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Original Article

A New Methodology to Aid Skull–Photograph Superimposition Technique Using Facial Asymmetries in Skull Identification

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ABSTRACT

The identification of decomposed head through DNA profiling is considered as conclusive, the identification of the deceased through DNA profiling is not feasible in all the cases because of various reasons. Hence, the investigating agency has to resort to SPS (skull–photograph superimposition) technique for identification purpose. Since there is similarity in facial features of the victims to twins, siblings and close relatives, the SPS technique using ante-mortem face photograph provides only probable opinion on identification. At this juncture, it is inevitable to increase the reliability in skull identification through new methodologies. Many researchers accepted that the asymmetries are the specific characters for skull and face identification. Facial asymmetries are indeed efficient in identifying people. The asymmetry of face is an individual characteristic, differing in perceptible ways even between identical twins. In this study, the correspondence in asymmetry between the skull and face are quantified by a new methodology using the software Adobe Photoshop and AutoCAD. This study establishes the use of symmetries in skull identification and takes SPS technique towards eliminating the subjectivity in skull identification.

Keywords: DNA profiling, Skull–photo superimposition, Asymmetries, Photo shop, AutoCAD

INTRODUCTION

The decomposed and disfigured dead bodies recovered from the scene of crime are to be identified to fix the deceased. Identification of unidentified skeletal remains is one of the main duties of Forensic Sciences Laboratories. The skull–photograph (ante-mortem face photograph) superimposition (SPS) and DNA profiling are the two techniques employed in Forensic Sciences Laboratories to identify the skeletal remains. Skull–photo superimposition technique was employed for first time in forensic setup by Glaister in 1935[39] but the DNA testing was started for identification only in 1986[14]. Since there is similarity in facial features of the victims to twins, siblings and close relatives, the SPS technique using ante-mortem face photograph provides only probable opinion on identification. The SPS technique is considered only second to DNA profiling due to its inability to produce definite identification. Although conclusive identity could be achieved using ante-mortem dental radiograph or ante-mortem radiograph of head for superimposition, the availability of such documented records is scarce.

Brues[12] categorically stated that it would be proved awkwardly wrong when a person declared as dead by the Scientists presents alive. Extensive researches have been done on the reliability of SPS technique by many researchers. Earlier the reliability of the opinions arrived from SPS technique appears to have been over-estimated[81,44]; The Judgement of the case related to Shankar Vs State of Tamil Nadu; Trial No. 3/1991 dated 17.7.92 High Court of Madras). In spite of the methodical

approach involved in SPS technique, more cautions have been insisted by the researchers like Stewart[91], Koelmeyar[58], Dorion[28], Schimmer *et al.* [80], Seta and Yoshino[82] and Yoshino *et al.*[102] regarding 'false match or 'mismatch' that a skull may fit with a photograph of a person known to be alive. It was substantiated by the experimental evidence of Austin-Smith and Maples[3] which proved the probability of mismatch estimated to be at 9% during superimposition of a skull with a single frontal view photograph. Several authors[16, 51, 92, 40, 37, 53, 52, 76, 29, 89, 27, 33, 47, 74, 09, 23, 07, 26, 48] suggested different methodologies to carry out craniofacial superimposition with its limitations. Gordon and Steyn[41] stated that a 100% positive identification rate has never been established, with the possibility of false positives and false negatives, being an ever present reality. They insisted for constant testing to ensure that the best available techniques and equipment are being used. They found 85% accuracy in skull–photo superimposition using morphological assessment and 80% accuracy in land-mark-based assessment in South African samples. Huete *et al.* [46] presented a literature and international surveys on the past, present and future of craniofacial superimposition. Hashim *et al.* [43] prescribed superimposition technique for determining a frontal sinus pattern match. Jayaprakash[54] explained the relevance of Whitnall's tubercle and auditory meatus in diagnosing exclusions during skull–photograph superimposition.

SKULL–FACE RELATIONSHIP

The skull–face relationship was named as cranio-facial morphanalysis by Jayaprakash[53] who stated that it depends upon the assessment of morphological correlates between a skull and the corresponding face photograph. A correlation between the skull and the face (skull–face relationship) was studied by Broadbent and Mathews[11], Krogman[59], Moss[68], Gerasimov[36], Farkas and Lindsay[31], Wolff[100], Angel[2], Gatliff and Snow[34], Stewart[91], Rhine and Campbell[75], Hodson *et al.* [45], Caldwell[15], Krogman and Iscan[60], Macho[64], George[35], Fedosyutkin and Nainys[32], Rosenstein *et al.* [78], Jayaprakash *et al.* [57], Taylor[94], Stephan[86], Wilkinson and Mautner[99], Ghosh and Sinha[37], Rynn[79], Stephan and Simpson[88], Balueva *et al.*[5], Stephan[87] and Deng *et al.*[26] and also they established the applications of skull–face relationship. The above researchers also provided criteria to increase the reliability and reduce the errors in forensic identification of skull. Jayaprakash[53] also added 10 more new correlations between skull and face to his credit. His method is used as a conjoint application with the SPS technique to eliminate the mismatch and increase the confidence of the analysing expert.

LIMITATION

Further, Iscan[50] has cautioned about the more common characteristic of facial features in specific racial or ethnic group. However, the application of skull–face relationship reduces the errors in identification using the SPS technique; the closely related individuals may resemble in their facial features and hence the findings from this technique cannot be given in definite term[53].

RECENT STUDIES IN CRANIO-FACIAL SUPERIMPOSITION (CFS)

Since there is no systematic methodology in cranio-facial superimposition, Ibanez *et al.* [47] designed a complete, automatic soft computing based procedure to aid forensic anthropologists in identification task by photographic supra projection. But they also stated that this fully automatic method is still to be refined by forensic experts to obtain good quality superimposition. Deng *et al.*[26] estimated the facial appearance for human skeletal remains using the relationship between the soft tissue and the underlying bone structure and concluded that the facial feature shapes, such as eyes and nose, also they deserve further research to improve the accuracy of facial reconstruction. The quality of the photograph is more important in skull–photo superimposition, because all parts of the face are not always clearly visible and the camera angles and distance are the main criteria[41]. Ibanez *et al.*[48] proposed an advanced scatter search design for skull–face overlay in cranio-facial superimposition and further, they recommended it for future development. Even recent studies are unable to give conclusive result on skull identification using superimposition of skull and photograph. Ibanez *et al.*[49] studied the performance of different cranio-facial superimposition approaches and presented the ratings of different methodologies.

