Original article

Facial dimension on three-dimensional computed tomography in patients with epilepsy: A preliminary study

Lubna Shirin[1], Tahamina Begum[2], Mohammed Shahjahan Kabir[3], Nor Farid Mohammed Noor[4], Hadif Zaidin Samsudin[5], Rehana Basri[6], Johari Yap Abdullah[7], Aminul Islam[8]

Abstract:

Purpose: This study was undertaken to establish the facial anthropometric discrepancies in epilepsy and normal population of both genders. ***Methods:*** This Retrospective study was done in School of Dental Sciences, Universiti Sains Malaysia (USM). CT images weretaken from CT database archive from year 2010 to 2017 in Hospital Universiti Sains Malaysia (HUSM). The study group consisted of 9 epileptics & 9 healthy volunteers (aged between 42-56 years) who had no history of mixed racial parentage. 13 linear measurements were taken from 13 facial anthropometric landmarks including mandibles were first identified on each image according to standard definitions. The attained images were analysed using the Mimics Materialize measurement software ((Mimics 17.02 Materialise Leuven, Belgium). ***Results:*** The current study consisting 3 females vs 6 males representing in epileptic population & 2 female & 7 males in control populations. The results revealed sexual dimorphism in all the dimensional features of face, ocular region and the nasal region. The males having higher mean values than the females.In comparison with control male vs epileptic male showed significant variation onxygomaxillary (zm-zm) parameters. With regards of females there were no significant differences present within control groups and epilepsy groups. In thecontrol male group, result showed significantly (p= 0.04) longer mean values of nasion_alveoli (71.88 ±2.80 mm) compared to the control female group (65.63±0.94 mm) and highly significant difference were found in nasion_alveoli (na-al) and nasion_subnasale (n-sn) in between the epilepsy population of both sexes. The study was not concerned about age and ethnicity. ***Conclusion:*** The main objective of this work is to provide the standard values of epileptic patients' data of both genders.The differences between that of epileptic patients against the control population may provide clear standards of variation with regards to facial analysis. This may contribute to a more in depth and nuanced phenotypic evaluation in the future. It has a large application to construct Forensic Medicine, Plastic Surgery, Orthodontics, Archaeology in the study epileptic populations. The facial, nasal and ocular, measurements among the most important cephalometric results that have been used to describe sexual differences.This study showed gender as an important factor in the description of human physiognomy.

Keywords: Facial anthropometry; Mimics 17.0 Materialise software.

Bangladesh Journal of Medical Science Vol. 22 No. 01 January'23 Page : 97-104
DOI: https://doi.org/10.3329/bjms.v22i1.61859

1. Lubna Shirin, Deparment of Anatomy, Faculty of Medicine, Universiti Teknolologi Mara (UiTM), Malaysia.
2. Tahamina Begum, Department of Neuroscience, School of Medical Sciences, 16150, Kota Bharu, Kelantan, Malaysia.
3. Mohammed Shahjahan Kabir,School of Medicine, Perdana University, Royal College of Surgeons Ireland (PURCSI), 50490, Kuala Lumpur, Malaysia.
4. Nor Farid Mohammed Noor, Faculty of Medicine, Universiti Sultan Zainal Abidin (Uni SZA) medical campus Malaysia.
5. Hadif Zaidin Samsudin, Department of Radiology, School of Medical Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian, Kota Bharu, Kelantan, Malaysia.
6. Rehana Basri, Department of Internal Medicine, Al-Jouf University, Kingdom of Saudia Arabia.
7. Johari Yap Abdullah, Craniofacial Medical Imaging Research group, School of Dental Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian, Kota Bharu, Kelantan, Malaysia.
8. Aminul Islam, School of Business Innovation and Technopreneurship, Universiti Malaysia Perlis, Perlis, Malaysia

Correspondence: Lubna Shirin, Deparment of Anatomy, Faculty of Medicine, Universiti Teknolologi Mara (UiTM), Malaysia. *E-mail:* lubna@mahsa.edu.my, lubnashirin91@gmail.com.

