

## Correlation of Facial, Orbital and Nasal Morphometry with age in a Subset of Karachi Population

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### ABSTRACT

**Objective:** To determine the association of age with facial, orbital and nasal craniofacial parameters in a sub-set of Karachi population.

**Study design:** Cross-sectional study.

**Place and duration:** This study was conducted on patients presenting to the Department of Radiology at Ziauddin University Hospital, Karachi, from 10 January 2025 to 30 May 2025.

**Methodology:** A total of 100 patients aged 18 years and above were included. Facial height, facial width, orbital height, orbital width, inter-orbital distance, bi-orbital distance and nasal septum length were measured via CT head scans. Normality was assessed using Shapiro-Wilk test. To determine correlation of age with different parameters Pearson's correlation was used. P-value<0.05 was considered significant.

**Results:** Out of 100 patients selected 45 (45%) were male and 55 (55%) were female patients. The results revealed that facial height, inter-orbital distance and nasal septum length showed significant negative correlation with age whereas facial width, right and left orbital heights, right and left orbital widths and bi-orbital distance showed significant positive correlation with age ( $p<0.001$ ).

**Conclusion:** The study concludes that as the age increases, there is decrease in facial height, inter-orbital distance and nasal septum length. Furthermore, there is an increase in facial width, right and left orbital heights, right and left orbital widths and bi-orbital distance with advancing age.

**Keywords:** Age-related changes, Craniometry, Facial Morphology, Personal identification, Surgical planning.

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### INTRODUCTION

Craniometry was introduced in order to study various skull dimensions by Hippocrates (450-357 BC). With progressing time, skull's structural complexity and its inspection was made comprehensible with multiple examination means like facial lines (introduced by Leonardo Da Vinci; 1452-1519), planes and angles (craniofacial height, length and breadth, bi-zygomatic

breadth, orbital breadth and nasal length, etc.) and likewise bony references that made calibration of the former easy. Measurement modalities although advanced but predominantly had been manual; tape-rulers, metered-rulers and Vernier calipers, etc, with dry and cadaveric skulls as chosen subjects. The mentioned measurement fashion is questionable as manual techniques reduces efficiency and consumes more time. Similarly, the skull remains with time loses their structural integrity under the effect of dehydration hence reducing measurement precision. Whereas the potential of digital methods, namely, CT scan, MRI and Cone Beam Computed Tomography (CBCT) to create images of deeper structures enable calibration possible of even those regions that are not visible to naked eyes.<sup>1</sup> Only in the recent years, the use of CT/MRI scans on live subjects have been brought into practice of craniofacial anthropometry.<sup>2</sup> In recent years, international practices have increasingly utilized images for applications such as reconstructing facial features using 3D graphic tools. However, there is lack of similar studies and with the mentioned criterion at national setting and the limited studies performed have mainly used manual measurement techniques.<sup>3</sup>

As the age advances, overall facial morphology alters and hence results in variable cranial forms. Facial, orbital and nasal regions of the face are all sensitive to changes with age and show variations as time progresses.<sup>4</sup> The practical applications

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of such studies are found in reconstructive and plastic surgery, as well as forensic anthropology, where understanding age-related anatomical changes is crucial. Having prior knowledge of these regions in the context of their respective fields is therefore of utmost importance. In one such study, correction of fragile facial skeleton was mentioned as a vital domain in growing field of reconstruction.<sup>5</sup> Surgery of the orbital region is also a very delicate matter due to the visual apparatus residing in it, therefore a prior knowledge of its structural parameters is considered an essential pre-operative step. In a study, data for orbital index was created in order to achieve precise anatomical structure to avoid/ reduce risk for enophthalmos - common outcome of orbital floor fractures.<sup>6</sup> Nose is also a highly aesthetic zone of the face and is given equal importance. Studies have aimed to determine the extent of nasal septal deviation and its effects on upper airway. In this study, one of the most encountered nasal pathologies, nasal septal height was recorded using CBCT.<sup>7</sup> Facial anthropometric dimensions have also been utilized in the past for assistance in developing facial prosthesis. A study in Korean population was carried out where various nasal parameter differences were established amid both genders for assistance in silicon implant creation for rhinoplasty.<sup>8</sup> Likewise, a study was performed where facial orbital anthropometry was retrieved through CT scans and compared with orbital prosthesis to establish accuracy.<sup>9</sup> The need of similar craniofacial data is of equal importance for forensic anthropologists as skull is one of the preferred remains for human personal identification. Sex and age are the most important parameters that need to be established in these cases. Measurement of facial height and width as well as orbits are of particular importance in the field of forensic science. With the incorporation of advanced imaging techniques, forensic anthropologists have introduced the use of data collected through CT or 3D-CT and utilized it in facial reconstruction for better identification of human remains received from mass disasters.<sup>10</sup> Such studies however, are few and far in Pakistani population. Thus, there is need for such studies in forensic sciences as well as in plastic and orbital surgeries. The present study thus aims to determine changes in facial, orbital and nasal morphometry with age in a subset of Karachi so that its population can benefit from in the field of surgery and forensic.