NECESSITY OF STRENGTHENING CAPACITY OF SPS TECHNIQUE

Before the establishment of DNA profiling technique, the findings of SPS technique were accepted in the court of

law as a definite identification method in the courts of Tamil Nadu (Shankar Vs State of Tamil Nadu, Judgement in Referred Trial No. 3/1991 dated 17.07.1992 High Court of Madras). Of late, opinions of SPS technique are being questioned by the court of law as its findings are considered to be subjective and the court of law insists identification using primary identification technique that is, the DNA profiling. As a result, difficulty is faced by the experts from SPS technique to defend their opinions from critical cross examination in the court of law. Due to above reasons, a question is raised on the role of SPS technique in Forensic Sciences Laboratories.

Though the identification through DNA profiling is considered as conclusive, the identification of the deceased through DNA profiling is not feasible in all the cases because of various reasons. In instances like the absence of blood relatives such as parents and children of the deceased for comparison, the identification through DNA profiling is not possible in India. Some other reasons could also be attributed for its failure such as the high rate of decomposition, burning of the dead bodies at high temperature, bones buried in the soil for a longer period, and the preservation of the skull and bones in formalin[73]. Hence the investigating agency has to resort to SPS technique for identification purpose. At this juncture, it is inevitable to strengthen the capacity of SPS technique through new methodologies.

FACIAL ASYMMETRIES AND SKULL IDENTIFICATION

Human faces are approximately bilateral symmetric, but no human face has been found to be perfectly symmetrical. More asymmetric faces are more recognizable[95]. Troje and Buelthoff[96] opined that there is a significant decrease in recognising of human face if facial asymmetry is removed from images. Burke and Healy[13] and Mealey *et al.* [66] reported the significant differences in facial asymmetry parameters of monozygotic twins. Right–left differences occur everywhere in nature, when two bilateral congruent parts are present in an entity[19]. Liu *et al.*[63] started using asymmetry in automatic human identification tasks in computer vision. Further extensive research was done in identifying certain quantified facial asymmetry for efficient identification of people[61].

The shape of the bony elements in the skull that imparts the features on the face is chiefly non-metric in nature and help to recognise the individuals[25]. Stewart[91] and Turkel[97] mentioned about the use of facial asymmetry to identify human. The bony morphological deviations are reliable indicators of corresponding deviations in the fleshy face[57]. Stewart[91] cited that asymmetries of the jaw helped police in identifying the victim. Asymmetry of a given face should remain constant even if visual appearance is altered by some additions in moustache or beard[84]. The asymmetry of bones in the nasal zone of skull and nose in the related photograph has been explained by Sivaram and Wadhera[85] and Farkas[30]. Correspondence between the asymmetry in the nasal bones and nose was also illustrated by Fedosyutkin and Nainys[32] and Jayaprakash *et al.* [57].

Many researchers accepted that the asymmetries are the specific characters for skull and face identification. Facial asymmetries are indeed efficient in identifying people. The asymmetry of face is an individual characteristic, differing in perceptible ways even between identical twins[66]. Asymmetry in the bone is associated with the asymmetry of the muscle that anchors on the corresponding bone[77, 53]. In this paper, the correspondence in asymmetry between the skull and face is quantified by a new methodology using the software Adobe Photoshop and AutoCAD. This paper establishes the use of symmetries and takes SPS technique towards eliminating the subjectivity in skull identification.

STUDY OF ASYMMETRIES USING NEW METHODOLOGY

Human face with asymmetries is evaluated in the field of aesthetics through clinical assessment, photograph, cephalograph and sometimes 3-dimensional computed tomography. In the field of human face identification, different methods are used[93, 13, 10, 63, 61, 18, 67] to quantify facial asymmetry. Dahan[22] proposed a simple digital procedure to assess facial asymmetry, which is used as a safer method to assess facial asymmetry for treatment in the field of aesthetics and dental medicine. Muraoka *et al.* [70] suggested CT scan to study the correlation between the features of the facial organs and the corresponding elements of the skull in fine way. Using CT scan for a large number of samples would be a costly affair.

MATERIALS AND METHOD

This is a new methodology introduced in this study for quantifying the asymmetries of homologous landmarks between skull and face. Twenty-five samples were selected for this analysis according to the specification fixed for face photograph. The cases with specified frontal view photographs such as the face with less flesh, neutral expression and both ears clearly visible were selected along with the images of related skulls to quantify the asymmetries between the skull and the face. The final images of skull and the face saved in the computer after the completion of skull–photograph superimposition using computer aided video superimposition device[57] were taken to evaluate the correlation of asymmetries between skull and face. The image of the skull was already positioned in accordance with the posture of the face in the photograph during superimposition. The images of skull and the face were imported into Adobe Photoshop-7.0 and reproduced those images as JPEG images. The midsagittal reference plane was constructed as a vertical line that crossed the midpoint of a line joining the Whitnall's tubercle of the skull and exocanthion of the face image. This midsagittal reference plane was located with a ruler on the screen in Photoshop. The homologous landmarks between the skull and face were marked separately in the images of skull and the face according to Singh and Bhasin[83] and their definitions are presented in Table 1. The homologous landmarks are classified in to paired and unpaired landmarks in this study.

Both images of skull and face with markings (landmarks) and midsagittal reference plane were imported to AutoCAD-2015 and the images of skull and the face were scaled equally. The distances from the midsagittal plane to the paired and unpaired landmarks were measured

Table 1: Definition of the landmarks fixed in the skull and face photograph to study the relationship in asymmetries

Sl.No.	Name of the Landmark in the Skull	Name of the Homologous Landmark in the Photograph
	Unpaired landmarks	
1.	**Nasion (n)** It is the point where the fronto-nasal suture meets the midsagittal plane.	**Nasion (n)** This is the point on the nasal root intersected by midsagittal plane.
2.	**Naso spinale (ns)** It is the deepest point on the lower margin of the piriform aperture projected in the midsagittal plane.	**Subnasale (sn)** It is the point where the lower margin of the nasal septum meets the integument of upper lip.
3.	**Prosthion (pr)** It is the point which lies on the alveolar margin of the upper jaw in the midsagittal plane.	**Stomion (sto)** It is the point where the slit of the mouth with close lips cuts the midsagittal plane.
4.	**Gnathion(gn)** It is the lowest point on the lower margin of the mandible in the midsagittal plane.	**Gnathion(gn)** It is the lowest point on the lower margin of the lower jaw intersected by the midsagittal plane.
	Paired landmarks	
5.	**Whitnall's tubercle (wt)** It is the point of attachment of the palpebral ligaments in the lateral orbital margin.	**Exocanthion (ex)** It is the point of lateral most projections of the eyes where the upper and lower margin meets.
6.	**Zygion (zy)** It is the most laterally placed point of the zygomatic bone.	**Zygion (zy)** Outward projecting points on the face at/or below the eyes.
7.	**Gonion (go)** It is the most downward, backward and upward point of the angle of the mandible made by the basal margin of the body and posterior margin of the ramus of the mandible.	**Gonion (go)** It is the lowest posterior and most lateral point on the angle of the lower jaw.

accurately in centimetre to assess the correspondence between the asymmetry in the skull and face. The values obtained from this study were analysed to assess the correlation in asymmetries between skull and face. This is a new methodology constructed in this study, and this method was tested and verified with the cases that were already identified in Anthropology Division of Forensic Sciences Department using the methodology framed by[53].

