42)	(4.62-5.86)	−0.22	<.001
Piriform width, cm	3.24 (0.37)	(3.08-3.40)	3.31 (0.32)	(3.17-3.45)	0.07	.002
Orbital width, cm						
Male	3.96 (0.48)	(3.75-4.17)	4.02 (0.26)	(3.91-4.13)	0.06	.35
Female	3.77 (0.32)	(3.63-3.91)	3.84 (0.48)	(3.63-4.05)	0.07	.04

Abbreviation: FZ, frontozygomatic.

not have a significant difference in orbital width, which can potentially be attributed to the smaller sample size (6 men to 14 women) in addition to sex differences in bone-resorption rates. The longitudinal changes observed in glabellar and maxillary angle in this study were not significant; however, the trends were consistent with previous studies.[2,7,8] The FZ junction was the point chosen to characterize aging around the orbit in the present study, and changes in this area likely contribute to the periorbital stigmata of aging. The widened piriform aperture is also consistent with previous findings[2,17] and possibly corresponds to the appearance of a widened and elongated nose and the drooping nasal tip seen with aging. The maxillary angles were measured to track retrusion and loss of cheek projection in the suborbital maxilla; however, contrary to the typical model of facial skeletal aging, there was minimal longitudinal change found in the black population of this study. Likewise, there was no significant longitudinal change in glabellar angle, which suggests relative stability of glabellar prominence as well in this population.

It is important for facial plastic surgeons to understand how the facial aging process differs among different racial and ethnic groups to best serve them.[16] In a pilot study,[7] our research group has previously studied facial skeletal changes in a longitudinal population with similar methodology over a similar time span and found significant decreases in mean glabellar and maxillary angles and increases in mean piriform width. Considering the findings of the present research, we reviewed the data from that pilot longitudinal study and found that the patients involved predominantly identified as white (12 of 14 identified as white, 1 declined to state their race/ethnicity, and 1 identified as Hispanic). This primarily white sample population of similar ages had a significantly decreased mean glabellar angle of 2.3° over a period of 9.6 years, whereas the black sample population of the present study had a decreased mean glabellar angle of only 0.68° over a slightly longer timeframe, which did not reach statistical significance. Unlike the predominantly white patients in our pilot study who had significantly decreased mean maxillary angles

Table 3. Changes per Year in Facial Skeleton Between Sexes

Measurement	Men	Change per Year	Women	Change per Year	*P* Value
Piriform width, cm					
Initial	3.08	0.01	3.30	<0.01	.68
Final	3.16		3.37		
Frontozygomatic junction, mm					
Initial	5.44	−0.03	5.47	−0.02	.76
Final	5.20		5.25		
Orbital width, cm					
Initial	3.96	<0.01	3.77	<0.01	.53
Final	4.02		3.82		
Glabellar angle, degrees					
Initial	68.10	−0.27	73.93	−0.04	.27
Final	65.56		73.45		
Right maxillary angle, degrees					
Initial	81.80	0.31	85.86	−0.01	.09
Final	84.65		83.15		
Left maxillary angle					
Initial	78.98	0.34	85.95	−0.01	.22
Final	82.13		83.58		

over time, the black patients in the present study had no significant change. Based on these findings, we conclude that compared with the black patients in the present study, the white population in our initial study had more pronounced facial skeletal changes with aging. We theorize that the relative lack of facial bony change in the black population can be attributed to an overall lesser rate of bone mineral loss.

Differences in overall bony aging among different populations are well established. Bone mineral density reaches a higher peak in African American individuals than in whites.[18,19] However, recent literature indicates the rate of bone loss seems equivalent among black and white populations.[19,20] If trends in facial aging mirror those of the rest of the axial skeleton, one could theorize that among black individuals, facial skeletal aging may not contribute significantly to aesthetic changes until relatively later in life. Moreover, variations in bone loss have been shown to be significantly different between groups of low and high socioeconomic status, with the loss being linear in both groups but steeper in the group of low socioeconomic status.[20] These determinants of bone mineral density may also lead to differences in facial skeletal aging, which will be a future subject of facial aging research. Current literature has not longitudinally investigated resorption rates of the bony face. Nevertheless, the measurements of the facial skeleton in the present study are the first to our knowledge to take race into account as a determinant of bony facial aging, and our findings suggest that the facial skeleton may also serve as a possible indicator of systemic bony aging.

Although the exact degree to which aesthetic facial aging is affected by these bony changes is not known, it is apparent that they do play a significant role. The current principle behind the use of dermal fillers in facial rejuvenation is to restore volume. Although fillers are most similar in consistency to adipose tissue, in select cases they may provide the necessary volume that is lost to bony aging. The data presented in this study suggest that the black population may experience less midfacial bony volume loss than whites, which would therefore suggest less need for procedures that restore volume to the midface.

Limitations

Our study has limitations that are important to consider. First, any study of anatomical measurements is inherently subject to observational error, which is related to the spatial resolution of CT; however, this is minimized with the application of a consistent measurement methodology based on easily identified cephalometric landmarks. Although this cohort of individuals is smaller than previous studies of facial skeletal aging, it is the largest study to our knowledge of a longitudinal nature. Finally, our methodology cannot account for extraneous variables within the selected sample, such as socioeconomic status, lifestyle, and various disease states (eg, osteoporosis) between the CT scans, which can have significant effect on bone deterioration.[20] This limitation can be addressed in future studies by using a prospective methodology.

Conclusions

To our knowledge, this is the first longitudinal study of facial skeletal change in a population of black individuals. We discovered significant changes in piriform width, FZ junction width, and female orbital width over an average 10.8-year period, but overall, the bony features were relatively stable compared with the patterns of change observed previously in the white population. To expand on this topic, future studies may look at other aging parameters or modalities for quantifying aging of the face, such as bone mineral densities. Ultimately, having a detailed model of facial skeletal change may allow us to anticipate, prevent, and treat these changes as they occur.

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Study concept and design: Buziashvili, Tower, Shah, Paskhover.
Acquisition, analysis, or interpretation of data: Buziashvili, Sangal.
Drafting of the manuscript: Buziashvili, Tower, Sangal, Shah.
Critical revision of the manuscript for important intellectual content: Buziashvili, Tower, Paskhover.
Statistical analysis: Sangal.
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