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FORENSIC AGE ESTIMATION IN CHILDREN USING CORONOID PROCESS OF MANDIBLE FROM DENTAL PANORAMIC TOMOGRAPHY: A GEOMETRIC MORPHOMETRIC STUDY

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ABSTRACT

Age estimation in children is crucial for forensic identification. The mandible coronoid process is the site of attachment of the temporal muscle and is one of the parts that has changed during development, making it a potential landmark for age estimation. This study aimed to determine the morphological differences between children in the coronoid process of the mandible. A total of 305 dental panoramic tomography (DPT) images were divided into two age groups: Group 1 (3–7 years) and Group 2 (8–12 years). Six landmarks of coronoid process of mandible were applied to the DPT using the TPSDig2 software. The coordinate was exported to MorphoJ for geometric morphometric analysis. The general procrustes analysis (GPA), Principal component analysis (PCA), Procrustes ANOVA, and Discriminant function analysis (DFA) was performed. The first five PCs represented 86% of total shape variation, with PC1 contributing the highest proportion (38%), followed by PC2 (20%) and PC3 (12.23%). Procrustes ANOVA demonstrated significant differences in centroid size and shape between groups ($p < 0.05$). DFA achieved 73% correct classification and 64% after cross validation. Wireframe visualization revealed a higher coronoid tip in Group 2 compared to Group 1, indicating mandibular growth with age. Coronoid process morphology demonstrates significant age-related changes and can serve as a useful supplementary marker for forensic age estimation in children. Geometric morphometric analysis provides a reliable and objective framework for quantifying mandibular growth.

Introduction

Age estimation is important biological profile in identification of unknown remains, forensic case and clinical cases (Ubelaker & Khosrowshahi, 2019). The crucial case is when juvenile cases involve when the age will affect the legal proceedings and outcome (Fitzgerald, 2023). In mass disaster, especially when all the soft tissue has been decomposed, the only left is the bone. The bone or skeletal remains are one of the structures that help in the identification of human remains (Marrone et al., 2022). There are 206 bones in our body. Each of the bones has their own characteristics that are different from each other (Alias et al., 2018).

The mandible is the strongest bone on the skull and is important for forensic age due to their significant morphological changes during growth (Shepherd et al., 2024). The mandible coronoid process is one of the parts of the mandible that involves the mastication attachment muscle and bone remodelling. The coronoid process changes actively during growth. It makes coronoid processes one of the valuable parts that help in age estimation other than the teeth itself (Shujaat et al., 2023).

Geometric morphometric analysis is a powerful analysis that measures not only size but also visualisation of bone variation. It started with a landmark application that preserves geometric biological structures. By combining Procrustes superimposition, principal component analysis, and discriminant function analysis, this method allows for morphological differences and variation. Recent advances in morphometric software, such as TPSDig2 and MorphoJ, have made this technique increasingly accessible in forensic anthropology and dental research (Clark et al., 2016).

Dental panoramic tomography (DPT) is a 2D radiograph that captures the entire mouth, including all teeth, the upper and lower jaws, the temporomandibular joints (TMJ), and the nasal area. It is used to diagnose and plan treatments for a variety of conditions, such as impacted or wisdom teeth, cysts, tumours, jaw fractures, and orthodontic treatment. DPT has the advantages of low dose radiation and is cheaper than 3D radiographs and can capture the whole structure of the mandible (Suomalainen et al., 2015).

Due to the significant morphology and the significant coronoid in forensic cases, this study aims to determine the differences shaped variation of coronoid of mandible in children by using geometric morphometric analysis on DPT images. This research investigates the potential marker of the coronoid process that can differentiate between early and late childhood. This finding can contribute to age estimation in cases of forensic anthropology and odontology in the future.

Methodology

A total of 305 dental panoramic tomographs (DPTs) of paediatric patients were retrospectively collected from the Dental Clinic, Faculty of Dentistry, Universiti Sains Islam Malaysia. The sample was divided into two age groups: Group 1: 3-7 years (early childhood) and Group 2: 8–12 years (late childhood). This ethics approval was obtained from the Research Ethics Committee, Universiti Sains Islam Malaysia, with the ethics number USIM/JKEP/2024-299. A good-quality DPT, absence of mandible pathology; Malaysian and patient age between 3 and 12-years were included. The low-resolution or distorted radiographs; presence of pathology affecting mandibular morphology; non-Malaysian and patient age more than 12 were excluded.

Landmark Selection and Digitisation

A total of six anatomical landmarks were identified in each hemimandible corresponding to anatomically stable and reproducible points along the coronoid process and mandibular ramus. The landmarks were selected based on previous studies on mandibular morphology and paediatric craniofacial growth (Alias et al., 2018, 2020; Franklin et al., 2008; Popa & Corici, 2009).