For the study of asymmetries, the paired and unpaired landmarks were marked separately on the images of skull and photograph. The distance from the midsagittal plane to the paired and unpaired landmarks was measured in all the 25 samples to assess the correspondence between the asymmetry in the skull and face. Since life size of the skull and the photograph was taken in 'cm', the measurements for the deviation of the landmarks were also measured in 'cm' and are given in Table 2. The images taken during the above process are given in the annexure along with its measurements. The correlation in asymmetries between skull and face image would be discussed with its measurements obtained.

RESULT AND DISCUSSION

Potter and Meradith[71], Harvold[42], Mulick[69], Dahan[21], Bishara[10] and Tallents[93] considered that skeletal asymmetry might be related to joint disorders. Mitra *et al.*[67] stated that the potential of facial asymmetry is a useful biometric in practice. However, Stewart[90] indicated that visual assessment is more effective than metrical studies while dealing with bony specimens. Dahan[22], Liu *et al.* [63] and Mitra *et al.*[67] suggested that measurements are the method for assessing asymmetry in the face. Jayaprakash *et al*.[56] stated that Austin-Smith and Maples[3] met the mismatch in skull–photo superimposition, since they did not evaluate the fitness in life-size images and they failed to apply anthropological measurements from the skull for bringing out the life-size of the face photographs.

Several forensic practitioners[6, 85, 56, 57] used visual assessments for assessing asymmetries when evaluating the goodness-of-fit during skull–photo superimposition. However, several researchers[24, 98, 65, 8, 38, 1, 76, 47, 41] evaluated the goodness-of-fit without mentioning about asymmetries during skull–photo superimposition. In practitioner's method, the extent of asymmetries could not be quantified, since their method was based on visual assessment. In this paper, the extent of asymmetry was quantified using above-said software. Chandrasekharan[17], Yoshino and Seta[101], Jayaprakash *et al.* [57] and Fenton *et al.* [33] correlated the Whitnall's tubercles of the skulls (wt) with the exocanthion, the outer eye angle (ex). Delfino *et al.* [25], Ricci *et al.* [76] and Gordon and Steyn[41] used landmarks for orienting the skull with photo during craniofacial superimposition. Gordon and Steyn[41] indicated that when other parameters are equal, the landmark method performs less reliability compared with the morphological method. In this paper, except 'wt' and 'ex', locating and marking the other 'paired' landmarks was not easy. However, the unpaired landmarks were located and marked easily.

Gordon and Steyn[41] oriented skull and photo after marking the landmarks for conducting craniofacial superimposition, in contrary; we used landmarks to correlate the asymmetries between skull and face. Jayaprakash[54] noted the issues in the study of Gordon and Steyn[41], but these issues are not applicable to this study, since the landmarks were not used for the orientation of skull and face for superimposition. The landmarks were marked only in the images of skull and face after the completion of superimposition. The life-sizes of both the skull and photo were also maintained, since the images were taken after the completion of superimposition.

Farkas[30] and Ricci *et al.*[76] are of the opinion that there is no scientific criterion for locating landmarks including the Gonion and Zygion in face images. Farkas[30] stated that Gonion and Zygion can be located only by palpating them in a living face. He also cautioned that the craniometric and cephalometric landmarks of similar names may not share similar or homologous locations in the skull and face. Locating the unpaired landmarks such as nasion, nasospinale/subnasale, prosthion/stomion and gnathion produced no issues while marking them in the images of skull and face photo. However, locating Gonion and Zygion (paired landmarks) created issues due to tissue thickness. The paired landmarks such as Whittnall's tubercle and exocanthion were marked and used only for constructing the midsagittal plane. The values obtained for the paired landmarks to correlate the asymmetry

Table 2: Measurements taken for the deviation of unpaired and paired landmarks from midsagittal plane. The left side is mentioned as plus (+) and the right side is m entioned as minus (-)

Sample No.	Case No.	Sample	Distance between wt/ex (cm)	Unpaired Landmarks (in cm)				Paired Landmarks (in cm)			
								Zy		Go	
				N	Ns/Sn	Pr/sto	Gn	R	L	R	L
1	49, 50/14	Skull	9.10	-0.19	+0.06	-0.27	-0.05	-5.36	+5.41	-3.99	+4.32
		Photo	9.10	-0.19	+0.15	-0.18	-0.05	-5.59	+5.78	-4.04	+4.44
2	33, 34/14	Skull	9.30	-0.13	-0.18	-0.18	-0.38	-5.06	+5.09	-3.85	+4.12
		Photo	9.30	-0.11	-0.18	-0.13	-0.06	-5.15	+5.46	-4.01	+5.01
3	87, 88/13	Skull	9.10	-0.08	+0.15	-0.11	+0.30	-5.46	+5.65	-3.79	+4.12
		Photo	9.10	-0.08	+0.22	-0.13	+0.49	-5.98	+6.50	-4.33	+4.94
4	116, 117/13	Skull	8.60	+0.07	+0.35	-0.06	+0.15	-4.97	+5.26	-3.67	+3.99
		Photo	8.60	+0.06	+0.37	-0.06	+0.15	-5.71	+5.69	-3.89	+4.68
5	73, 74/07	Skull	9.20	+0.04	-0.36	+0.02	-0.17	-5.82	+5.47	-3.98	+3.85
		Photo	9.20	+0.07	-0.23	+0.01	-0.10	-5.92	+5.96	-4.02	+4.33
6	44, 45/09	Skull	9.80	-0.13	+0.09	-0.31	-0.63	-5.60	+5.52	-4.47	+4.20
		Photo	9.80	-0.04	+0.10	-0.24	-0.45	-6.06	+5.96	-5.01	+5.07
7	136, 137/08	Skull	9.20	-0.18	+0.24	-0.11	+0.24	-5.02	+5.09	-3.64	+4.31
		Photo	9.20	-0.11	+0.31	-0.08	+0.27	-5.93	+6.08	-5.13	+5.38
8	122, 123/08	Skull	9.60	-0.09	-0.68	-0.50	-0.63	-6.34	+5.05	-4.75	+3.85
		Photo	9.60	-0.09	-0.38	-0.42	-0.64	-6.41	+5.72	-5.99	+4.92
9	145, 146/08	Skull	9.50	+0.11	-0.27	-0.21	+0.14	-5.13	+5.79	-3.91	+4.81
		Photo	9.50	+0.08	-0.08	-0.14	+0.18	-6.07	+5.79	-5.10	+5.42
10	102, 124/08	Skull	9.40	+0.31	+0.20	+0.34	-0.04	-6.38	+5.71	-4.71	+3.73
		Photo	9.40	+0.35	+0.25	+0.38	-0.10	-7.20	+6.10	-6.11	+4.83
11	88, 89/08	Skull	9.20	+0.19	-0.11	+0.18	-0.30	-5.70	+5.64	-4.41	+3.73
		Photo	9.20	+0.17	-0.09	+0.27	-0.30	-6.37	+6.06	-6.00	+5.17
12	03, 04/14	Skull	9.10	+0.17	+0.18	+0.18	-0.20	-5.83	+5.71	-3.81	+3.86
		Photo	9.10	+0.21	+0.20	+0.04	-0.17	-6.49	+6.01	-4.97	+4.91
13	05, 06/14	Skull	9.15	-0.22	-0.11	-0.23	-0.39	-5.54	+5.87	-4.17	+4.38
		Photo	9.15	-0.35	-0.05	-0.05	-0.37	-6.17	+6.14	-5.15	+4.99
14	59, 60/14	Skull	9.20	+0.05	-0.41	-0.07	-0.17	-5.73	+5.86	-5.00	+4.45
		Photo	9.20	+0.14	-0.29	+0.24	-0.18	-6.49	+6.32	-5.74	+5.39
15	92, 93/14	Skull	9.18	+0.11	+0.08	+0.01	+0.24	-5.27	+5.52	-4.05	+3.96
		Photo	9.18	+0.09	+0.14	+0.24	+0.31	-5.85	+6.08	-4.50	+5.34
16	129, 130/14	Skull	9.05	+0.06	-0.06	-0.07	-0.36	-5.42	+5.45	-4.07	+3.83
		Photo	9.05	+0.11	-0.16	-0.05	-0.37	-6.16	+5.78	-4.86	+4.33
17	94, 95/14	Skull	9.12	+0.03	+0.18	+0.04	+0.14	-6.05	+5.75	-4.36	+4.48
		Photo	9.12	+0.10	+0.18	+0.06	+0.19	-6.31	+6.19	-4.82	+5.46
18	137, 138/14	Skull	9.08	-0.16	+0.12	-0.09	+0.10	-5.93	+5.41	-4.20	+4.19
		Photo	9.08	-0.16	+0.18	-0.05	+0.22	-6.06	+6.36	-4.86	+5.68