Introduction:

For the diagnosis of genetic and craniofacial disease, facial appearance is one of the important phenotypic features[1].Facial dysmorphism is caused by many pathogenic structural modifications of human genome. Hereditary factors can alter the human face shape[2] and on the contrary 30–40% of genetic disorders have craniofacial manifestations[3]. Many disorders have a characteristic facial feature that is important in genetic diagnosis and management[4]. Pathogenic structural variants are currently the most commonly known genetic risk factor for epilepsy, such as 15q13.3 microdeletion which has been associated with autism[5], schizophrenia[6],epilepsy[7]a ndintellectual disability with facial dysmorphism[8]. Epilepsy is believed as a genetic disorder and it is defined as disease which has at least two unprovoked or reflex seizures happening more than 24 hours at a distance[9]. Currently, ILAE revised the definition of epilepsy and was mentioned as a disease rather than a disorder. A study showed that prolonged use of AEDs therapy in young male epilepsy patients causes atypical face shape and significant bone loss at the hip in the absence of vitamin D deficiency[2]. Facial data also provide the information in sexual dimorphism. It was seen that males have higher measurement than female mostly in the lower third of face tends to be narrower than men. The implications extend to the surgical planning related to the gender differences[10]. Few studies have conducted the craniofacial measurement on epilepsy patient on aborad[2] but there is no study in Malaysia. Hence,the present study showed craniofacial measurement in epilepsy patients including mandible.

As of now 2D & 3D computed tomography are used for the linear measurement of the facial landmark instead of digital cephalometry because they are found to be the most effective and reliable[11]. 3D CT technology also applied to the study of congenital craniofacial abnormalities,3Dsurface reconstruction, assist clinical management, differentiation of phenotype, effect of craniofacial surgery on craniofacial growth and the formation and evaluation about the mechanism of malformation and defection[12]. The 3D imaging devices includes photogrammetry, laser acquisition systems, structured light systems, video imaging, and x-ray methods such as computerized tomography (CT), cone beam computerized tomography (CBCT), magnetic resonance imaging (MRI) and ultrasound (US)[13]. The 3-D models will give us better information for surgical treatment of different facial irregularities[11]. Concerning the facial features between the middle age and younger age groups the differences are identified only in neck height, weight and circumferences[14]. Many more studies have been conducted all over the world on different craniofacial morphological variants of normal populations[15,16,17,18,1]. Therefore, the present study consists of 13 linear craniofacial measurementsincluding mandible between control and epilepsy groups using 3DCT scan applying mimics 17.02 software.

Materials and Methods:

This is a retrospective study. Simple random sampling was used in this current study. A single examiner performed all the measurements. CT images was collected from CT database archive from year 2010 to 2017 in Hospital Universiti Sains Malaysia (HUSM). The attained images were analyzed using the Mimics Materialize measurement software((Mimics 17.02 Materialise Leuven, Belgium).13 anthropometric landmarks were first identified on each image according to standard definitions [14] (Table 1). The study group consisted of 9 epileptics & 9 healthy volunteers (aged between 42-56 years).

The following linear measurements between these landmarks were automatically calculated by the software.The landmarks of the facial skeleton measurements will be determined on the 3D-CT with their definitions following Table 1.

Table 1 Skeletal craniofacial landmarks and their definitions.

Mid face with mandible anthropometric measurement

Landmark	Definition	Measurement
fz-fz	Fronto-zygomatic	Lowest point on the suture between the zygomatic proses of frontal bone and frontal proses of maxillary bones.
if-if	Infra orbital	Most medial point of infraorbital foramen.
zm-zm	zygo maxillary	Maximum maxillary width Lowest point on the suture between the zygomatic and maxilla bones

Landmark	Definition	Measurement
zy-zy	zy=Zygion to zygion	Bizygomatic arch width
n-gn	n=nasion gn= gnathion	The junction between the nasal and frontonasal sutures to the most inferior point on the mandibular symphysis in the midsagittal plane
na-al	na=Nasion al= Alveoli	nasion Midsagittal point at junction of frontal and nasal bones at nasofrontal suture to tip of maxillary alveolar bone between the incisors.
en-en	en=endocanthus	Interorbital width.
ex-ex	ex=exocanthus	Maximum orbital width.
n-sn	n=Nasion sn=Subnasale	point in the midline of the nasal root and the nasofrontal suture to midpoint of the columella base at the apex of the angle where the lower border of the nasal septum and the upper lip meet.
al-al	al=ala of nose	Nasal aperture width, Most lateral point on each alar contour.
go-go	go= gonion	Bigonial width.
mf-mf	mf=mental foramen	Foramen mentalia breadth.
go-me		Mandible body length (right and left)

Data Analysis:

All data was analysed by SPSS version 22.0 for Windows (Statistical Package for the Social Sciences, Chicago, IL, USA) using Mann-Whitney U test to evaluate if there was any significant difference in the measurement between the genders of epilepsy and control.The significant difference was determined by the p -value less than ≤ 0.05 (P ≤ 0.05).