### METHODOLOGY

This cross-sectional study was conducted in the Department of Radiology at Ziauddin University Hospital, Karachi, and included patients presenting to the hospital's outpatient department who underwent head CT scans between 10 January 2025 and 30 May 2025. "Quota Sampling" technique was used. Ethical approval was taken from Ethical Review Committees of Ziauddin University (Reference Code: 9471124SIANA) dated: December 12, 2024. Sample size was calculated using OpenEpi sample size calculator with confidence level (CL) at 95%, margin of error at 5% and power of study as 80%. The calculated sample size was 94 which was rounded off to 100.

All patients 18 years and above, referred to the radiology department for CT head were selected for the study. Patients with history of facial trauma, previous orthodontic/ orthognathic, plastic/ reconstructive surgery or any other facial surgery, congenital facial deformity, ongoing infection and with history of or present neoplastic growth on face were excluded from the study.

Head CT scans from the Radiology Department of Ziauddin University Hospital of patients meeting all inclusion criterion were used for the study. Demographic data of each patient was noted separately for each scan with gender, age, height, weight and medical history by the principal investigator and under the supervision of radiology expert. Coronal view was selected for each parameter. Facial height (Nasion-Prosthion), facial width (Zygion-Zygion), orbital height (Maximum distance between superior and inferior orbital rims), orbital width (Maximum distance between the medial and lateral orbital rims), inter-orbital distance (Distance between medial orbital rims), bi-orbital distance (Distance between lateral orbital rims) and nasal septum length (Distance from base of crista gilli to anterior nasal spine) were measured. All measurements were recorded in mm. CT Toshiba Alexion 16 slicer scan was used with kVp 120 200 MAS. All images were received in axial plane and then reformed into coronal plane for ease of measurement. The collimation limit was from the base of the skull to the mandible. Field of view was small. Slice thickness was 3 mm. The screen used for the image display was LED screen from Dell. All measurements were recorded using display of the CT scans on the screen using the measurement tool available with it.

**Data Analysis:** Data were analyzed using SPSS version 24. The normality of quantitative variables was evaluated with the Shapiro-Wilk test. Qualitative variables are presented as frequencies and percentages, whereas normally distributed quantitative data are expressed as mean  $\pm$  standard deviation. Pearson's correlation analysis was used to assess the relationship between age and the measured parameters. A p-value of less than 0.05 was considered statistically significant for all analyses.

### RESULTS

100 CT scans of patients meeting the pre-set criteria from the Radiology Department of Ziauddin University, Karachi were analyzed. Gender distribution was 45 (45%) males and 55 (55%) females. Mean age of the total participants was  $45.01 \pm 16.50$  years however, the mean age of males and females were  $46.0 \pm 17.84$  and  $44.18 \pm 15.42$  years respectively (Table I).

**Table I: Frequency & mean  $\pm$  Standard deviation (SD) distribution of both genders (N=100)**

Gender	Frequency, n(%)	Mean $\pm$ SD
Male	45 (45%)	46.00 $\pm$ 17.84
Female	55 (55%)	44.18 $\pm$ 5.42

Facial parameters: Analysis revealed a significant strong negative correlation of facial height with age ( $r = -0.772/p < 0.001$ ) (Figure-1A/Table-II). On comparing facial width with age, a significant mild positive correlation was seen ( $r=0.332/p=0.001$ ) (Figure-1B/ Table-II).