Table 2 cont.....

Sample No.	Case No.	Sample	Distance between wt/ex (cm)	Unpaired Landmarks (in cm)				Paired Landmarks (in cm)			
								Zy		Go	
				N	Ns/Sn	Pr/sto	Gn	R	L	R	L
19	159, 160/02	Skull	9.18	-0.12	-0.14	-0.05	-0.46	-5.15	+5.79	-4.00	+4.15
		Photo	9.18	-0.16	-0.18	-0.39	-0.61	-5.79	+5.93	-5.03	+4.18
20	179, 180/14	Skull	9.22	+0.10	+0.22	+0.21	+0.01	-5.42	+5.69	-4.04	+4.42
		Photo	9.22	+0.24	+0.38	+0.40	+0.41	-6.25	+6.31	-5.71	+5.77
21	200, 201	Skull	9.25	-0.14	-0.17	+0.14	+0.05	-5.57	+5.42	-4.24	+4.19
	& 202/14	Photo	9.25	-0.05	-0.07	+0.15	+0.39	-5.70	+5.26	-4.02	+4.36
22	213, 214/13	Skull	9.28	+0.05	+0.14	+0.05	+0.17	-5.17	+5.89	-3.59	+4.23
		Photo	9.28	+0.02	+0.13	+0.09	+0.13	-5.94	+6.19	-4.72	+5.41
23	242, 243/13	Skull	9.15	+0.12	+0.12	+0.11	+0.38	-4.90	+5.18	-3.87	+3.67
		Photo	9.15	+0.06	+0.16	+0.13	+0.40	-5.72	+5.92	-4.62	+4.47
24	214, 25/14	Skull	9.23	-0.19	-0.10	-0.02	-0.27	-5.71	+5.34	-4.19	+3.76
		Photo	9.23	-0.17	-0.11	-0.03	-0.29	-6.58	+6.19	-5.37	+4.96
25	135, 136/14	Skull	9.16	+0.12	+0.45	+0.26	+0.27	-5.45	+5.43	-4.84	+3.43
		Photo	9. 16	+0.14	+0.59	+0.35	+0.29	-6.61	+6.26	-5.38	+5.45

between skull and face show higher variation than the values obtained for unpaired landmarks. The distance measured from the midsagittal plane, the unpaired landmarks show nearly the same values (Table 2).

Since the values obtained for unpaired landmarks showed better correlation in asymmetries between skull and face than the paired landmarks, this methodology fits only for unpaired landmarks and hence it cannot be used as a main tool for identification, but can be used as an additional tool for correlating symmetry. The number of landmarks for studying asymmetries in skull and face may increase in future to use this method in a more effective manner. Hence, the present study suggests this new method of correlating asymmetries using Adobe Photoshop and AutoCAD for skull identification as an additional tool along with the method suggested by Jayaprakash[53] which is being followed in Anthropology Division of Forensic Sciences Department, Chennai, Tamil Nadu. Continuous practice in this regard would bring refinement in this new method for obtaining unambiguous results and possibly replace the SPS technique in order to eliminate of subjectivity in future.

No study has been reported to fix the mean tissue thickness of Tamil Nadu population in the field of craniofacial superimposition. To fill the void, this present study may be extended to find out the mean tissue thickness of Tamil Nadu population using this new method in future.

