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ORIGINAL ARTICLE

Three-Dimensional Facial Morphometric Analysis: A reliability study Based on Facial Data of North Indian Population

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ABSTRACT

CONTEXT: Accuracy of Non-Invasive structure from motion photogrammetry technique for facial data measurement analysis.

AIM: The purpose of the study was to calculate reliable facial anthropometric measurementsusing 3D photogrammetry and its correlation with direct measurements.

MATERIALS AND METHOD: Three-dimensional facial morphometry was investigated in a sample of 40 males and 40 females with structure from motion photogrammetry technique using specific software. Subjects ranged between 18 to 40 years belonging to the Rajput community in the Arki region of Solan district Himachal Pradesh. The subjects had no history of any facial deformity and had sound dentitions. For each subject, the facial and nasal indexes were measured and compared with previous studies.

STATISTICAL ANALYSIS: The SPSS version 23.0 was used to determine the difference between the mean caliper and mean photogrammetry values.

RESULTS: The study shows that the pervasiveness in both male and female facial types hyper-leptoprosopic (very long face)with a mean facial index of 100.76 and 96.70 respectively. The nasal index calculated for males was 90.04 and for females was 78.96. The mean values were in acceptable agreement with the literature data gathered with direct methods. The results suggest that using SfM photogrammetry for facial measurements is accurate when compared with direct anthropometry.

CONCLUSIONS: The technique permits the non-invasive calculation of 3D linear measurements that could be applied in the field of physical anthropology, medical and forensic science.

KEYWORDS | anthropometry, morphology, three-dimensional photogrammetry

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INTRODUCTION

FACIAL MORPHOLOGY ESTIMATION AND grouping assume a significant part in the face anthropometry of numerous scientific applications. Anthropometry is an efficient and non-invasive method for describing craniofacial morphology but with the advent of more sophisticated technologies, we have seen a shift of gathering 3D data of face from manual to digital methods as the measurements are often made manually, which is a tedious and time-consuming process.[1,2] There are various non-invasive methods for the acquisition of data relating to the shape of a 3D object like laser scanning, structured light scanning, and 3D photogrammetry.[3,4] Toalleviate the potential of these methods, it is essential to have reliable anthropometric data of reference populations, which is made possible through the investigation of a large number of representative samples.[5] Facial information

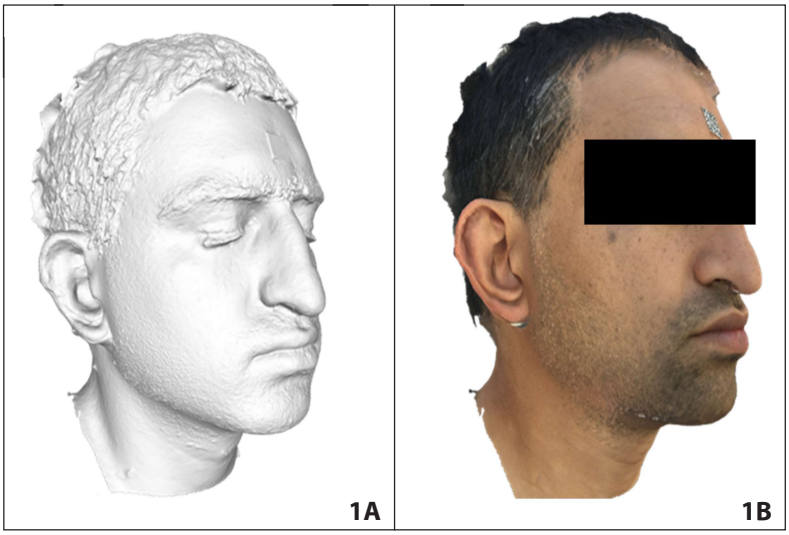

Figure 1: Overview of 3D models. Figure 1A shows 3D generated facial model without texture information and figure 1 B shows the same 3D model with texture information.

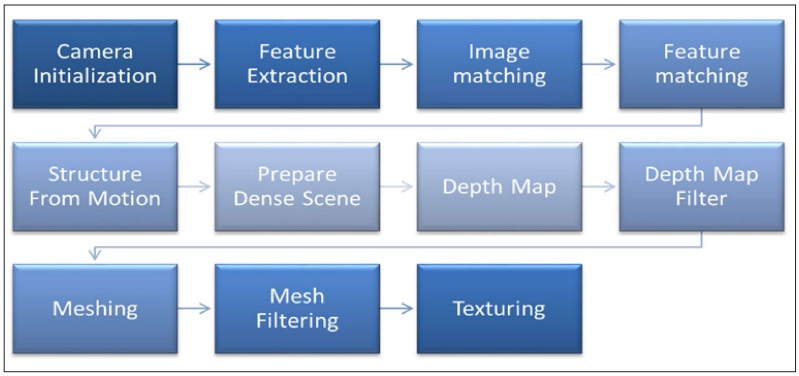

Figure 2: Resulting SfM (Structure from Motion) models were processed in Autodesk Remake 2020.

is ordinarily estimated by anthropometric estimation. The investigation of anthropometry incorporates facial length, facial width, a facial and nasal index which plays an important role in defining facial characteristics.[6,7] As each race has the characteristics that make it unique to other races which help in facial identification in a forensic context. This can then be used for the study of different subjectstoperform repeated measurements of the soft tissue of the face. Photogrammetry is a technique that relies upon photographs to change three-dimensional shapes utilizing the triangulation method to gauge the directions of landmarks on the item to be examined that is the reason it is incorporated inside the non-intrusive procedure. This framework thus requires the distinguishing proof of landmarks that are detectable in each view.[8] Examiners changed and organized this framework with the objective that particular anthropometric estimations could be assessed to a significant degree of accuracy like direct techniques.[9,10] The outcome would be indistinguishable from a 3D surface output (Fig.1) above.