Orbital parameters: Meanwhile, right orbital height and left orbital height were found to have significant moderate positive correlation with age ( $r=0.350/p < 0.001$  &  $r=0.481/p < 0.001$ , respectively) (Figure-2A & 2B/ Table-II). The right orbital width

also showed significant moderate positive correlation with age ( $r=0.563/p < 0.001$ ) whereas left orbital width showed significant strong positive age-related correlation ( $r=0.732/p < 0.001$ ) (Figure-2C & 2D/ Table-II). Again, when compared with age, inter-orbital distance gave significant mild negative correlation ( $r=-0.297/p=0.003$ ) while correlation with the same was significant and mildly positive for bi-orbital distance ( $r=0.458/p < 0.001$ ) (Figure-2E & 2F/ Table-II).

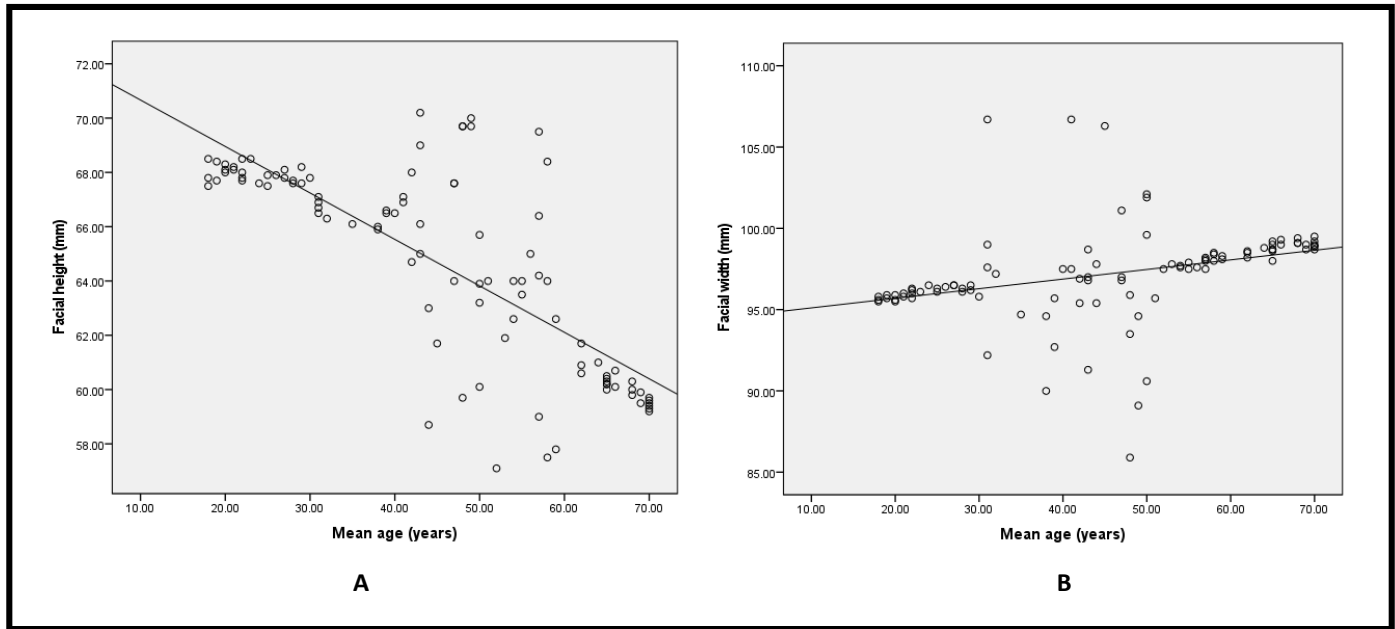
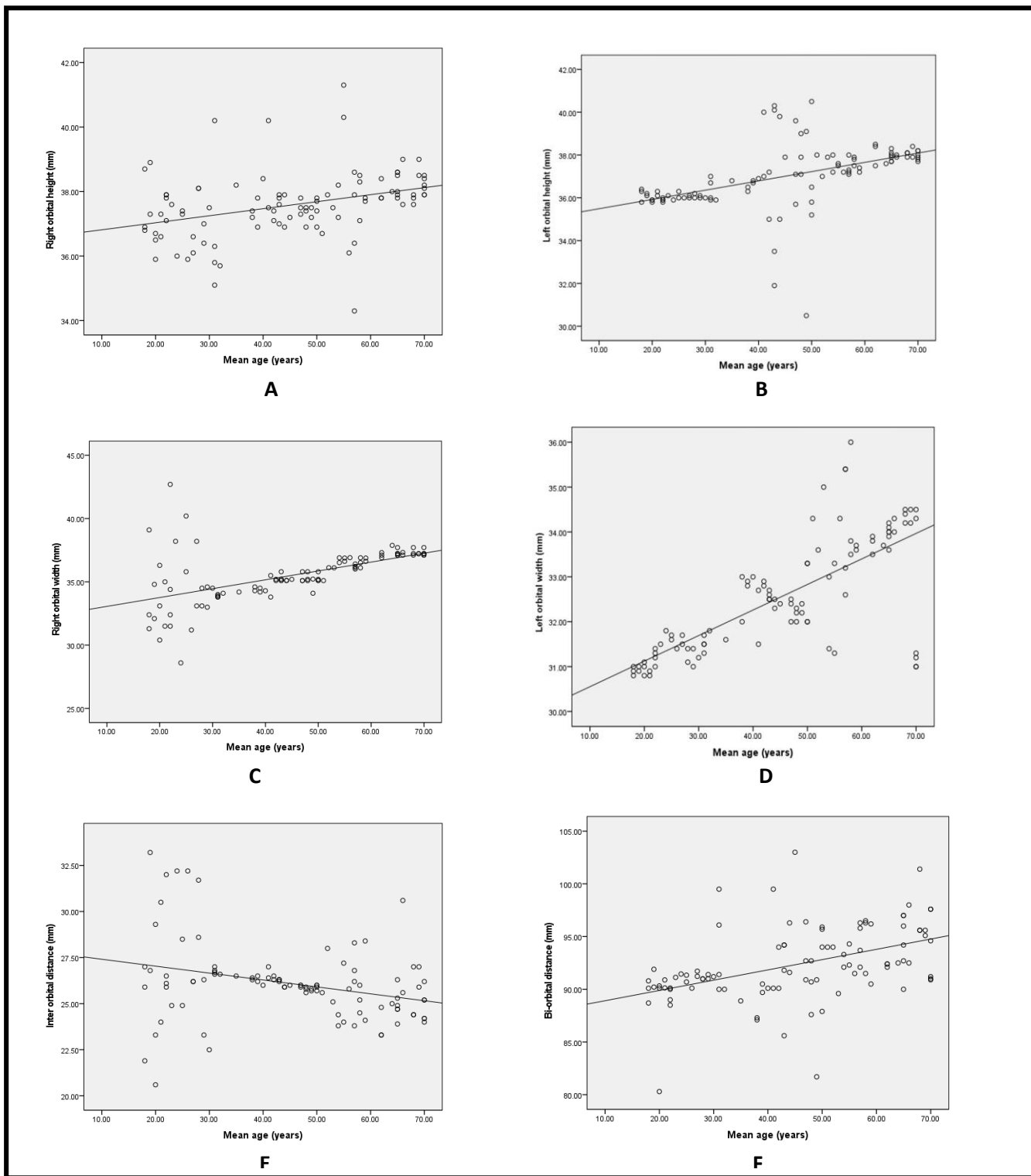