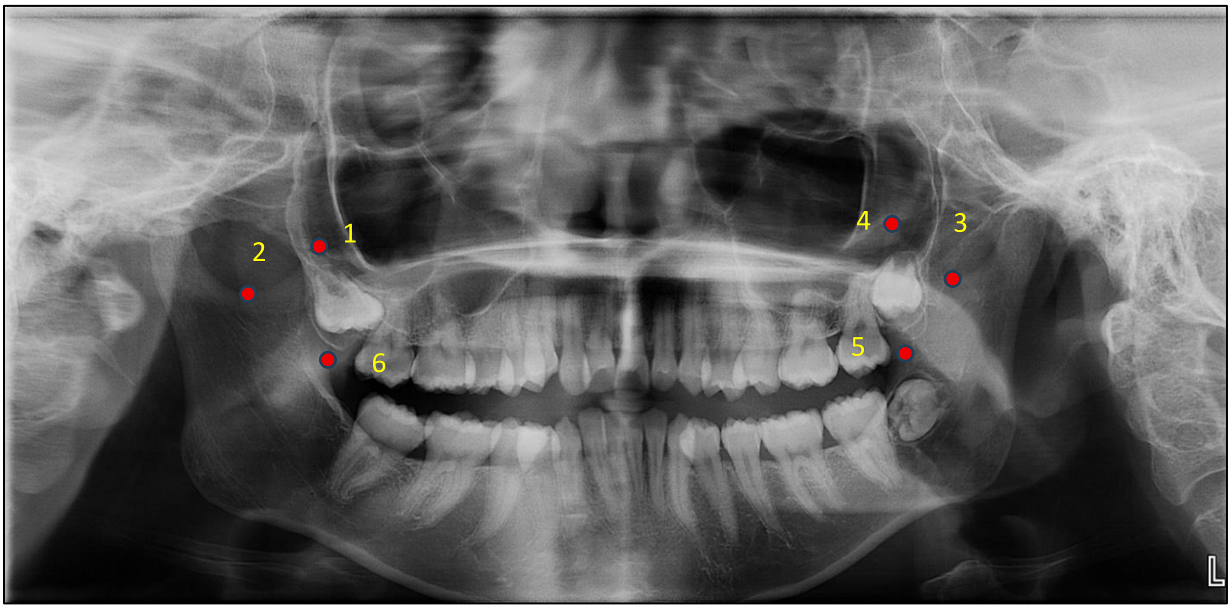

Figure 1. Landmarks of the mandible coronoid process on DPT

Table 1. Definition and number of landmarks in the mandible of DPT

Number	Landmark	Definition
1	Coronion (Co)	The most superior point in the coronoid process (right)
2	Mandibular notch (Mn)	The lowest point on the mandibular notch (right)
3	Mandibular notch (Mn)	The lowest point on the mandibular notch (left)
4	Coronion (Co)	The most superior point in the coronoid process (left)
5	Anterior ramus (Ar)	The deepest part of the anterior ramus (left)
6	Anterior ramus (Ar)	The deepest part of the anterior ramus (right)

All landmarks were digitised using TPSDig2 on DPT images. Each image was calibrated prior to digitisation to minimise measurement error. To ensure intra-observer reliability, 10% of the sample was randomly re-digitized after a two-week interval. The intra-class correlation coefficient (ICC) was calculated, and only values above 0.90 were accepted.

Geometric Morphometric Analysis

The coordinate data were exported into MorphoJ (Klingenberg, 2011) for geometric morphometric analysis. The coordinates of the TPSdig2 software were exported to the MoprhoJ software in TPS coordinate format for geometric morphometric analysis. In MorphoJ software, Generalised Procrustes Analysis (GPA) was performed to remove non-shape variation (translation, rotation, and scaling). Principal component analysis (PCA) was then conducted to summarize and visualize the major shape variation within the groups. The procrustes ANOVA was performed to assess size and shape of different group. The Discriminant function analysis (DFA) and cross validation were performed to see the percentage accuracy of age estimation of the different groups. The wireframe diagrams were generated to visualize the morphological differences between the mean shapes of the two age groups.

Results and Discussion

Results

During GPA, non-shaped variations (translation, rotation, and size) were removed. The blue dots represent the mean landmark positions, while the black dots represent the landmark for an individual sample. The landmark numbers are indicated by red numbers (Figure 2).

