

Facial Index and Zygomatic Arch Dimensions: A Cadaveric Morphometric Study

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ABSTRACT

Objective: To examine whether the facial index is associated with the dimensions of the zygomatic arch, in order to provide reference data for surgical planning.

Methods: Observational morphometric study of 20 adult cadaveric head and neck specimens from voluntary body donors aged 45 to 80 years (40 anatomical sides). The facial index was calculated from facial height (nasion to gnathion) and bizygomatic breadth, measured with vernier calipers. After dissection of the temporal fossa, the length of the zygomatic arch was measured, together with thickness and height of its upper border and its distances to the temporalis muscle and to the temporal bone at three points (anterior, middle and posterior). Right and left sides were compared with paired t-tests. Correlations with the facial index were assessed with Pearson's coefficient, using one bilateral mean per donor.

Results: The mean facial index was 84.87 ± 16.84 (range, 59.26 to 111.00). Mean arch length was 4.490 ± 0.433 cm on the right and 4.495 ± 0.463 cm on the left; no right-left difference was statistically significant. The facial index was not significantly correlated with arch length ($r = 0.137$; 95% confidence interval, -0.326 to 0.546 ; $p = 0.566$), nor with any of the other 12 measurements (all $p > 0.05$).

Conclusion: No statistically significant correlation was detected between facial index and arch measurements in this sample of 20 adults; paired side comparisons were also non-significant. The descriptive findings require confirmation in larger, age-appropriate samples before clinical generalization.

Keywords: Zygoma; Zygomatic Fractures; Cadaver; Face; Anthropometry.

INTRODUCTION

The zygomatic arch is a slender bony bridge on the lateral aspect of the skull, formed by the temporal process of the zygomatic bone and the zygomatic process of the temporal bone.¹ It provides attachment to the temporal fascia and masseter muscle and contributes to facial contour and mastication. The arch is also a target of aesthetic reduction malarplasty, which must be distinguished from fracture treatment.² Facial fractures may occur after road traffic collisions, falls and other trauma; pediatric and adolescent maxillofacial injuries have been documented in clinical series, although the patterns of facial injury are not specific to the arch.³ Zygomatic arch fractures may impair mandibular movement and produce functional or aesthetic deformity.⁴

Operative approaches have been described for aesthetic arch reduction,⁵ while cadaveric research has clarified the regional anatomy of the arch and temporal fossa.⁶ Classification systems have also been proposed for zygomatic arch fracture patterns.⁷ In a computed tomography morphometric study, Kim et al. examined regional arch height and thickness and reported that frequent fracture sites did not coincide with locations of minimum thickness or height.⁸ This finding cautions against inferring fracture susceptibility from isolated linear dimensions alone.

Few investigations have directly tested whether facial index can predict zygomatic arch dimensions. Such an association could potentially contribute to preoperative anatomical assessment, but it has not been established. Accordingly, the present cadaveric study evaluated correlations between facial index and 13 bilateral-average arch measurements in adult donors. Because no adolescents were included, the findings cannot provide adolescent-specific morphometric reference ranges.

METHODS

This observational morphometric study was conducted in the Department of Anatomy, Kasturba Medical College, Manipal, India. Twenty head and neck specimens from voluntary body donors aged 45–80 years from Coastal Karnataka were examined, yielding 20 matched right–left pairs (40 anatomical sides). Donor sex information was unavailable. The Institutional Ethics Committee approved the study (approval no. IEC1–159/2024). The source ethics statement confirms that the bodies were donated for educational and research

purposes; the specimen photographs included in Figure 1 have the eye regions masked. The authors' supplied ethics declaration states that separate consent for publication was not required for this observational study of donated specimens.

Facial height was measured with vernier calipers as the vertical distance from nasion (P) to gnathion (Q), and bizygomatic breadth as the horizontal distance between the right and left zygia (R-S; Figure 1A). Facial index was calculated as (facial height/bizygomatic breadth) $\times$ 100 and is dimensionless. After dissection of the temporal fossa by standard anatomical methods, zygomatic arch length was measured. Thickness and height at the anterior (A), middle (B) and posterior (C) arch regions, together with distances between the arch and the temporalis muscle and temporal bone, were recorded (Figure 1B). Measurements were entered in a standardized proforma. Arch length and facial dimensions were recorded in centimetres. The source documents contain conflicting unit labels for the remaining arch measures; therefore, these are retained as recorded values pending verification against the measurement records.