Ethical clearance: This study was approved by the Ethical Committee of HUSM(USM/JEPeM/17030155).

Results:

Demographic information was shown in Table 1 for both control and epilepsy groups. Craniofacial anthropometric measurements were done between intra and inter groups which were described in Table 2, 3, 4, 5 and Figure 1, 2, 3 and 4, respectively.

Table 1: Demographic information for control and epilepsy groups

Groups	Control		Epilepsy	
	Male	Female	Male	Female
Number (n)	7	2	6	3
Mean age (±SD)	42.29 (±15.23)	44 (±6)	45.66 (±19.23)	56 (±17.91)

In the control group, a total of nine (9) subjects were recruited; seven (7) malesand two (2) females. Their mean ages were 42.29 ±15.23 & 44 ±6 years, respectively. In contrast, the epilepsy group consisted of six (6) males and three (3) females with the mean ages of 45.66±19.23 & 56±17.91years, respectively (Table 1).

Table 2: Craniofacial anthropometric measurement was shown in male between control and epilepsy groups

Measurement (in mm)	Control. Male	Epilepsy. Male	*p*-value
frontozygomatic (fz-fz)	110.09±4.82	106.46±3.86	0.153
Infraorbital(if-if)	55.66±6.06	58.82±8.50	0.352
Zygomaxillary (zm-zm)	76.31±8.95	104.50±5.89	***0.003***
Zygion (zy-zy)	123.62±4.87	126.10±6.08	0.391
nasion_gnathion (n-gn)	122.22±8.25	111.84±9.13	0.63
nasion_alveoli (na-al)	71.88±2.80	71.65±3.01	1.00
Endocanthus (en-en)	24.61±4.76	29.38±14.18	0.475
Exocanthus (ex-ex)	96.37±2.95	96.77±3.13	0.886
nasion_subnasale (n-sn)	52.96± 2.73	53.67±1.37	0.775
ala_ala (al-al)	20.69±2.41	32.13±23.36	0.116
Gonion (go-go)	99.7±3.93	107.25±8.56	0.086
mental_foramen (mf-mf)	48.25±2.85	49.94±5.09	0.668
gonion_menton (go-me)	101.24±22.85	93.54±13.64	0.568

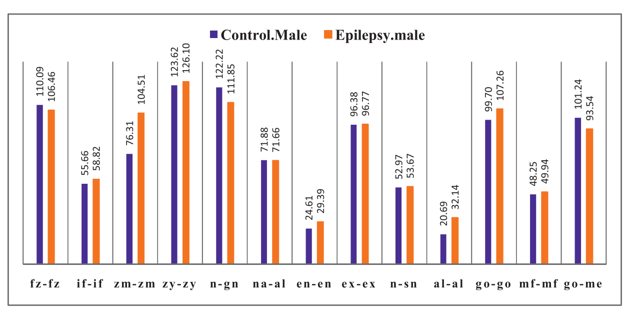

Figure 1: Bar chart showed the craniofacial anthropometric measurement in male between control and epilepsy groups.

13 parameters of craniofacial anthropometric measurement were revealed in male between control

and epilepsy groups. There wereno significant differences between groups in male except zygomaxillary (zm-zm) measurement. Epilepsy male group showed significantly (*p= 0.003*) larger (104.5 ± 5.91mm) zm-zmmeasurement than control (76.31±8.95mm) group (Table 2, Figure 1).