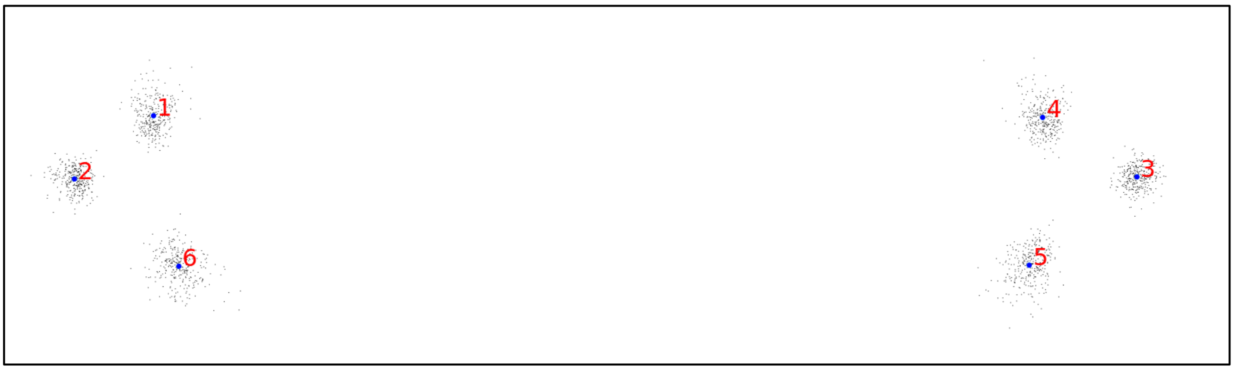

Figure 2. Generalised Procrustes Analysis (GPA) of the coronoid process

The principal component analysis (PCA) represents the shape of the coronoid process and its variation. In this study, there were 8 shape variations of the coronoid process that represent 100% of the shape. PC1 contributed 37.73% of the total variance in the sample, followed by 20% by PC2 and 12.2% of PC3 (Table 2). The percent variance represents the percentage of variance represented in the corresponding principal component, while the cumulative percentage represents the amount of variance accounted for in the corresponding principal component and all the ones preceding it (Table 2).

Table 2. The 8 principal component analysis with the eigenvalues

PC number	Eigenvalues	% Variance	Cumulative %
1.	0.00063	37.727	37.727
2.	0.00034	20.406	58.133
3.	0.00020	12.213	70.345
4.	0.00014	8.650	78.995
5.	0.00012	7.318	86.313
6.	0.00010	6.008	92.320
7.	0.000070	4.198	96.518
8.	0.000058	3.482	100.000

PC1 explains the largest proportion of shape variation in the dataset, followed by PC2. Red (G1) points cluster more toward the center of the plot, indicating less shape variability among younger children (3–7 years old). Blue (G2) points are slightly more spread out along PC1, suggesting more shape variability or morphological development in older children (8–12 years old). Each ellipse represents the 95% confidence interval of the distribution for each group. The blue ellipse appears slightly larger, indicating greater shape variance in Group 2. The overlap between the red and blue ellipses shows that while there is shape variation with age, the two groups are not completely separated, which is common in biological growth patterns (Figure 3).

Wireframe show the overall shape variation of the coronoid of mandible on PC1, PC2 and PC3. PC1 is the largest pattern shape variation in the dataset. The changes are observed at coronion (landmark 1 & 4) and mandibular notch (landmark 2 and 3). The coronoid process shifts upward as indication of vertical growth. The mandibular notch moves inferiorly and slightly posteriorly. The anterior ramus of mandible (Landmarks 5 & 6) shows a mild lateral and anterior displacement. PC1 likely reflects overall vertical ramus elongation and increased coronoid height. This is consistent with age-related growth of the mandible between 3–12 years, where the ramus height increases as part of normal craniofacial development. PC1 represents superior–inferior growth of the ramus and coronoid, explaining the largest proportion of shape variance. The light blue coronion is higher, it indicates taller ramus height and more developed coronoid, usually seen in the older age group.

