ORIGINAL ARTICLE

Reveal the concealed – Morphological variations of the coronoid process, condyle and sigmoid notch in personal identification

CrossMark

Dathar Sahithi *, Sudhakara Reddy, D.V. Divya Teja, Jyothirmai Koneru, Kotu Nagavenkata Sai Praveen, R. Sruthi

Department of Oral Medicine and Radiology, Vishnu Dental College, India

Abstract: *Objective of the study:* The study was conducted to evaluate different morphological variations of the coronoid process, the condyle and the sigmoid notch using panoramic radiographs for personal identification.

Materials and methods: The study was carried out using 200 digital orthopantomographs (OPGs) comprised of both sexes; and the different shapes of the coronoid process, condyle and the sigmoid notch were traced on projection sheets for both the right and left sides and the data obtained were subjected to statistical analysis.

Results: The current study has illustrated various morphological shapes of the three selected entities and the most common shape of the coronoid process was observed to be triangular and that of sigmoid notch was the wider form. Whereas the condylar shape commonly observed among the males and females were angled and round shapes respectively. These variations when compared on both the sides had shown no statistical significance.

Conclusion: The present study has tried to unfold the unknown aspects pertaining to our ethnic group for identification of a person by means of panoramic radiographs. The results have exemplified that the variations in the morphology of the coronoid process, condyle and the sigmoid notch using panoramic radiography can tentatively be used as a screening tool in human identification owing to its ready availability in most of the hospital settings.

* Corresponding author at: Department of Oral Medicine and Radiology, Vishnu Dental College and hospital, Bhimavaram, West Godavari District, Andhra Pradesh, India. Tel.: +91 9581319318.

E-mail addresses: sahithi.dathar9@gmail.com (D. Sahithi), sudhakarareddyomr@gmail.com (S. Reddy), divyateja.dalli@gmail.com (D.V. Divya Teja), sp.kotubds@gmail.com (K.N. Sai Praveen), sruthi.rayapureddy@gmail.com (R. Sruthi).

1. Introduction

Identification of an individual has always been a prerequisite not only to certify the death but also for various personal, civil and legal aspects pertaining to the individual's identity. For decades DNA matching, and fingerprint analysis have facilitated in identification of a person.[1] But human identification actually becomes difficult and challenging when the carcass is completely charred and skeletonised. In such circumstances anthropological and dental analyses play a key role in determining the individual's identity.[4]

The human mandible is considered as the largest and strongest bone in the face, it consists of two ascending rami one on either side that in turn bears the coronoid and condyle process. The coronoid process is a flat triangular plate that projects upwards and slightly forwards,[2] whereas the condyle is a rounded projection that articulates with the glenoid fossa of the temporal bone. The sigmoid notch; also called the mandibular notch is a deep notch separating the coronoid process and the condyle.[2]

Different morphological variations of the coronoid process (triangular, round, beak/hook and flat)[3], condyle (angled, round, convex and flat)[5] and the sigmoid notch (wide, round and sloping)[3] have been documented in literature as indispensable aids in anthropological and forensic studies. These variations occur either due to the genetic background or due to functional changes that occur with the progression of growth. Till date most of these studies have been done using the dry mandibles obtained from the cadavers of the deceased individuals.

Radiographs play an essential role in forensic dentistry to uncover the hidden facts that cannot be easily noticed by regular physical examination. Maxillofacial radiography by means of orthopantamogram is used as a routine screening tool[6] in the diagnosis and treatment planning in various fields of dentistry and is found to be less expensive when compared to other advanced imaging modalities like CT, MRI and CBCT. In a panoramic image, different shapes of the coronoid process, condyle and sigmoid notch can often be appreciated and thus this radiographic data when available as ante mortem records and correlated with the post-mortem records can thereby aid in the identification of a person either living or dead. The need for this study was to accomplish more accessible means for personal identification by comparison of various morphological patterns of the coronoid process, condyle and sigmoid notch with the help of panoramic radiographs pertaining to our geographic area.