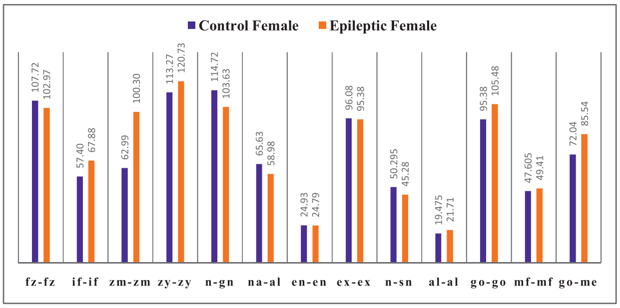

Figure 2: Bar chart showed the craniofacial anthropometric measurement in female between control and epilepsy groups

Table 3: Facial anthropometric measurement in female between control and epilepsy groups

Measurement (in mm)	Control. Female	Epilepsy. Female	*p*-value
frontozygomatic (fz-fz)	107.71±1.71	102.97±3.03	0.083
Infraorbital(if-if)	57.39±1.30	67.88±21.54	0.564
Zygomaxillary (zm-zm)	62.99±1.58	100.30±8.67	0.083
Zygion (zy-zy)	113.27±0.79	120.73±1.99	0.083
nasion_gnathion (n-gn)	114.71±0.23	103.62±7.55	0.083
nasion_alveoli (na-al)	65.63±0.94	58.98±7.69	0.564
Endocanthus (en-en)	24.92±1.89	24.79±1.96	1.000
Exocanthus (ex-ex)	96.07±1.92	95.37±3.71	1.000
nasion_subnasale(n-sn)	50.29±0.20	45.28±6.01	0.564
ala_ala (al-al)	19.47±0.98	21.71±2.84	0.564
Gonion (gn-gn)	95.38±1.46	105.48±9.20	0.248
mental_foramen (mf-mf)	47.60±0.63	49.41±2.85	0.564
gonion_menton (gn-me)	72.03±8.875	85.54±6.46	0.248

Table 3 and Figure 2 demonstrated the craniofacial anthropometric measurement of control female VS epileptic female. A Mann Whitney test was performed to evaluate if there were any significant differences in the measurement between two groups. A *p*-value of < 0.05 was set as being statistically significant. But no significant difference was found (Figure 2, Table 3).

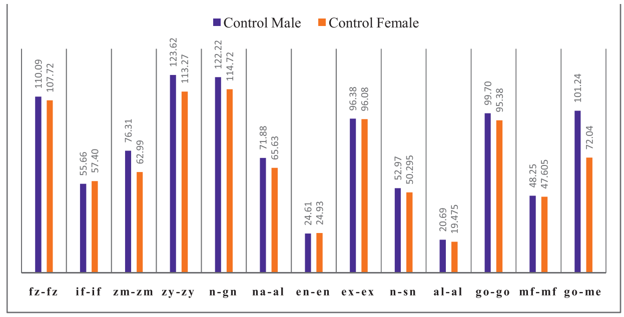

Figure 3: Bar chart showed the craniofacial anthropometric measurement between control male and control female groups.

Table 4: Craniofacial anthropometric measurement between control male andcontrol female

Measurement (in mm)	Control. Male	Control. Female	*P*-value
frontozygomatic (fz-fz)	110.09±4.82	107.71±1.71	0.242
Infraorbital (if-if)	55.66± 6.06	57.39±1.30	0.380
Zygomaxillary (zm-zm)	76.31±8.95	62.99±1.58	0.079
Zygion (zy-zy)	123.62±4.87	113.27±0.79	0.079
nasion_gnathion (n-gn)	122.22±8.25	114.715±0.23	0.380
nasion_alveoli (na-al)	71.88±2.80	65.63±0.94	***0.040***
Endocanthus (en-en)	24.61±4.76	24.92±1.89	0.380
Exocanthus (ex-ex)	96.37±2.95	96.075±1.92	1.000
nasion_subnasale (n-sn)	52.96±2.73	50.29±0.205	0.143
ala_ala (al-al)	20.69±2.41	19.47±0.98	0.770
Gonion (go-go)	99.7±3.93	95.38±1.46	0.242
mental_foramen (mf-mf)	48.25±2.85	47.605±0.63	0.770
gonion_menton (go-me)	101.24±22.85	72.035±8.87	0.079

Table 4 and Figure 3 revealed 13craniofacial anthropometric measurement between control male and control female. Control male group showed significantly (*p= 0.04*) longer mean values of nasion_alveoli (71.88±2.80 mm) compared to the control female group (65.63±0.94mm).The other 12 parameters showed no significant differences (> 0.05) between groups (Figure 3, Table 4).