MATERIALS AND METHOD

Three-dimensional facial morphometry was investigated in a sample of 40 males

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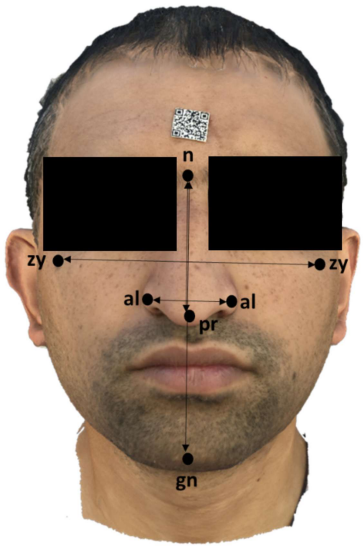

Figure 3: Shows 3D facial model with frontal view and landmarks included in the study for facial measurements.

and 40 females with structure from motion photogrammetry technique using specific software. Subjects ranged in age between 18 to 40 years belonging to the Rajput community in the Arki region of Solan district Himachal Pradesh.The subjects had no history of any facial deformity and had sound dentitions. For each subject, the facial and nasal indexes were measured and compared with previous studies.

The equipment used was a digital single-lens reflex camera without flash (Canon 40D, 10 Mpx) that was mounted on a tripod stand. The photographs were clicked in an open environment in the evening time to avoid any overexposure on the face due to sunlight. The processing of the point cloud and the creation of virtual 3D models were carried out through the use of the SfM technique using Autodesk Recap pro-2020 software. The operation protocol for image processing has been defined in Figure 2 (facing page).

wwMeasurements included in the study are highlighted in Figure 3:

- Facial index (FI) = facial height (n-gn) ×100/ mid face width (zy-zy)
- Nasal index (NI) = nasal height (n-pr) ×100/ nasal width (al-al)
- Here, n- nasion is the root of the nose.
- gn - ganthion is the median point on the lower border of the mandible.
- zy- zygion is the most lateral point on the zygomatic arch.

RESULT AND DISCUSSION

In this study, we have evaluated the facial landmarks obtained using SfM photogrammetry and compared them to manual measurements done with the help of sliding and spreading caliper to access the reliability of our technique. For the assessment, 80 3-D face meshes were created. This 3-D facial data specifies facial traits of the North Indian Rajput community of the Arki region in Solan district of Himachal Pradesh. The result of the study shows that the pervasiveness in both male and female facial types hyperleptoprosopic - very long face - with a mean facial index of 100.76 and 96.70 cm, respectively. The nasal index calculated for males was 90.04 (broad) and for females was 78.96 (medium) as presented in Tables 1 and 2.

The results of the accuracy portion of the study are presented in Table 3. The four variables investigated, demonstrated minimum mean difference of .02 cm in nasal length of male subjects while the maximum difference was observed in nasal width of male subjects

No.	Shape of Face	Range of Face Index	Shape of Nose	Range of Nasal Index
1.	Hypereuroprosopic (very broad face)	< 79.9	Very narrow	< 54.9
2.	Europrosopic (broad face)	80 to 84.9	Narrow	55 – 69.9
3.	Mesoproscopic (round face)	85 to 89.9	Medium	70 -84.9
4.	Leptoprosopic (long face)	90 to 94.9	Broad	85 – 99.9
5.	Hyperleptoprosopic (very long face)	> 95	Very broad	> 100

Table 1: Classification of Face and Nose type.

	Mean (Male)	Min	Max	Mean (Female)	Min	Max
Morphological Facial Length	11.08	10.02	11.8	10.17	8.22	11.7
Morphological Facial Width	11.04	10.03	11.9	10.5	8.9	11.3
Facial Index	100.76	89.65	110.7	96.70	85.65	115.2
Morphological Nasal Length	4.42	3.6	5.2	4.15	3.4	5.2
Morphological Nasal Width	4.04	3.4	5.1	3.29	2.6	4.6
Nasal Index	90.04	75.45	110.88	78.96	64.2	103.23

Table 2: Shows the Mean and Range of meameasurements observed in the study.

Landmark Distances	Obtained by Photogrammetry	Obtained by Sliding Caliper	Difference
n-gn Facial Height	11.08 10.17	11.40 10.30	0.32 0.13
zy-zy Facial Width	11.04 10.50	11.20 10.30	0.16 0.20
n-pr Nasal Length	4.42 4.15	4.40 4.20	0.02 0.15
al-al Nasal Width	4.04 3.29	4.50 3.40	0.44 0.11

Table 4: Inter-method comparison of measured mean values and their difference :

on comparison with direct anthropometry. The mean values were in acceptable agreement with the literature data gathered with direct methods. The results suggest that using SfM photogrammetry for facial measurements is accurate when compared with direct anthropometry.

CONCLUSION

The goal of our research was to create 3D facial data for scientific applications. In this preliminary study, we focused on measuring facial and nasal index for which we intended to reproduce the classification results obtained manually by different authors on similar populations. This 3D facial morphometric study assists in normative and gene studies where such data sets are crucial. IJFMP

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