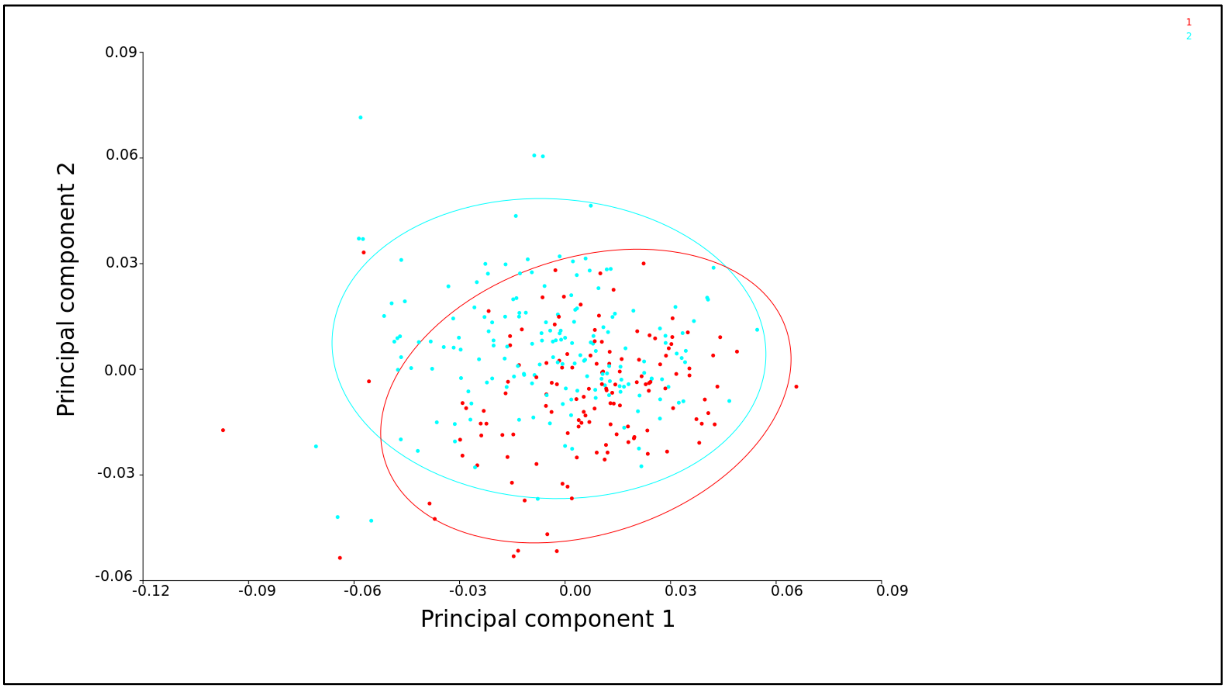

Figure 3. The principal component graph PC1 (x-axis) and PC2 (y-axis) with cluster of younger children (group 1 (red) and older children (group 2(blue))

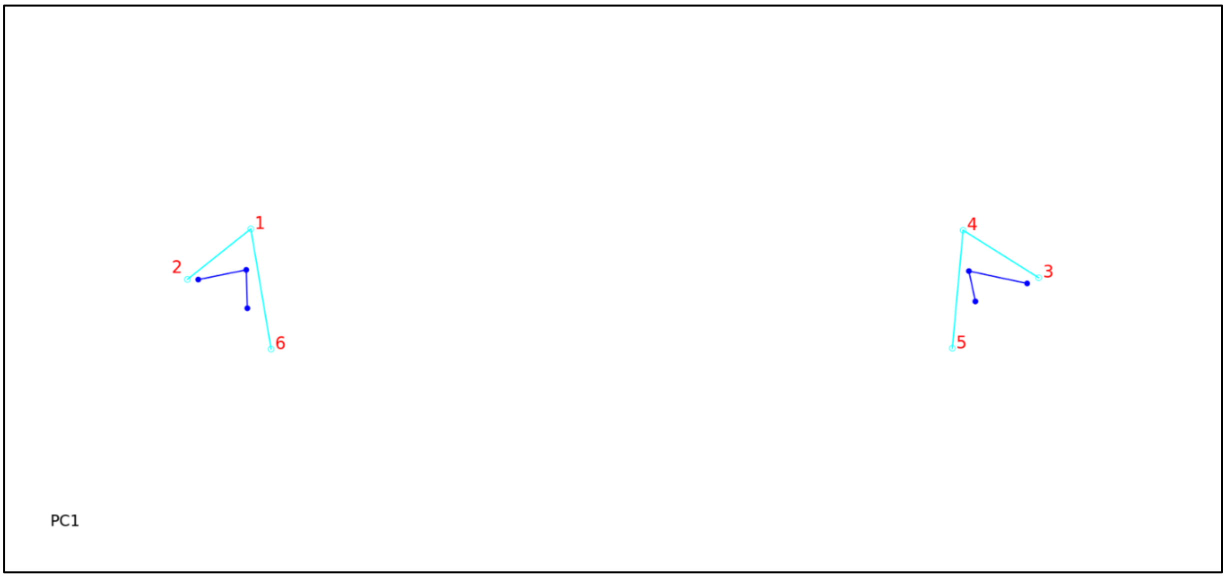

Figure 4. The wireframe of shape changes in PC1

PC2 captures the second largest pattern of shape variation in the dataset. In this mandibular study, PC2 mainly affects the orientation and anteroposterior positioning of the ramus and mandibular notch. Notable displacement at Mandibular notch (Landmarks 2 & 3) — more anteroposterior movement compared to PC1. Coronion shows slight medial or lateral displacement rather than vertical elongation. Anterior ramus points are more anteriorly rotated, indicating changes in ramus inclination. PC2 appears to represent anteroposterior remodelling of the ramus, with subtle changes in ramus inclination or orientation rather than size. This may reflect functional adaptation (e.g., masticatory muscle activity) during growth. PC2 reflects positional changes and rotation of the ramus, especially at the mandibular notch. This (light blue) positive PC2 shape represents a more anteriorly positioned and inclined ramus, typically seen in older children (8–12 years) as growth advances (Figure 5).