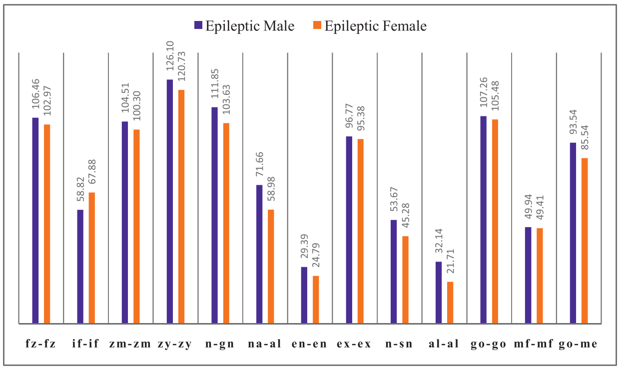

Figure 4: Bar chart showed the craniofacial anthropometric measurement between epilepsy male versus epilepsy female group.

Table 5: Craniofacial anthropometric measurement between epilepsy male and epilepsy female

Measurement (in mm)	Epilepsy. Male	Epilepsy. Female	*p*-value
frontozygomatic (fz-fz)	106.46±3.86	102.97±3.03	0.197
Infraorbital (if-if)	58.8216±8.51	67.88±21.54	0.796
Zygomaxillary (zm-zm)	104.51±5.90	100.30±8.68	0.606
Zygion (zy-zy)	126.10±6.08	120.73±1.99	0.197
nasion_gnathion (n-gn)	111.84±9.14	103.63±7.55	0.302
nasion_alveoli (na-al)	71.66±3.01	58.98±7.70	***0.039***
Endocanthus (en-en)	29.39±14.19	24.80±1.97	0.439
Exocanthus (ex-ex)	96.77±3.14	95.38±3.71	0.606
nasion_subnasale (n-sn)	53.67±1.38	45.28±6.02	***0.039***
ala_ala (al-al)	32.14±23.37	21.71±2.84	0.302
Gonion (go-go)	107.26±8.56	105.48±9.21	0.796
mental_foramen(mf-mf)	49.94±5.10	49.41±2.86	0.796
gonion_menton (go-me)	93.54±13.64	85.54±6.46	0.606

Table 5 and Figure 4 demonstrated the craniofacial anthropometric measurement of epileptic male between epileptic female. A Mann Whitney test was performed to evaluate if there were any significant differences in the measurement between two groups. A *p*-value of < 0.05 was set as being statistically significant. Highly significant difference was found in nasion_alveoli (na-al) and nasion_subnasale (n-sn)in between 2 groups (Figure 4, Table 5).

Discussion:

The facial, nasal and ocular dimensions are the most important cephalometric parameters of human. Many facial anthropometric studies have been based on ethnicityin normal population of various country. Ethnic differences were not considered in our study.

In the current study, observed the 13 linear dimensions of facial measurements of both gender in the epileptic and control group. The study group consists of 9 epileptic (3 female & 6 male) mean ages of 45.66 ±19.23 & 56 ±17.91 years respectively and 9 control (2 female & 6 male). Their mean ages were 42.29 ±15.23 & 44 ±6 years accordingly. The main objective was to find out any differences between the 2 groups in both genders.

In the comparison with the male gender of control and epilepsy population out of the 13 parameters, zygomaxillay (zm-zm) was found to be significant. Epilepsy male group showed significantly (*p= 0.003*) larger than control group (Table 2, Figure 1). Yahya., MRB (2013) in his study presented the zygomaxillary (zm-zm) measurement is significant in both genders but higher in the male control group as well all ethnic (Malay, Chinese and Indian) populations in Malaysia. Out of 13 parameters, the other parameters like fz-fz, is higher in control male in this present study, which is similar with Yahya[11] study.

In another contrastbetween the control and epileptic population suggested that na_alveoli were significant in both sexes. In both groups the mean values exhibited nasion_alveoliin higher in male than in female. Yahya, MRB.,2013 also presented a study that nasionalveoli measurement in male is higher than normal female which is completely agree with our study[11]. The findings by Kharbandaetet al (1991) found significant differences in Indian male and females[19]. Another study by Pandey (2006) examined about the sexual dimorphism seen in the Onges tribes in India. Mean facial height is of adult Igbo males in Nigeria were significantly higher than Igbo females[20].