Figure 1: Scatter plot showing a significant strong negative and mild positive correlation of facial height (A) & facial width (B) with age.

Table II: Correlation of age with each morphometric parameter (N=100)

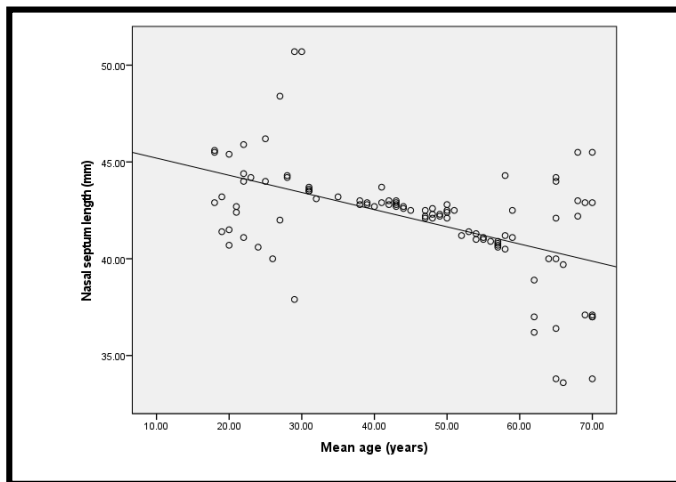
Parameter	r	p-value
Facial height	-0.772	<0.001*
Facial width	0.332	0.001*
Right orbital height	0.350	<0.001*
Left orbital height	0.481	<0.001*
Right orbital width	0.563	<0.001*
Left orbital width	0.732	<0.001*
Inter-orbital distance	-0.297	0.003*
Bi-orbital distance	0.458	<0.001*
Nasal septum length	-0.512	<0.001*