Statistical analyses were performed using Python version 3.12.3. Means and standard deviations summarized the 20 donors. Right and left sides were compared within donors using two-sided paired t-tests. To avoid treating bilateral observations as independent, each arch measurement was averaged across sides before calculating its Pearson correlation with facial index (13 correlations). The 95% confidence interval for the arch-length correlation was calculated by Fisher's z transformation; Spearman's rank correlation for arch length was an additional sensitivity analysis. All p-values were two-sided, without adjustment for multiple testing; $p < 0.05$ was the nominal significance threshold.



Figure 1. (A) Facial-index landmarks: nasion–gnathion height (PQ) and right–left bizygomatic breadth (RS). Eye regions are masked in the donor photograph. (B) Dissected temporal fossa illustrating anterior (A), middle (B) and posterior (C) arch landmarks, and the temporalis muscle. Orientation: S, superior; I, inferior; A, anterior; P, posterior.

RESULTS

Twenty specimens were analyzed (40 sides; donor age range, 45 to 80 years). There were no missing values for the facial measurements or for the 13 bilateral anatomical variables. Mean facial height was 10.14 ± 0.61 cm, mean bizygomatic breadth was 12.35 ± 2.24 cm, and the mean facial index was 84.87 ± 16.84 (range, 59.26 to 111.00).

Mean zygomatic arch length was 4.490 ± 0.433 cm on the right and 4.495 ± 0.463 cm on the left (mean paired difference, -0.005 cm; paired $p = 0.804$). Tables 1 and 2 present all bilateral measurements. None of the 13 paired right–left comparisons reached the nominal significance threshold (all $p > 0.05$). This does not establish anatomical equivalence. Values for thickness, height and adjacent-structure distances are given on the original recorded numerical scale; the measurement units have not been independently verified.

Table 1. Zygomatic arch length, regional thickness and height in 20 adult cadaveric specimens (mean $\pm$ SD).

Measurement	Location	Right: mean $\pm$ SD	Left: mean $\pm$ SD	Paired p-value ^t
Length of zygomatic arch (cm)	Whole arch	4.49 ± 0.4327	4.495 ± 0.4628	0.804
Thickness (unit to be confirmed)	A	0.43 ± 0.2179	0.4375 ± 0.2378	0.481
Thickness (unit to be confirmed)	B	0.275 ± 0.0851	0.265 ± 0.0933	0.541
Thickness (unit to be confirmed)	C	0.2 ± 0.0725	0.195 ± 0.0394	0.748
Height (unit to be confirmed)	A	1.485 ± 0.2159	1.505 ± 0.2188	0.681
Height (unit to be confirmed)	B	0.91 ± 0.2382	0.905 ± 0.2259	0.772
Height (unit to be confirmed)	C	1.125 ± 0.2653	1.105 ± 0.2625	0.163

A, anterior; B, middle; C, posterior; SD, standard deviation. †Two-sided paired t-test of 20 donor pairs. Values for thickness and height are shown in their recorded numerical scale; the original documentation gives inconsistent physical units, which require verification before submission.

Table 2. Distances from the zygomatic arch to adjacent anatomical structures in 20 adult cadaveric specimens (mean $\pm$ SD).