Nasion_subnasale (n-sn) presented significant variation between epileptic male vs epileptic female. The mean values of epileptic male are higher than epileptic femaleNgeow, W.C. (2012) was done his study in young Malaysian Indian population of both genders. The study similar to thecurrentstudy[18]. According to Omotoso et al, (2011)nasal length was significantly higher in male which was concurred with the present study[15]. The mean nasal height of adult Igbo males in Nigeria were significantly higher (P < 0.05) than the values for adult Igbo females showed by Olotu et al (2009) and H. Jagadish

Chandra, (2012)had done his study in India but the parameters were dissimilar with the present study[21, 22].

Other parameters in the present study incracanthal width, bioccular width, intra alar length, gonion_ gonion, mentral _foramen and gonion_menton, bizygomatic width showed no significant differences in control genders from the epileptic genders. The parameters of present study if-if, zy-zy, en-en, n-sn, al-al, go-go, go-me were increased values in epileptic male. V. Kaplanoglu (2014) stated biorbital and interorbital were found to be higher in normal males population[23]. Malaysian Malay men, compared to women, have a wider distance between the eyes, longer and more prominent noses and longer faces according to Siti[17].

In control and epileptic female, if-if, zm-zm, zy-zy, ex-ex, al-al, go-go, mf-mf, go-me have increased values. Saba Alkhairy, (2016) concluded in her study that outer canthal distance in male is larger in control male than female, which was agreed with study done on the ljaws, Turks, Nigerians, and Latvians[16].

The comparison study was done between normal population of Sudanese female, North American Women (NAW) and African American (AA) women by Muhia Salah, (2014). The study presented the midface, nasal, upper and lower face heights were significantly taller but decreased values was seen in bizygomatic width in Sudanese female compare with North American women sample. The parameters of outer canthal distance (ex-ex) have less values than African American compared to North American Women and Sudanese female revealed reduced intra alar width (ala-ala) compared with AA but wider in NAW[24]. A study by H. Jagadish Chandra., (2012) India showed highly significant variation were observed in, facial, mandibular—face width, upper face, mandibular width—face height, mouth—face width, lower face—face height proportions in local population[22].Georgios V Zacharopoulos, (2016) stated thatGreek males had significantly wider faces and mandibles than the North American Caucasian males, whereas Greek females had only significantly wider mandibles than their North American counterparts[25]. The present study exhibits the mandibular width, mental foramen and mandibular body width was higher in epileptic female than control.

Gulf Cooperation Council (GCC) Arab males had significantly wider noses, broader maxillary arches and wider mouths than females ($P<0.001$). Anterior maxillary arches were found to be wide in males and females, which looks to be an ethnic characteristic in Arabs of this region by Amol Dharap, (2013). In the present work showed the intra alar width (al-al) was higher in the epilepsy of male & femaleboth but mandibular body width is higher in control male and epileptic female[26]. Gender dimorphism is observed in many craniofacial bones markedly in maxilla and mandible. Facial aging in dentate patient is categorized through retrusion of the face in relation to lower jaw. Systemic osteoporosis often seen in the female, but radiological diagnosis is quite rare[27]

Accurate determination of gender from the human skull is of great importance in anthropologic and forensic investigations. It must be good that a population-specific work is involved in society to receive. Exact results in identifying biological sex from a skeleton derived from that population [5, 28].

Conclusion:

Facial anthropometric differences were observed from 3D CT images of control and epileptic patients of both male and female by using Mimics 17.0 software. Males generally have a bigger value in many measurements as compared with females. The data which was attained from the study hopefully used by the oral & maxillofacial surgeon, plastic surgeons, and orthodontist. The process of diagnosis, investigations and treatment planning become easier and faster by means of different new generation imaging techniques. The grandness of this work is to furnish the standard values of data that can be employed to construct the epileptic patients of both genders to face shape analysis, which may contribute to deepening phenotypic evaluation in future.

Limitation:

1. Limited sample size.
2. In this retrospective 3D CT study having few samples of whole face with mandible. Whole CT scans with head, face & mandible together is very difficult to obtain.Thus, the present study only got 6 epileptic male and 3 epileptic female population and for comparison 7 control male & 2 control female population. So, the study did not manage equal size and small number male and female population.