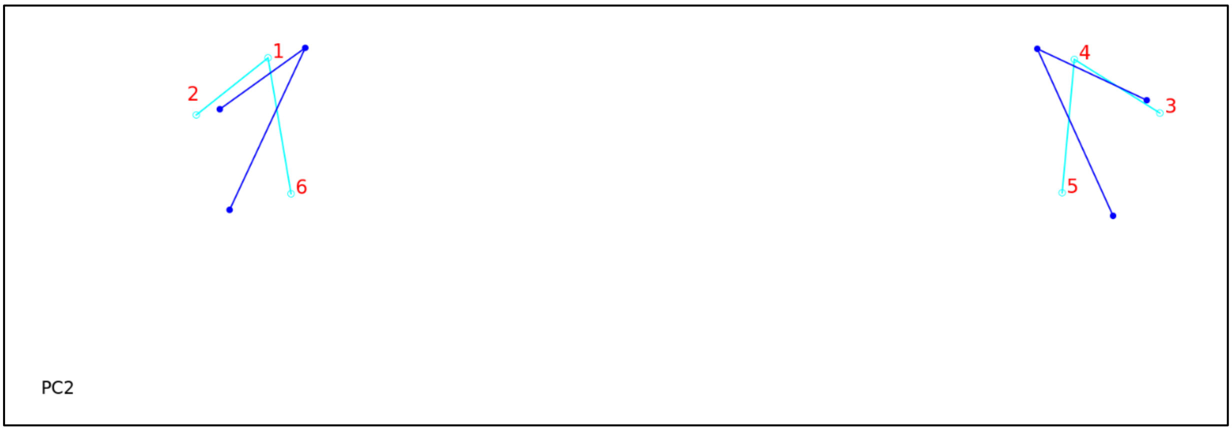

Figure 5. The wireframe of shape changes in PC2

PC3 represents subtle morphological differences — usually individual variation or minor growth-related changes — rather than the major developmental trends seen in PC1 (vertical growth) or PC2 (anterior-posterior remodeling). Smaller magnitude of displacement compared to PC1 and PC2.The anterior ramus (Landmarks 5 & 6) shows a transverse (mediolateral) displacement. Coronion and mandibular notch move slightly outward, indicating broadening of the upper ramus. Biological interpretation PC3 likely represents transverse widening or subtle asymmetrical variations of the ramus region. This could correspond to individual variation rather than dominant age effects. PC3 captures minor transverse and asymmetrical variation, often reflecting individual growth differences. The light blue reflects a wider and more laterally developed ramus, possibly indicating normal lateral growth or individual anatomical variation at older ages (Figure 6).