Measurement	Location	Right: mean $\pm$ SD	Left: mean $\pm$ SD	Paired p-value†
Arch to temporalis muscle (unit to be confirmed)	A	1.005 $\pm$ 0.0510	1.02 $\pm$ 0.0616	0.083
Arch to temporalis muscle (unit to be confirmed)	B	0.83 $\pm$ 0.0733	0.83 $\pm$ 0.0657	1.000
Arch to temporalis muscle (unit to be confirmed)	C	0.575 $\pm$ 0.1803	0.575 $\pm$ 0.1803	1.000
Arch to temporal bone (unit to be confirmed)	A	1.83 $\pm$ 0.1559	1.82 $\pm$ 0.1542	0.428
Arch to temporal bone (unit to be confirmed)	B	1.63 $\pm$ 0.1525	1.625 $\pm$ 0.1997	0.804
Arch to temporal bone (unit to be confirmed)	C	1.14 $\pm$ 0.1957	1.15 $\pm$ 0.1762	0.577

A, anterior; B, middle; C, posterior; SD, standard deviation. †Two-sided paired t-test of 20 donor pairs. Physical units of these recorded distance values must be verified before submission. Facial index showed a weak, non-significant correlation with bilateral mean zygomatic arch length (Pearson $r = 0.137$; 95% CI, -0.326 to 0.546 ; $p = 0.566$; Figure 2). The Spearman sensitivity analysis was also non-significant ($p = 0.099$; $p = 0.677$). None of the other 12 bilateral-average measurements correlated significantly with facial index (Table 3; all $p > 0.05$). The strong right-left correlation for length ($r = 0.983$) measures within-donor similarity between sides; it must not be interpreted as a correlation between arch length and facial index.

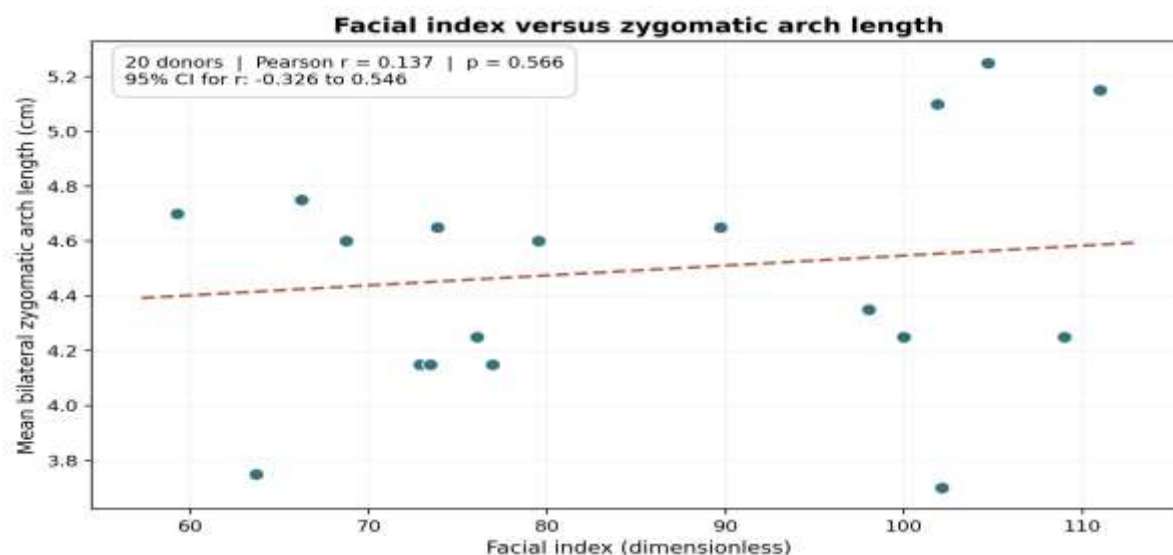


Figure 2. Facial index and mean bilateral zygomatic arch length across 20 adult donors. Each point represents one donor; the dashed line is a least-squares trend. Pearson $r = 0.137$ (95% CI, -0.326 to 0.546); two-sided $p = 0.566$. The relationship was not statistically significant.

Table 3. Pearson correlations of facial index with donor-level bilateral-average zygomatic arch dimensions (n = 20).