In this regard, the present study was undertaken to depict various morphological disparities of the coronoid process, condyle and sigmoid notch in our ethnic group so as to aid in personal identification.

2. Methodology

A retrospective study was carried out using 200 digital orthopantamograms (OPGs), which were obtained from the archives of the Department of Oral Medicine and Radiology, Vishnu Dental College and Hospital, Bhimavaram, Andhra Pradesh, India.

All the digital OPGs were taken by Orthoralix machine and PSP sensors (Digora) under standard exposure parameters as recommended by the manufacturer and the final images were obtained by Digora software (Digora for Windows 2.7.103.437). The print outs of these images were taken and were traced over projection sheets with the help of the viewer box. All the OPGs recorded by correct means and appropriate techniques without any distortions were included in the study and those with the presence of any developmental defects of the mandible, trauma or any other diseases affecting the bone were excluded from the study. The radiographs thus obtained were subjected for the assessment of the various morphological shapes of the coronoid process, condyle and sigmoid notch (see Figs. 1–4).

The various shapes of the coronoid process and sigmoid notch were interpreted as given by Shakya et al.[3] and those of the condyle were interpreted according to Hegde et al.[5]

These shapes were recorded for both right and left sides using each panoramic image including both the sexes. Thus a total of 400 sides were evaluated and compared for both sides and between both the sexes.

3. Results

Of 200 digital OPG images obtained, corresponding to 400 sides among which, 84(168 sides) were of males and 116(232 sides) were females. The mean age for the males was as 36.45 ± 15.2 and for females as 34.81 ± 15.93.

Among all 200 panoramic images consisting of 400 sides, the most common shape for coronoid process was observed as triangular (215) which was distributed as 105(48.8%) on the right side and 110(51.2%) on the left side. The next shape was found to be the round (143), of which 75(52.4%) were on the right side and 68(47.6%) on the left side and then followed by the beak shape (34), of which 16(47.1%) were on the right side and 18 (52.9%) on the left side. The least common shape observed for the coronoid process was flat (8), which was equally distributed on both sides. The distribution of the shapes of the coronoid process among the right and left sides had shown no statistical significance (p value = 0.90) as illustrated in Table 1.

The shape of condyle frequently observed was round (157), of which 76(48.4%) were on the right and 81(51.6%) on the left side. The next observed shape was angled (142) that were equally seen on both the sides, followed by convex shape (85) which was more or less equally distributed on both sides. The flat shape (16) of the condyle was least observed with 10 (62.5%) and 6(37.5%) on the right and left sides respectively. The distribution of condylar shape among right and left sides had shown no statistical significance (p value = 0.76) as depicted in Table 2.

The shape of the sigmoid notch commonly observed was the wide form (174), distributed as 86(49.4%) on the right and 88(50.6%) on the left side. The next shape commonly observed was round (133) with almost equal distribution on both sides and lastly the sloping form (93) with 48(51.6%) and 45(48.4%) on the right and left sides respectively as shown in Table 3.