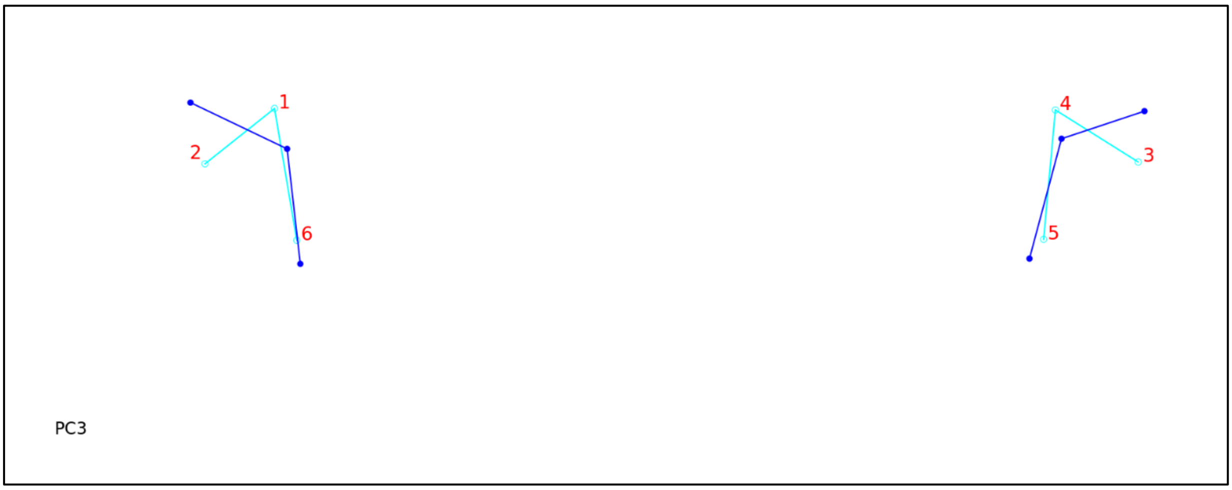

Figure 6. The wireframe of shape changes in PC3

Discriminant Function Test

Discriminant Function Analysis is a statistical method used to determine how well shaped variables correctly classify individuals into predefined groups Group 1 = Age 3 to 7 years and Group 2 = Age 8 to 12 years. In Group 1 there were 74% correctly classified into their true age group While, Group 2 specimens were correctly classified (65%). The cross validation was done Group 1: Accuracy slightly decreased from 74% → 72%. While Group 2: Accuracy slightly decreased from 65% → 63%. Overall, this indicates moderate to good discrimination between the two age groups. The DFA results indicate that shape data can correctly classify individuals by age group with reasonable accuracy. The slightly higher accuracy in Group 1 reflects more distinct mandibular morphology in early childhood. Overlap between the groups, especially in Group 2, suggests that individual variation increases with age, making classification more challenging. These findings align with biological expectations, younger children show more homogeneous shape patterns, while older children display greater morphological variability (refer to Table 3).

Table 3. The discriminant function analysis and cross validation of the age group

Group	Group 1	Group 2	Total	Percentage
Discriminant function analysis				
Group 1	**98**	**35**	**133**	**74%**
Group 2	**61**	**111**	**172**	**65%**
Cross validation				
Group 1	**96**	**37**	**133**	**72%**
Group 2	**64**	**108**	**172**	**63%**

Procrustes ANOVA

Procrustes ANOVA is a statistical test used in geometric morphometrics to examine whether shape and size differences between groups (or individuals) are statistically significant compared to the residual variation (error). Centroid Size ANOVA tests for differences in size. Shape Procrustes ANOVA tests for differences in shape after removing effects of translation, rotation, and scaling. $F = 36.1$, $p < 0.0001$ indicates a highly significant difference in centroid size between the two groups (younger and older children). This means the ramus region of the mandible is significantly larger in one group, most likely the 8–12 years group, reflecting expected age-related growth. High F-value also shows that between-group variation is much larger than within-group variation. Mandibular size increases significantly with age, consistent with normal craniofacial development. $F = 14.21$, $p < 0.0001$ indicates a highly significant difference in shape between the two age groups.

The low MS for residuals (0.0002) compared to MS for individual (0.0028) shows that most of the variation in shape is attributable to group differences rather than random error. This aligns with the PCA and DFA results, where Group 2 (older) displayed more elongated and anteriorly inclined ramus morphology. The mandibular shape changes significantly with age, particularly vertical elongation of the coronoid process and widening of the ramus.

Table 4. Centroid size and procrustes ANOVA of shape analysis

Centroid Size	**SS**	**MS**	**df**	**F**	**P**
individual	433975.65	433975.65	1	36.1	<0.0001
Residual	3642798.01	12022.44	303		
Shape, Procrustes ANOVA	**SS**	**MS**	**df**	**F**	**P**
Individual	0.023	0.0028	8	14.21	<0.0001
Residual	0.485	0.0002	2424		

Discussion

This study showed that coronoid process of mandible can be used for age estimation in children. The geometric morphometric analysis revealed that there are 8 variations of shape on coronoid process of mandible that showed in principal component analysis. Procrustes ANOVA and discriminant function analysis also showed that significant differences between age group in children. The wireframe also showed obvious shape changes especially at area of tips of coronoid process. Visualisation of wireframe showed that tips of coronoid process in group 2 higher than group 1.

This reflects the growth of coronoid process and ramus of mandible elongated accommodation by the mastication function and temporalis activity (He et al., 2025). The endochondral ossification during childhood contributes to vertical mandibular growth. This pattern suggests that the primary shape variation is associated with vertical and horizontal growth of mandibular (Galea et al., 2021). This study is supported by previous studies that PC1 typically reflects major growth-related transformations, such as increased height of the coronoid process and remodeling of the mandibular ramus (Liu et al., 2010).

The significant Procrustes ANOVA values for both centroid size ($F = 36.1$) and shape ($F = 14.21$) indicate that both size and shape vary significantly between the age groups ($p < 0.05$). This suggests that growth involves changes in size and shape. This finding is supported by previous study that emphasizes that shape and size changes happen during increasing age in children in this study, the discriminant function analysis showed 73% correct classification rate with 64% accuracy after cross validation. Although cross validated is lower, it remains an insight for forensic field as it will be used as supplementary method beside dental and other skeletal elements (Sullivan et al., 2022).