Morphometric variable	Pearson r	p-value (two-sided)	n (donors)
Arch length	+0.137	0.566	20
Thickness A	-0.389	0.090	20

Morphometric variable	Pearson r	p-value (two-sided)	n (donors)
Thickness B	-0.081	0.733	20
Thickness C	+0.404	0.078	20
Arch height A	+0.298	0.202	20
Arch height B	+0.124	0.602	20
Arch height C	+0.345	0.137	20
Arch-temporalis A	-0.203	0.391	20
Arch-temporalis B	-0.262	0.265	20
Arch-temporalis C	+0.249	0.289	20
Arch-temporal bone A	+0.263	0.262	20
Arch-temporal bone B	+0.277	0.236	20
Arch-temporal bone C	-0.401	0.079	20

A, anterior; B, middle; C, posterior. Each donor contributes one bilateral average to each correlation. All p-values are two-sided and unadjusted for multiple testing; no p-value was below 0.05.

DISCUSSION

The principal finding was the absence of a statistically significant association between facial index and any measured zygomatic arch dimension in these 20 adult cadaveric specimens. For mean arch length, the point estimate was small ($r = 0.137$), but the confidence interval (-0.326 to 0.546) remained wide; consequently, clinically meaningful associations cannot be excluded. The additional 12 comparisons were exploratory and unadjusted for multiple testing. Results with p-values near 0.05 should not be treated as evidence of an association, and the present data do not validate facial index as a predictor of arch dimensions.

The zygomatic arch forms part of the midfacial bony framework and provides a functional relationship to the masseter and temporalis regions.^{1,4} Mean right and left arch lengths differed by 0.005 cm, with strong within-donor correlation ($r = 0.983$). These observations are compatible with similar average dimensions on both sides, but a non-significant paired test does not prove individual symmetry or interchangeability. In some unilateral injuries the unaffected side may assist clinical planning; its suitability as a reference should be evaluated individually rather than assumed from this small series.

Anatomical findings may be considered alongside earlier work. Song et al. examined 37 male and 33 female cadavers, assessed the arch at anterior, middle and posterior landmarks, and found an approximately 8-mm arch-to-temporalis clearance anteriorly and centrally, with a slightly smaller posterior clearance.⁶ Our recorded arch-to-temporalis values also decreased posteriorly, but a quantitative comparison is inappropriate until measurement units are confirmed. In addition, reference definitions of the arch-to-temporal bone measurement may differ between studies. Kim et al. used computed tomography in 51 adults with unilateral isolated arch fractures and showed that common fracture sites did not correspond to the thinnest or shortest regions; their results emphasize the need to consider three-dimensional anatomy when planning fixation.⁸ Zhang et al. documented sex-related variation in dry-skull zygomatic morphology,⁹ a factor we could not evaluate because donor sex was unavailable.

From a clinical perspective, closed reduction by temporal (Gillies) or intraoral (Keen) access is used for suitable, particularly simple, zygomatic arch fractures.^{10,11} Complex or unstable patterns may require other measures, including open treatment; however, Yoon et al. described successful reduction of selected unstable fractures with a percutaneous K-wire and a Dingman elevator through Keen's approach, without an open incision.¹¹ Surgical selection therefore depends on fracture morphology and stability rather than a single anatomical dimension. Descriptive arch measurements may inform anatomical orientation, but our results do not support replacing individual examination or imaging with facial-index-based estimates. Clinical maxillofacial injuries also occur in adolescents,³ yet all donors in the present series were adults; no age-specific inference for adolescents is justified.

LIMITATIONS AND FURTHER SCOPE

The small sample (20 donors) limited precision and power, and the 13 exploratory correlations were not multiplicity-adjusted. Donor sex was unavailable, preventing sex-stratified analysis. The specimens came from a single geographical region and were aged 45–80 years, so adolescent facial morphology cannot be inferred from these results. The original measurement records must be checked to resolve inconsistently labelled units for arch thickness, height and distances. Measurement reproducibility and preservation-related effects were not reported. These limitations preclude using the values as definitive clinical norms.

CONCLUSION

In this sample of 20 adult cadaveric specimens, no statistically significant correlations were detected between facial index and zygomatic arch measurements, and no significant paired right–left differences were observed. The results offer preliminary descriptive observations rather than validated predictive or age-specific reference values. Larger studies with verified units, documented sex, reproducibility assessments and age-appropriate samples are required before clinical application.

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