The most commonly observed shape of coronoid process among the males and females was found to be triangular (47 on the right side, 50 on the left side among the males; and 58 on the right side and 60 on the left among the females) followed by round (30 on the right side, 25 on the left side in males; and 45 on the right and 43 on the left in females) and beak shapes (7 on the right side and 9 on the left in males;
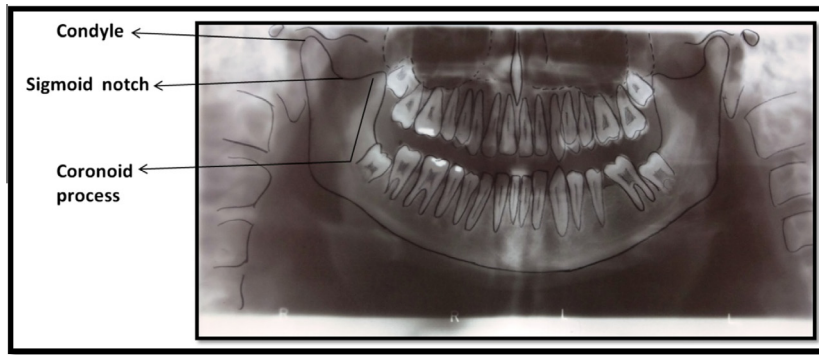
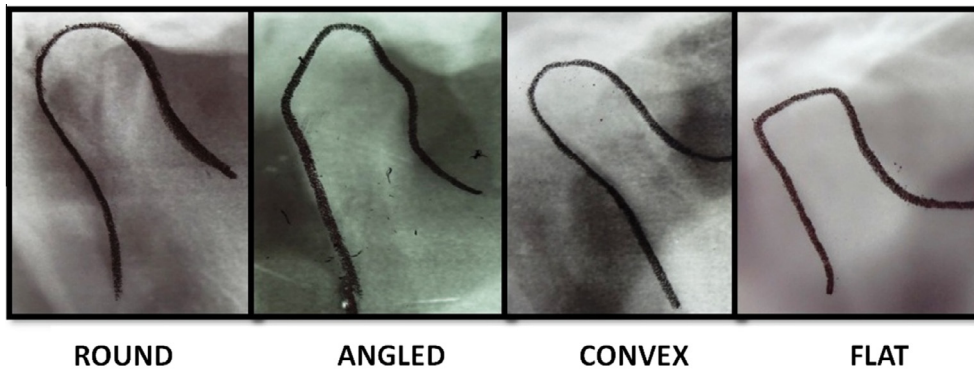**Figure 1**   Showing the orthopanoramic image of the condyle, coronoid process and sigmoid notch.

Figure 2   Showing various shapes of the condyle.
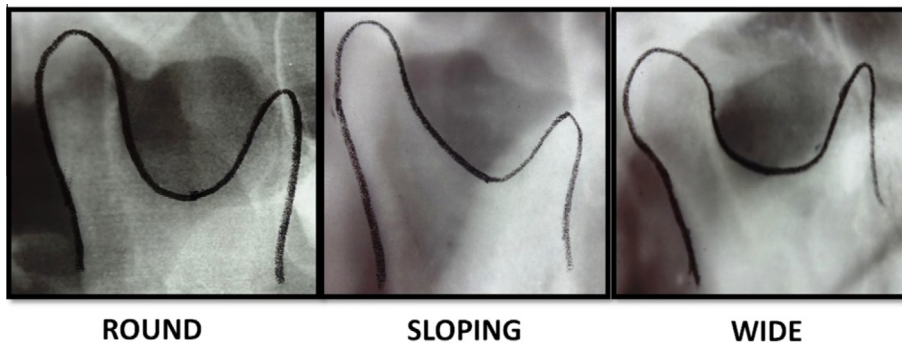

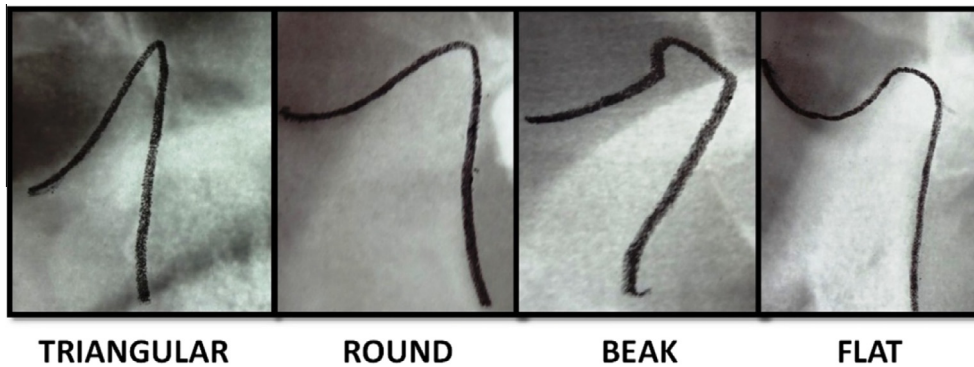**Figure 3**   Showing various shapes of the sigmoid notch.