The coronoid process of mandible is for the attachment of muscle of mastication which is masseter and temporalis. Both muscles are involved in elevation and retraction of lower jaw and are important for biting. The variations in the shape and size of the coronoid process are useful in anthropological studies for race detection and forensic investigations. These variations can provide insights into population-specific anatomical differences. The coronoid process has evolutionary significance in the population that affects the changing of eating food (Veerraju et al., 2025)

The coronoid process of mandible has different shapes including triangular, hook-shaped, and round shape. These shapes can vary by sex, side of the mandible and age group (Subbaramaiah et al., 2015). The highest percentage of coronoid processes are triangular shapes, followed by hook-shape and lastly round shape (Pessa et al., 2008). In age estimation from the mandible study showed that the younger individuals tend to have more triangular shapes, while older individuals may exhibit more rounded or hook-shaped processes (Alias et al., 2018). The study in Malaysia and German shows the younger individuals showing more triangular than eldest. There also study on sex on coronoid process of mandible. The females have triangular shape of mandible, while male exhibit more rounded. These differences can aid in sex determination alongside age estimation (Ariessa et al., 2023; Dudde et al., 2025)

The coronoid process of the mandible can be accessed via 2D and 3D imaging modalities. Orthopantomograph (OPG) is the 2D radiograph that is commonly used in dental routine for the diagnostic of the patient. OPG can visualize most of the structure of the upper and lower jaw, the teeth, temporomandibular bone, the sinuses and other bone on skull (Ohite et al., 2011). While 3D radiographs like cone beam computed tomography (CBCT) usually can accurately measure the mandible offering details in three-dimensional image. However, CBCT needs causes more radiation and more expensive than OPG (He et al., 2025).

Geometric morphometric analysis (GMM) has many advantages. It is advanced shape analysis by using advanced statistical software on the landmark of the mandible. It not only shows the shape changes but also shape variation in the population. It's also covered the size and shape analysis that can explain thorough shape of the structure study. However, the complexity of the analysis need specialized software and higher-level technical expertise in accurately putting the landmark and analysis (Ariessa et al., 2023; Kimmerle et al., 2008). In traditional method, the measurement involved simple techniques in measure the structure of mandible. It lacks detail shape complexity measurement of the structure of mandible. However, it can provide basic analysis for the clinical and education purposes (Popa & Corici, 2009; Subbaramaiah et al., 2015). GMM has shown promising results in age estimation in children mandible. GMM also can identify shape changes in various age groups. GMM highlights as non-invasive method for age estimation and suitable for forensic cases. It allows visualization of shape changes which can aid in forensic odontology identification.

Conclusion

In conclusion, geometric morphometric analysis is an option tool for estimating the age of the children mandible. The focus on the coronoid process of the mandible is given another option than teeth in age estimation of the children. In the future, the integration of using artificial intelligence (AI) needs to be used in thousands of data sets for a more accurate result in age estimation.

References

Alias, A., Ibrahim, A., Noorain, S., Bakar, A., Shafie, M. S., & Das, S. (2018). Anthropometric analysis of mandible: An important step for sex determination. *Clinica Terapeutica*, *169*(5), e218–e223. https://doi.org/10.7417/CT.2018.2082

Alias, A., Nasser, A., Ibrahim, M., Noorain, S., Bakar, A., & Rokhani, F. (2020). Morphometric analysis of coronoid process of mandible by CT in the Malaysian population: An important step for determination of sex. *Journal of Anthropology*, *1*(1), 1–8.

Ariessa, N., Zulkifli, F., Aliya, N., Mohd, S., Alias, A., Ibrahim, N. M., Fitri, B., & Roosyanto, W. (2023). Age estimation from mandibles in Malay: A 2D geometric morphometric analysis. *Journal of Taibah University Medical Sciences*, *18*(6), 1435–1445. https://doi.org/10.1016/j.jtumed.2023.05.020

Clark, M. A., Guatelli-Steinberg, D., Hubbe, M., & Stout, S. (2016). Quantification of maxillary dental arcade curvature and the estimation of biological ancestry in forensic anthropology. *Journal of Forensic Sciences*, *61*(1), 141–146. https://doi.org/10.1111/1556-4029.12910

Dudde, F., Giese, M., Schuck, O., Duda, S., & Krüger, C. (2025). Panoramic radiographic analysis of age- and sex-related variations in upper mandibular morphology: Focus on the condyle, sigmoid notch, and coronoid process. *In Vivo*, *39*(317), 311–317. https://doi.org/10.21873/invivo.13829

Fitzgerald, E. (2023). Put the juvenile back in juvenile court. *Villanova Law Review*, *68*(3), 1–39. https://digitalcommons.law.villanova.edu/vlr/vol68/iss3/1