r = correlation coefficient; \* = significant



**Figure 2:** Scatter plot showing significant moderate positive correlation of right (A) & left (B) orbital height and right orbital width (C) with age, significant strong positive correlation of age with left orbital width (D) and significant mild negative and mild positive correlation of (E) inter-orbital distance (IOD) and (F) bi-orbital distance (BOD) correlation with age, respectively.

Nasal parameters: Nasal septum length displayed significant mildly negative correlation with age ( $r=-0.512/p<0.001$ ) (Figure 3/Table-II).



**Figure 3: Scatter plot showing significant mild negative correlation of nasal septum length with age.**

## DISCUSSION

This study is purposed to investigate association of age with facial, orbital and nasal regions using seven craniofacial parameters measured via head CT scans of the individuals between 18 to 70 years from Karachi. This data is meant to generate insights that may assist plastic/reconstructive surgeons to attain better procedural outcomes and forensic anthropologists in achieving precise calibrations for establishment of personal identity in cases of unknown dead bodies especially in cases of fragmentary or skeletonized remains. Such comparisons are very scanty in our national setting.<sup>11</sup>

Age of a person provides a fundamental aspect of personal identity. Human age from the aspect of age estimation is divided into three categories based on the difficulties and challenges to accurate age prediction that are encountered as human age progresses. The first category is proliferative age group starting from intra-uterine life to 25 years of age, in which age estimation can be done easily and age can be predicted more accurately as rapid growth related changes are taking place in human body. The second age groups is considered as the static age group initiating after the 25<sup>th</sup> year of life and goes on till the age of 50 years during which minimal changes are observed in the human body as physiological functions stabilize, growth ceases and minimal age related changes are taking place. This age group is considered most challenging as far as age prediction is concerned. The third category is considered as the retrogressive age group starting after the 50<sup>th</sup> year of human life and progresses till death in which degenerative changes are taking place in the body and accurate age prediction is easier than the static group.<sup>12</sup> The beauty of the selected age group relies upon the fact that it completely covers the static age group, in which prediction of human age is most challenging while it also overlaps partially into the other two previously mentioned age categories.

Computed Tomography (CT) was chosen as the mode of

calibration because of its excellence over other techniques in recording hard tissue, specifically because of its quality to produce finest results in spatial resolution.<sup>13</sup>

In our study, we observed a peculiar reduction in facial height (FH) as one ages. A similar result was observed in a study where superoinferior recession of facial configuration was observed in the population sample of 19<sup>th</sup> and 20<sup>th</sup> century adult African-American and European-American using dry crania.<sup>14</sup>

We observed a minor yet distinctive increase in facial width (FW) when correlated with age. Likelihood of such change was present in another study where morphometric analysis revealed superoinferior facial reduction along with lateral expansion with increasing age. Mid-facial expansion results from anteroposterior bone remodeling (a process of deposition and resorption) in the zygomatic bone with aging, making the bone longer and thicker thus resulting in increased facial width.<sup>15</sup>

Using the results achieved from this study, a data-bank of facial morphometric values (varied with age) for the population of Karachi may be generated later that could assist surgical professionals in more accurately performing various craniofacial procedures, like facial asymmetry correction, genioplasty, syndrome correction surgery, orthognathic surgery and gender affirming surgery. This may also help maxillofacial surgeons in making 3D models that are imprinted on patient's current facial images.<sup>16</sup> The images generated with assistance of AI tools can then be used to fabricate ideal facial measurements needed to produce successful procedural outcome thus making it easier to discuss treatment plans with the patient. This database may also be utilized by forensic anthropologists in specific age assessment of Karachi population purposed for identification in scenarios of mass disasters or when fragmentary or skeletal remains comprising of human skulls are retrieved from disaster sites or when criminal investigation is needed.<sup>17</sup>