Figure 4   Showing various shapes of the coronoid process.

Table 1 Distribution of coronoid process shapes on the right and left sides.

	Right side	Left side	Total	P-value
Triangular	105	110	215	0.902
	48.8%	51.2%	100.0%	(Chi square test)
Round	75	68	143	
	52.4%	47.6%	100.0%	
Beak	16	18	34	
	47.1%	52.9%	100.0%	
Flat	4	4	8	
	50.0%	50.0%	100.0%	
Total	200	200	400	
	50.0%	50.0%	100.0%	

Table 2 Distribution of condylar shapes on the right and left sides.

	Right side	Left side	Total	P-value
Angled	71	71	142	0.760
	50.0%	50.0%	100.0%	(Chi square test)
Round	76	81	157	
	48.4%	51.6%	100.0%	
Convex	43	42	85	
	50.6%	49.4%	100.0%	
Flat	10	6	16	
	62.5%	37.5%	100.0%	
Total	200	200	400	
	50.0%	50.0%	100.0%	

Table 3 Distribution of sigmoid notch shapes on the right and left sides.

	Right side	Left side	Total	P-value
Wide	86	88	174	0.938
	49.4%	50.6%	100.0%	(Chi square test)
Round	66	67	133	
	49.6%	50.4%	100.0%	
Sloping	48	45	93	
	51.6%	48.4%	100.0%	
Total	200	200	400	
	50.0%	50.0%	100.0%	

and 9 on each side in females). In our present study, the flat shape of the coronoid process was solely found in females (4 on either side) rather than in males as described in Table 4. There were no statistical differences found for the shapes of the coronoid process among both the sexes except that the flat shape was found only in females as per the present study (with p value = 0.671 and p value = 0.994 in males and females respectively).

The most frequently observed shape of the condyle (35 on the right side and 33 on the left side) among the males was angled followed by round (30 on the right side and 35 on the left side), convex (15 on the right side and 14 on the left side) and flat shapes (4 on the right side and 2 on the left side) and among the females was the round (36 on the right side and 38 on the left side) followed by angled (46 on either side), convex (28 on either side) and flat (6 on the right side and 4 on the left

side) as illustrated in Table 5. There were no statistical differences found for these shapes of the condyle in both the sexes (with p value = 0.766 and p value = 0.929 in males and females respectively).

The wider form of the sigmoid notch was most common among both the sexes (35 on the right side and 36 on the left among males; and 51 on the right side and 52 on the left side among females) followed by the round (29 on the right side and 31 on the left side among males; and 37 on the right side and 36 on the left side among females) and the sloping forms (20 on the right side and 17 on the left side among males; and 28 on each side among females) showing no statistical difference in both the sexes (with p value = 0.850 and p value = 0.988 in males and females respectively) as given in Table 6.

Inter observer variability was also performed by using kappa statistics on both sides which showed a high agreement for the coronoid process followed by sigmoid notch and condyle.

4. Discussion

For decades various anthropological studies using dry skulls had been conducted for identification of a deceased person. Forensic analysis by means of comparison of ante-mortem and post-mortem radiographs are one of the most unswerving and rapid methods used for personal identification.[8] Panoramic images are the most frequently advised radiographs for diagnosis as well as to monitor the prognosis of various treatment procedures in dentistry. In addition, panoramic radiography has been described to be reliable in representing the condyle and in evaluating the temporomandibular joint abnormalities.[13,14] Nevertheless, these radiographs when preserved can serve as ante-mortem records in personal identification process.