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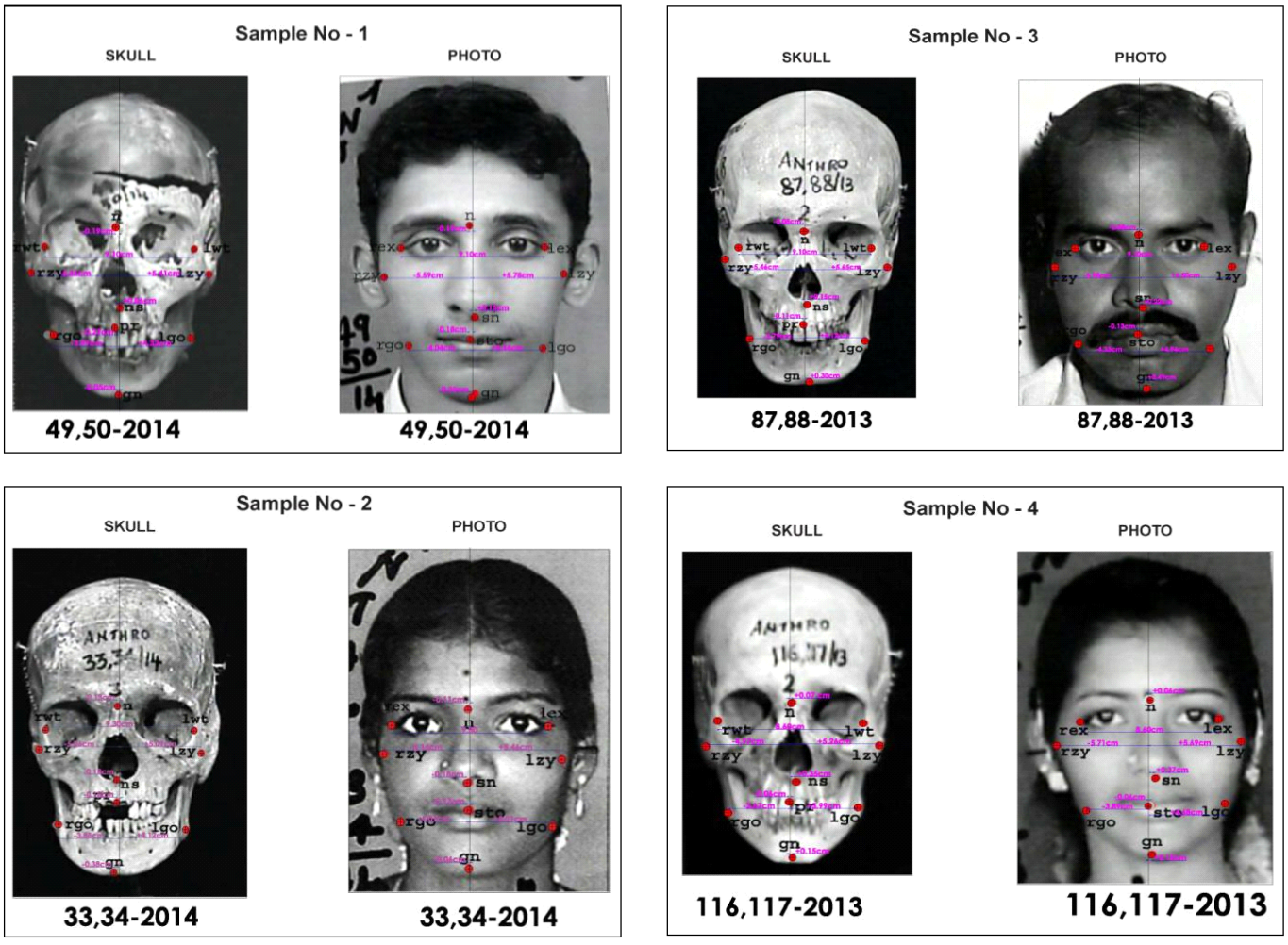
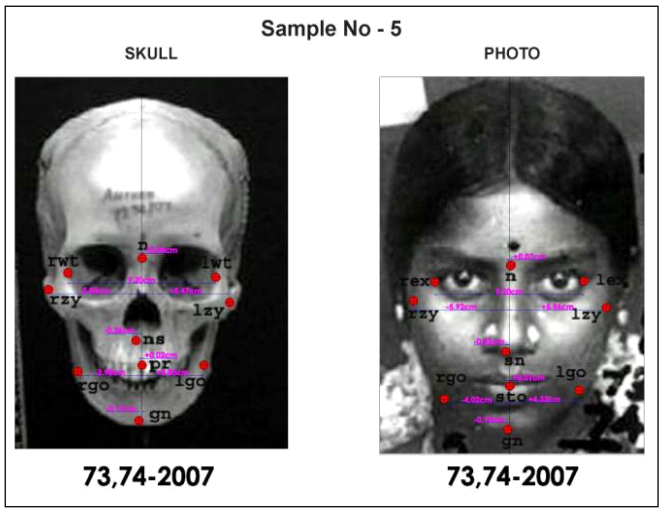
ANNEXURE – I