Significant yet varied patterns of change were established with increasing age for every orbital parameter. The right (R-OH) and left orbital heights (L-OH) showed displayed moderate increase with age. Although both of these showed a constant increase, but the change was greater in left orbit as compared to the right. Right (R-OW) and left orbital widths (L-OW) also showed slower but persistent widening with increasing age – the relation of which was found to be moderate for the former and strong for the latter. The bony reduction of orbital width demonstrates an inverse correlation with inter-orbital distance (IOD) and direct correlation with bi-orbital distance (BOD) as they both lie in similar axis to the orbital width. Under the effect of orbital width expansion, the space between both the right and the left orbits, i.e., IOD, shortened establishing a mild but significant correlation. Similar but more appreciable effect of orbital width increment was on BOD. A study explains the fashion in which the orbits resorb with age.<sup>18</sup> The orbital aperture is made up of 4 rims and the rate at which each rim undergoes recession varies with respect to age. The inferolateral and superomedial portions of the orbital opening recede predominantly with former undergoing changes in middle-ages followed by latter bringing change in older ages

while the changes in the remaining portions of the orbital opening were not noticeable. The said pattern of orbital resorption has direct effect on both their height and width. It was also deduced that the overall hard tissue alteration results into enophthalmic positioning of the eye (pulling of the eye into its socket). Contrary to this explanation, the data received from the population of Karachi showed harmonious bony regression of the entire orbit with increasing age in height and width of the orbits. Also, the amount of resorption in both right and left orbits was found to be different from one another amid Karachi's population, where left orbits was found to be more reduced than the right orbits as the age passed by. Whereas, similarity with the aforementioned explanation was found in a study where orbital height and width changing with age showed significant difference medially in their superior orbital rims and laterally in inferior orbital rims.<sup>19</sup> Familiarity with the present research's results was found with a study where significant correlation was observed with increasing age in orbital height and width.<sup>20</sup>

As discussed earlier, the skull is of immense importance when it comes to identification of human remains in forensic facilities. Orbital bones - as the history says and so does the present study, bring about very noticeable change on the human face as one ages.<sup>18</sup> Hence, it becomes imperative for forensic experts to observe the orbit when determining the age of an individual. Studies with similar aim, i.e., to assist forensic experts in identification procedures for various populations have been conducted, like, in southwestern Iranian population where orbital calibration were observed using 3D-CT scans and were found to have significant correlation with age.<sup>21</sup>

Similar to the present study, other studies have also been performed with purpose of utility of morphometric data in orbital surgeries, like, orbital fracture correction surgery, tumor removal surgery, enophthalmic eye correction surgery, etc.<sup>22</sup>

Nasal septum length (NSL) is of vital importance in plastic/corrective surgeries where complete septal anatomical constituents are essential to be known for successful outcomes. In our study, we observed a mild but statistically significant NSL regression with increasing age. A distinguishable mean difference of 4.17 mm was found between the means of both the youngest and the eldest age group (43.84±3.04 mm to 39.67±3.83 mm). Similar findings were seen in the Korean population, where the mean NSL noted for age range of 18-81 years was close to that in our study.<sup>23</sup>

The nose is a highly aesthetic sensitive area of face and requires keen attention and precision from a surgeon when working on it. It is of vital importance to have a known morphometric data for a population on whom surgical procedure is being performed. Because of the aforesaid reason, a study was carried out among Asian population with age group of 20-80 years. They used CT scans to analyze data and a significant change in hard tissues resulted with increasing age. It was concluded that the result retrieved can be used by maxillofacial surgeons as reference.<sup>24</sup>

The strength of this study relies in the practical applicability of this research in developing population specific prediction models that will be helpful not only in performing craniofacial surgeries

but will also aid in carrying out relevant forensic work in cases of unidentified partial or skeletonized remains. This also holds the potential to carve the pathway for similar studies in other demographics.

## CONCLUSION

The study concludes that as the age increases, there is decrease in facial height, inter-orbital distance and nasal septum length. Furthermore, there is an increase in facial width, right and left orbital heights, right and left orbital widths and bi-orbital distance with advancing age.

## AUTHOR'S CONTRIBUTION

**Ishaat S:** Conceptualization, Methodology, Data collection, Data analysis, Manuscript writing and Review editing

**Borges KJJ:** Conceptualization, Methodology, Manuscript writing and Review editing

**Rehman H:** Conceptualization, Methodology, Data collection

**Urooj T:** Methodology, Manuscript writing and Review editing

**Ali A:** Data analysis, Manuscript writing and Review editing

**Ali MI:** Data analysis, Manuscript writing and Review editing

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