Morphological variations of anatomic structures occur either corresponding to the developmental discrepancies through hereditary determinants or due to the functional variations that arise during the growth process.[1,2] In the present study different shapes of the coronoid process, condyle and sigmoid notch were assessed with help of orthopanoramic images. The common shapes of the coronoid process were observed to be the triangular followed by round in our geographic area pertaining to the Southern part of India which goes in harmony with the studies conducted by Shakya et al.[3], Sudha et al.[10] and Pradhan et al.[12] among the South Indian populations. Our observations were in contradictory to the studies conducted by Tapas et al.[1] among the North Indian population and Kadam et al.[9] among the West Indian population wherein they had reported the hook/beak shape to be common followed by the triangular shape. Prajapati et al.[7] had conducted a study using dry mandibles and the results showed that triangular coronoid processes were common followed by the round and the hook shapes and the incidence of the hook shape was almost equal in both the sexes, which goes in accordance with the current study. Observations made by Isaac et al. were not similar to those of the present study, which showed triangular shape to be more common followed by hook and round shapes and the incidence of round shape was almost equal among both the sexes.[15]

Our study had showed the most common shape of condyle among the males was angled and among the females was round. The studies reported by Ribeiro et al.[11] and Choudhary

Table 4   Shapes of coronoid process among males and females.

Males	Right side	Left side	Total	P-value	Females	Right side	Left side	Total	P-value
Triangular	47	50	97	0.671	Triangular	58	60	118	0.994
	48.5%	51.5%	100.0%	(Chi square test)		49.2%	50.8%	100.0%	(Chi square test)
Round	30	25	55		Round	45	43	88	
	54.5%	45.5%	100.0%			51.1%	48.9%	100.0%	
Beak	7	9	16		Beak	9	9	18	
	43.8%	56.2%	100.0%			50.0%	50.0%	100.0%	
Flat	0	0	0		Flat	4	4	8	
	0%	0%	0%			50.0%	50.0%	100.0%	
Total	84	84	168		Total	116	116	232	
	50.0%	50.0%	100.0%			50.0%	50.0%	100.0%	

Table 5   Shapes of condyle among males and females.

Males	Right side	Left side	Total	P-value	Females	Right side	Left side	Total	P-value
Angled	35	33	68	0.766	Angled	36	38	74	0.929
	51.5%	48.5%	100.0%	(Chi square test)		48.6%	51.4%	100.0%	(Chi square test)
Round	30	35	65		Round	46	46	92	
	46.2%	53.8%	100.0%			50.0%	50.0%	100.0%	
Convex	15	14	29		Convex	28	28	56	
	51.7%	48.3%	100.0%			50.0%	50.0%	100.0%	
Flat	4	2	6		Flat	6	4	10	
	66.7%	33.3%	100.0%			60.0%	40.0%	100.0%	
Total	84	84	168		Total	116	116	232	
	50.0%	50.0%	100.0%			50.0%	50.0%	100.0%	

Table 6   Shapes of sigmoid notch among males and females.

Males	Right side	Left side	Total	P-value	Females	Right side	Left side	Total	P-value
Wide	35	36	71	0.850	Wide	51	52	103	0.988
	49.3%	50.7%	100.0%	(Chi square test)		49.5%	50.5%	100.0%	(Chi square test)
Round	29	31	60		Round	37	36	73	
	48.3%	51.7%	100.0%			50.7%	49.3%	100.0%	
Sloping	20	17	37		Sloping	28	28	56	
	54.1%	45.9%	100.0%			50.0%	50.0%	100.0%	
Total	84	84	168		Total	116	116	232	
	50.0%	50.0%	100.0%			50.0%	50.0%	100.0%	

et al.[13] pertaining to the Brazilian and East Indian population respectively had shown that round/oval shape to be common in both the sexes which goes in accordance with our study but with correspondence to the females of our ethnic group. A study conducted by Oliveira et al., had shown the round shape to be more frequent followed by pointed and flat shapes, which was a similar finding among females in the present study.[16]

In the current study, pertaining to our population the wider form of the sigmoid notch was frequently observed followed by the round and the sloping forms which were not in accordance with the study reported by Shakya et al.[3] wherein the sloping forms were commonly observed followed by round and wide forms. However, in our study the variation of all the three entities when compared on either side and among both the sexes were not statistically significant.