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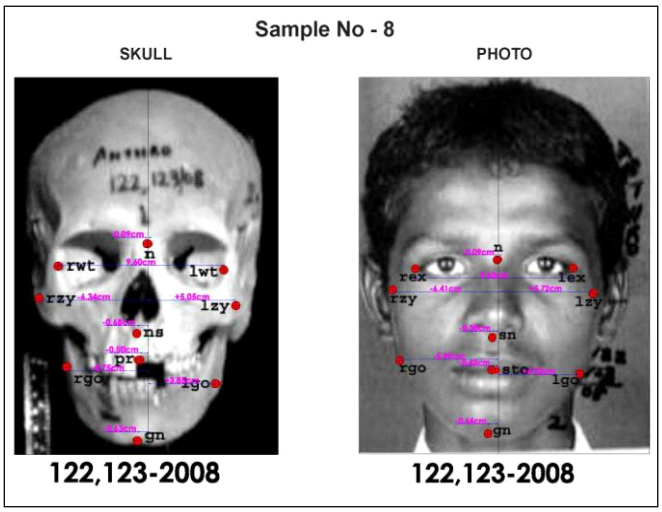
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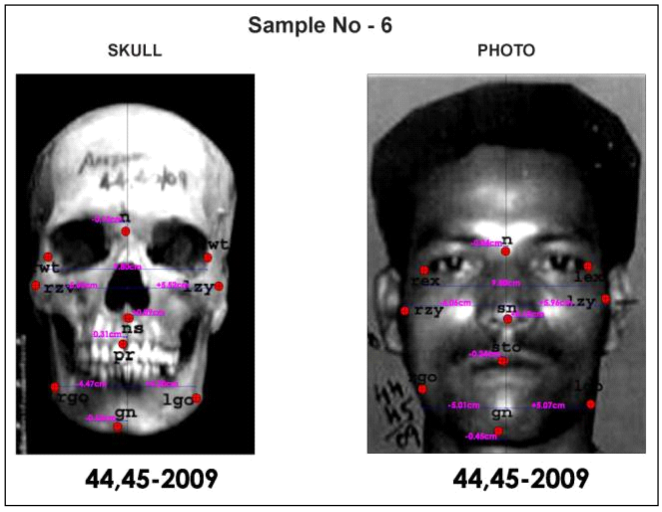
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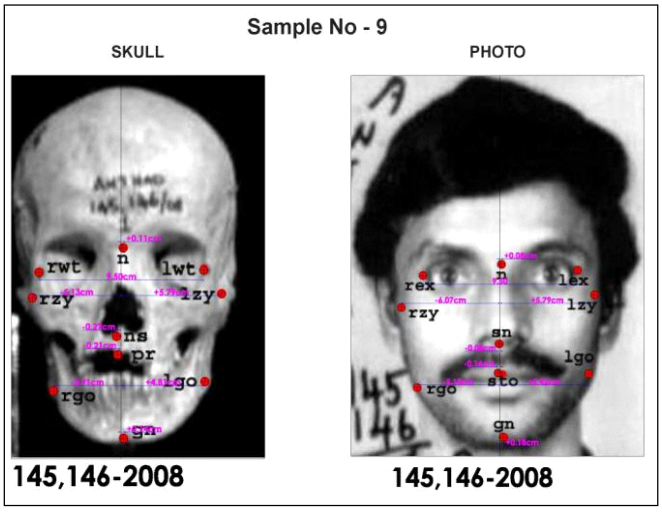
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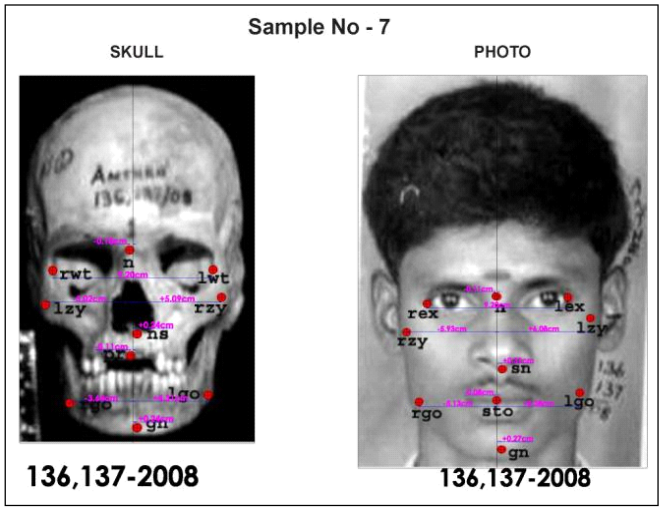
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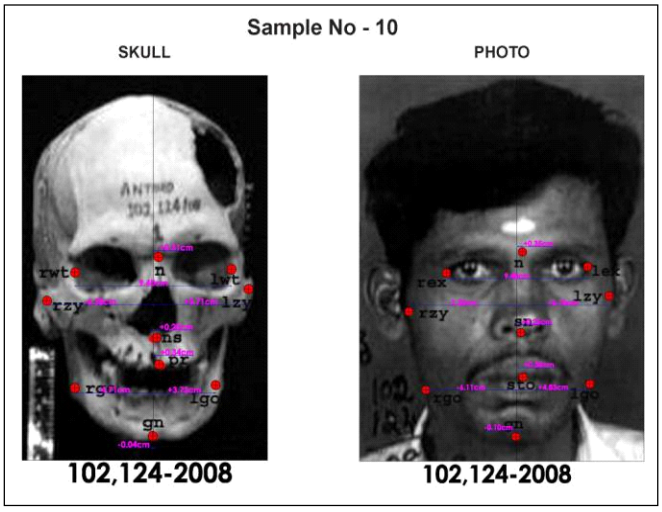
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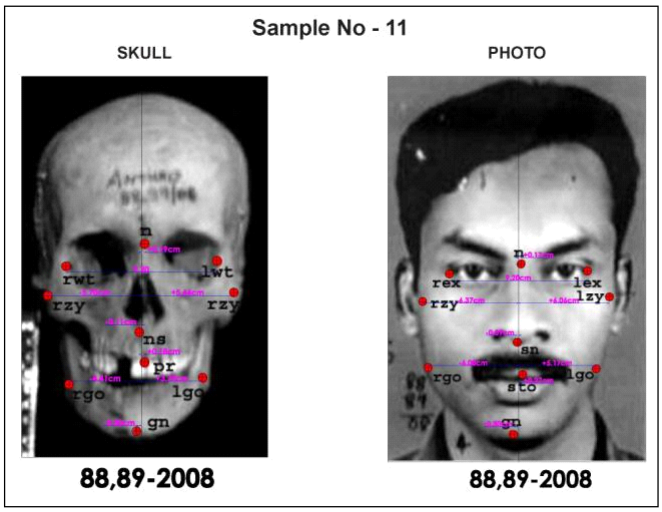
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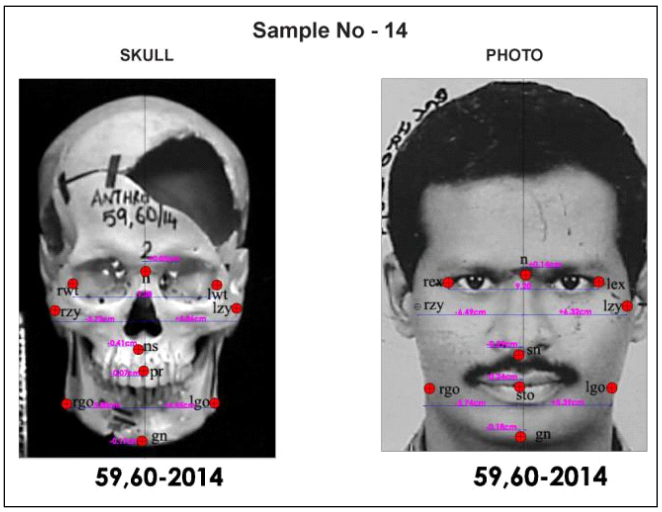