Franklin, D., Cardini, A. A., Higgins, P. O., Oxnard, C. E., & Dadour, I. (2008). Mandibular morphology as an indicator of human subadult age: Geometric morphometric approaches. *Forensic Science, Medicine, and Pathology*, 91–99. https://doi.org/10.1007/s12024-007-9015-7

Galea, G. L., Zein, M. R., Allen, S., & Francis-West, P. (2021). Making and shaping endochondral and intramembranous bones. *Developmental Dynamics*, *250*, 414–449. https://doi.org/10.1002/dvdy.278

He, S., Gu, D., Jiang, C., Yi, Y., Su, X., Fan, Z., Min, L., & Yang, X. (2025). Three-dimensional measurement of the coronoid process and structural consistency analysis in patients with long-face morphology. *BMC Oral Health*, *25*(1456), 1–11. https://doi.org/10.1186/s12903-025-06845-y

Kimmerle, E. H., Ross, A., & Slice, D. (2008). Sexual dimorphism in America: Geometric morphometric analysis of the craniofacial region. *Journal of Forensic Sciences*, *53*(1), 54–57. https://doi.org/10.1111/j.1556-4029.2007.00627.x

Liu, Y., Behrents, R. G., & Buschang, P. H. (2010). Mandibular growth, remodeling, and maturation during infancy and early childhood. *Angle Orthodontist*, *80*(1), 97–105. https://doi.org/10.2139/020309-67.1

Marrone, M., Tarantino, F., Stellacci, A., Baldassarra, S. L., Cazzato, G., Vinci, F., & Erba, A. D. (2022). Forensic analysis and identification processes in mass disasters: Explosion of gunpowder in the fireworks factory. *Molecules*, *27*(1), 1–10. https://doi.org/10.3390/molecules27010244

Ohite, D. P. M., Haudhary, M. S. C., & Ohite, P. M. M. (2011). Age assessment from mandible: Comparison of radiographic and histologic methods. *Journal of Clinical and Diagnostic Research*, *52*(2), 659–668. *(Tiada DOI)*

Pessa, J. E., Slice, D. E., Hanz, K. R., Broadbent, T. H., & Rohrich, R. J. (2008). Aging and the shape of the mandible. *Plastic and Reconstructive Surgery*, *121*(1), 196–200. https://doi.org/10.1097/01.prs.0000293864.94138.ae

Popa, F. M., & Corici, P. (2009). Forensic value of mandibular anthropometry in gender and age estimation. *Romanian Journal of Legal Medicine*, *17*(2), 45–50.

Shepherd, S., McGregor, S., Abualhija, D., & Julieta, G. (2024). Biological profiling using the human mandible. *Journal of Oral Biosciences*, *66*, 5–12. https://doi.org/10.1016/j.job.2023.11.006

Shujaat, S., Politis, C., Van Den Bogaert, T., Vueghs, P., Smeets, M., Verhelst, P. J., Grymonprez, E., & Jacobs, R. (2023). Morphological characteristics of coronoid process and revisiting definition of coronoid hyperplasia. *Scientific Reports*, *13*(21049), 1–9. https://doi.org/10.1038/s41598-023-46289-4

Subbaramaiah, M., Bajpe, R., & Jayanthi, S. R. J. K. S. (2015). A study of various forms of mandibular coronoid process in determination of sex. *Journal of Clinical and Diagnostic Research*, *2*(4), 199–203. https://doi.org/10.5958/2394-2126.2015.00020.1

Sullivan, E. O., Van De Lande, L. S., El, K., Koudstaal, M. J., Schievano, S., Khonsari, R. H., & Dunaway, D. J. (2022). Growth patterns and shape development of the paediatric mandible – A 3D statistical model. *Bone Reports*, *16*, 101528. https://doi.org/10.1016/j.bonr.2022.101528

Suomalainen, A., Esmaeili, E. P., & Robinson, S. (2015). Dentomaxillofacial imaging with panoramic views and cone beam CT. *Insights into Imaging*, *6*, 1–16. https://doi.org/10.1007/s13244-014-0379-4

Ubelaker, D. H., & Khosrowshahi, H. (2019). Estimation of age in forensic anthropology: Historical perspective and recent methodological advances. *Forensic Sciences Research*, *4*(1), 1–9. https://doi.org/10.1080/20961790.2018.1549711

Veerraju, A. N. V. V., Deepika, K., & Sailaja, G. (2025). Morphometric study of the coronoid process of the mandible in population of East Godavari District, Andhra Pradesh. *European Journal of Cardiovascular Medicine*, *15*(2), 211–214. https://www.healthcare-bulletin.co.uk/