The results elucidated in our study suggest that various shapes of the coronoid process, condyle and sigmoid notch depicted by means of panoramic images can thus be used as a quite easier and quicker method for identification of an individual especially in cases of mass disasters, provided when the ante-mortem records are preserved.

5. Conclusion

In the latest scenario the process of personal identification by means of radiographs had gained utmost importance owing to its feasibility. These radiographs render to uncover the concealed facts in forensic dentistry, provided the ante-mortem records have to be preserved. Within its limitations, confining to our population, the present study had witnessed various morphological shapes of the coronoid process, condyle and

sigmoid notch using the panoramic radiographs as a probable approach for personal identification.

Funding

None.

Conflict of interest

None declared.

Ethical approval

The study was approved by the College ethics committee.

References

1. Priscilla DM, Runjhun S. Use of frontal sinus and nasal septum patterns as an aid in personal identification: A digital radiographic pilot study. *J Forensic Dent Sci* 2010;**2**(2):77–80.
2. Tapas S. Morphological variations of coronoid process in dry adult human mandibles. *Ind J Basic Appl Med Res* 2014;**3**(2):401–5.
3. Shakya S, Ongole R, Nagraj SK. Morphology of coronoid process and sigmoid notch in orthopantomograms of south indian population. *World J Dent* 2013;**4**(1):1–3.
4. Patil N, Karjodkar FR, Sontakke S, Sansare K, Salvi R. Uniqueness of radiographic patterns of the frontal sinus for personal identification. *Imaging Sci Dent* 2012;**42**:213–7.
5. Hegde S, Praveen BN, Shetty SR. Morphological and radiological variations of mandibular condyles in health and diseases: a systematic review. *J Dent* 2013;**3**:154.
6. Mathew AL, Sholapurkar A, Pai KM. Condylar changes and its association with age, TMD, and dentition status: a cross-sectional study. *Int J Dent* 2011;1–7.
7. Prajapati VP, Malukar O, Nagar SK. Variations in the morphological appearance of the coronoid process of human mandible. *Int J Med Res* 2011;**1**(2):64–6.
8. Cameriere R, Ferrante L, Molleson T, Brown B. Frontal sinus accuracy in identification as measured by false positives in kin groups. *J Forensic Sci* 2008;**53**(6):1–3.
9. Kadam SD, Roy P, Ambali MP, Doshi MA. Variation in the shape of coronoid process in dry mandible of Maharashtra population. *Int J Anat Res* 2015;**3**(1):895–8.
10. Sudha R, Chandrasekaran S, Aruna N. Study of morphological variations in the shape of coronoid process of mandible in South Indian population. *Int J Cur Res Rev* 2013;**05**(10):84–92.
11. Ribeiro EC, Sanches ML, Alonso LG, Smith RL. Shape and symmetry of human condyle and mandibular fossa. *Int J Odontostomat* 2015;**9**(1):65–72.
12. Pradhan S, Bara DP, Patra S, Nayak S, Mohapatra C. Anatomical study of various shapes of mandibular coronoid process in relation to gender and age. *IOSR J Dent Med Sci* 2014;**13**(8):9–14.
13. Chaudhary S, Srivastava D, Jaetli V, Tirth A. Evaluation of condylar morphology using panoramic radiography in normal adult population. *Int J Sci Stud* 2015;**2**(11):164–8.
14. Hintze H, Wiesel M, Wenzel A. Comparison of three radiographic methods for detection of morphological temporomandibular joint changes: panoramic, scanographic and tomographic examination. *Dentomaxillofac Rad* 2009;**38**:134–40.
15. Isaac B, Holla SJ. Variations in the shape of the coronoid process in the adult human mandible. *J Anat Soc India* 2001;**50**(2):137–9.
16. Oliveira C, Bernardo RT, Capelozza AA. Mandibular condyle morphology on panoramic radiographs of asymptomatic temporomandibular joints. *Int J Dent* 2009;**8**(3):114–8.