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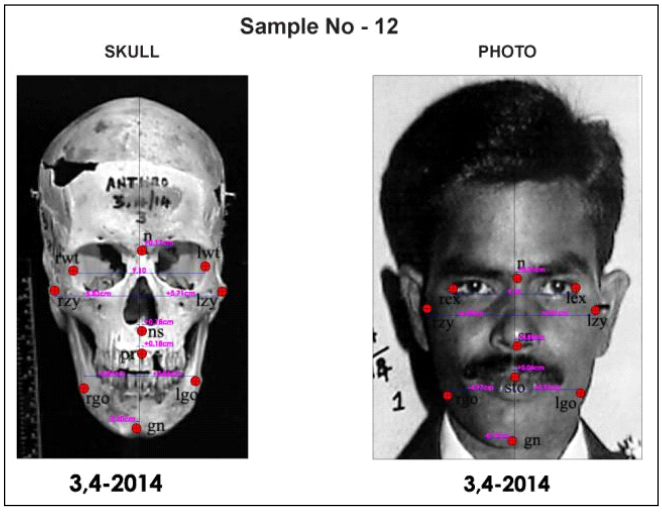
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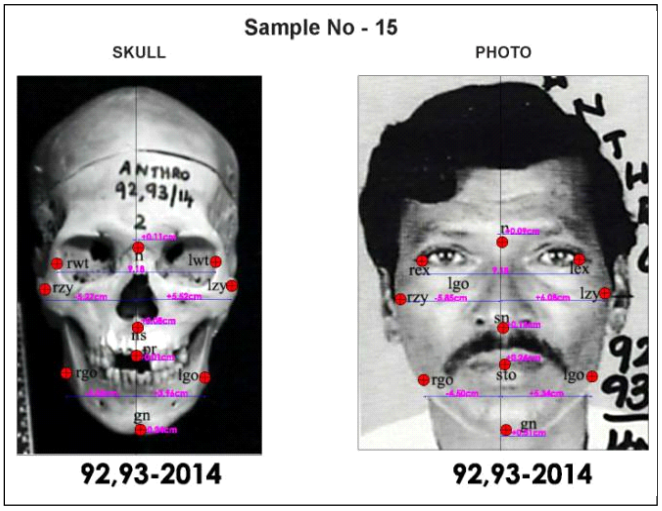
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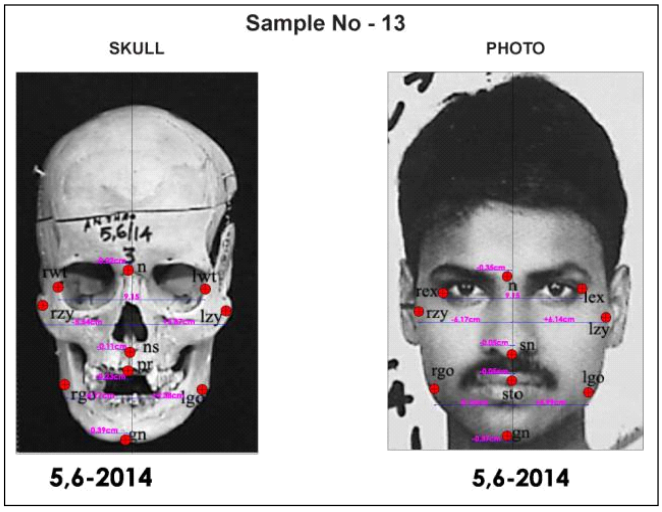
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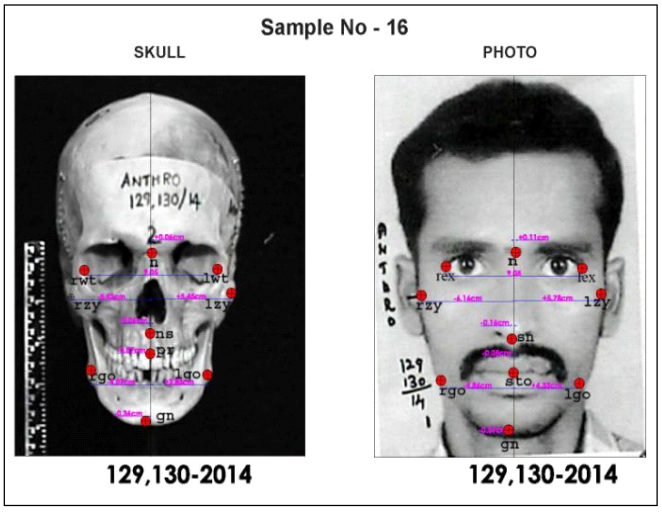
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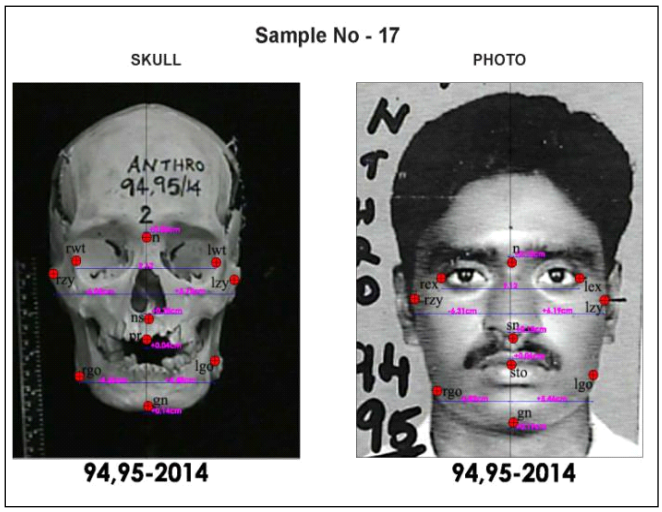
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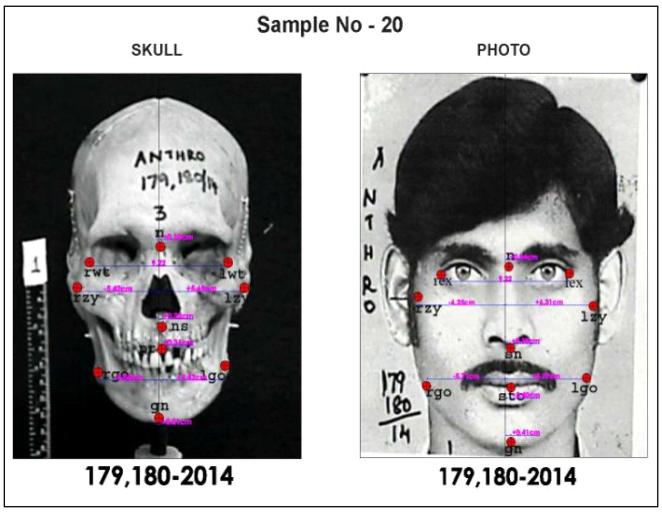
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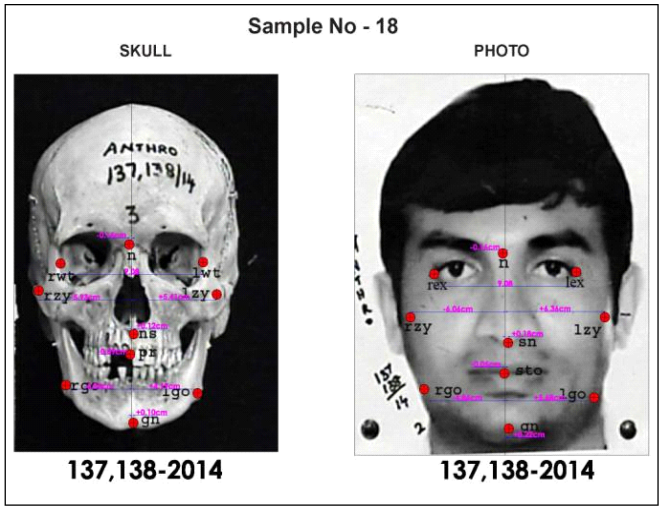
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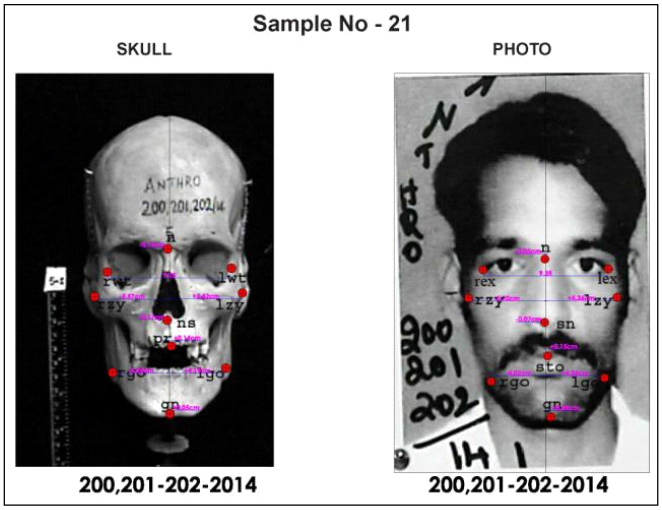
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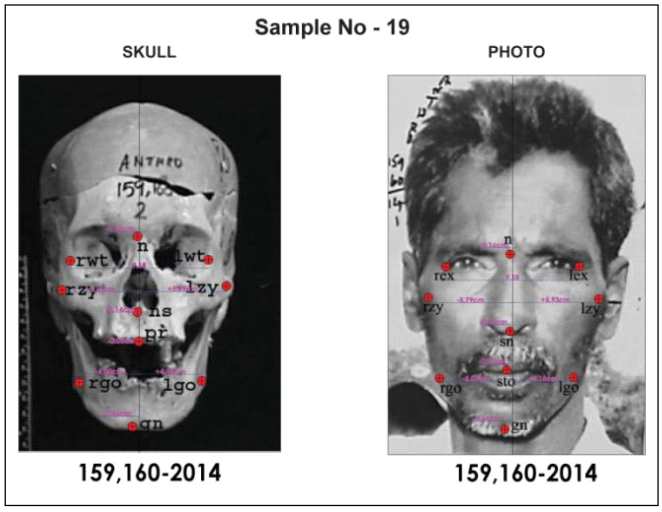
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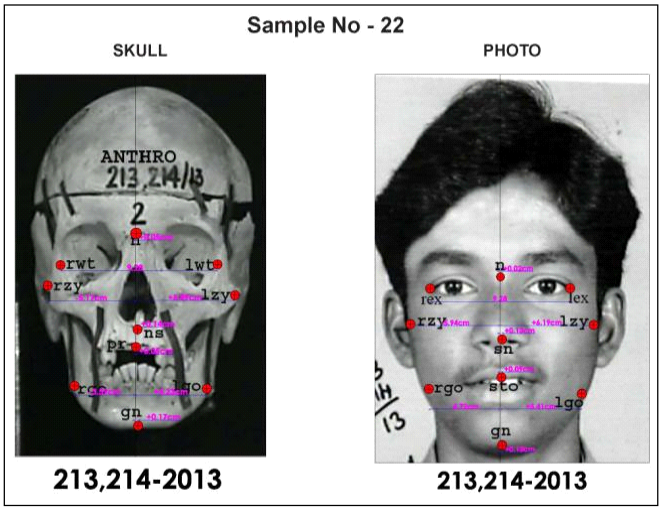
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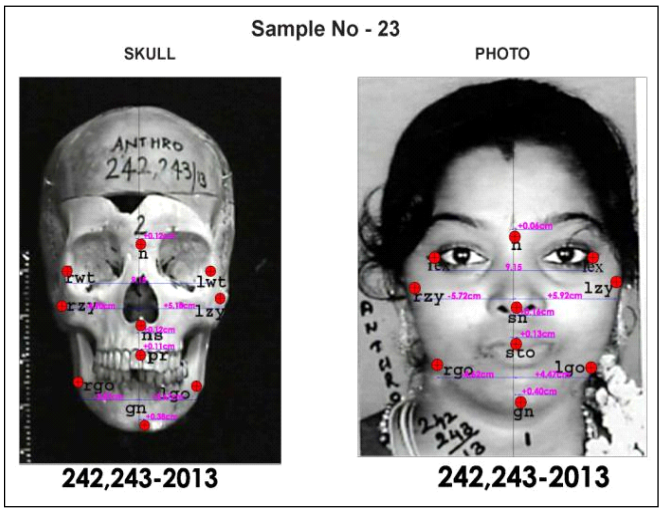
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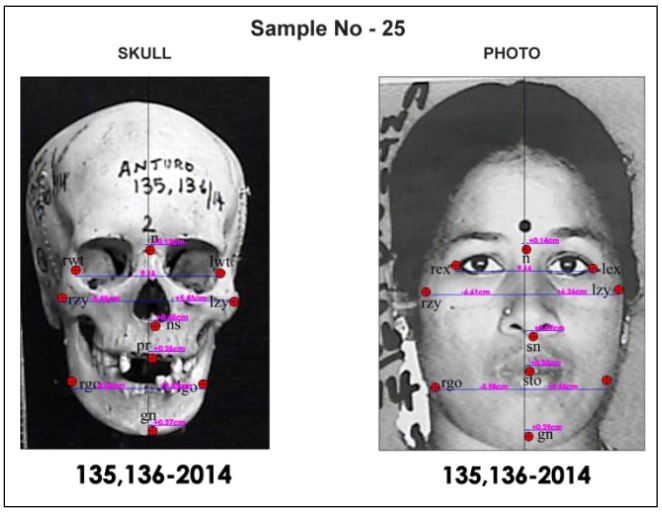
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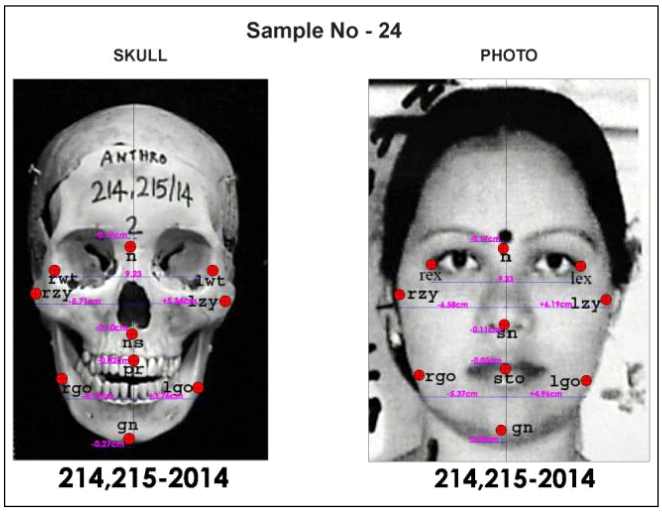
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