Conflict of interest: None

Author contribution:

S.No.	Name	Role in the study
1	Lubna Shirin	Plan the study, Data collection, Revision
2.	Tahamina Begum	Editing, Revision
3.	Mohammed Shahjahan Kabir	Editing, Draft Preparation
4.	Nor Farid Mohammed Noor	Draft preparation
5.	HadifZaidinSamsudin	Data colletion
6.	Rehana Basri	Plan the study, Data collection
7.	Johari Yap Abdullah	Data analysis
8.	Md. Aminul Islam	Data analysis evaluation

References:

1. Jayaratne Yasas S. N, Curtis K Deutsch aoger A Zwahlen. Normative Findings for Periocular Anthropometric Measurements among Chinese Young Adults in Hong Kong. *BioMed Research International* 2013. DOI: :10.1155/2013/821428. http://dx.doi.org/10.1155/2013/821428.
2. Chintapalli, K, Bartolini E., Novy J., Suttie M., Marini C, Falchi, M, Fox Z, M. S. Clayton L, Sander JW, Guerrini R, Depondt C, Hennekam R, Hammond P, Sisodiya SM. Atypical face shape and genomic structural variants in epilepsy. *Brain a Journal of Nueurology*; 2012: 1-14. DOI: http://brain.oxfordjournals.org/
3. Hart TC and Hart PS. Genetic studies of craniofacial anomalies: clinical implications and applications. *Orthod Craniofac Res* 2009;**12**: 212–20.

4. Hennekam RC, Krantz ID and Allanson JE. Gorlin's syndromes of the head and neck. *Oxford University Press* 2010*;* ***5***, Oxford; New York.
5. Miller DT, Adam MP, Aradhya S, et al Consensus statement: chromosomal microarray is a first-tier clinical diagnostic test for individuals with developmental disabilities or congenital anomalies. *Am J Hum Genet* 2010.**86**: 749–764.
6. Stafstrom CE and Carmant l. Seizures and Epilepsy: An Overview for Neuroscientists. *Cold Spring HarbPerspect Med* 2015;1-18. doi: 10.1101/cshperspect. a022426
7. HelbigI, et al. Structural genomic variation in childhood epilepsies with complex phenotypes *European Journal of Human Genetics*2014. **22**;896–90141:160–2. DOI:10.1038/ejhg.2013.262.
8. Sharp AJ, Mefford HC, Li K, Baker C, Skinner C, Stevenson RE A recurrent 15q13.3 microdeletion syndrome associated with mental retardation and seizures 2008. *Nat Genet*; **40** (3): 322–8.DOI: 10.1038/ng.93
9. Fisher RS, et al. A practical clinical definition of epilepsy. *Epilepsia*2014; **55** (4): 475-482.DOI: 10.1111/epi.12550https://plus.google.com/109426761449189158141/?hl=en
10. Yahya MRB, Rahman SA, Alam, MK. Facial Skeleton Morphometry: A 3D Study. *International Medical Journal* 2013; **20**:6716 – 720. DOI:https://www.researchgate.net/publication/259694953
11. Z.A. Rajion. Craniofacial Computed Tomography Imaging: A Review. *Archives of Orofacial Sciences* 2006; **1**: 5-8.DOI: https://www.researchgate.net/publication/45459001
12. Kau CH, Richmond S, Incrapera A, English J and Xia JJ. Three-dimensional surface acquisition systems for the study of facial morphology and their application to maxillofacial surgery. *Int J Med Robot* 2007; **3**: 97-110. DOI: https://doi.org/10.1002/rcs.141
13. Shah S and Koirala S. Role of Craniofacial Anthropometry in Medical Science International Invention. *Journal of Medicine and Medical Sciences* 2015; Vol. **2**(4); pp. 44-48.DOI: http://internationalinventjournals.org/journals/IIJMMS.
14. Omotoso DR, Oludiran OO and Sakpa CL. Nasofacial Anthropometry of Adult Bini Tribe in Nigeria. *Afr J Biomed Res* 2011*;* **14**:219-21.
15. Alkhairy S, Siddiqui F and Hassan UM. Orbitofacial Anthropometry in a Pakistani Population. *Pak J Ophthalmol* 2016; 32 (1).
16. Othman SA, Majawit LP, Wan Hassan WN, Wey MC and Mohd Razi R. Anthropometric Study of Three-Dimensional Facial Morphology in Malay Adults. *PLoS* 2016 1 **11**(10). DOI: 10.1371/journal.pone.0164180
17. Ngeow WC and Aljunid ST. Craniofacial anthropometric norms of Malays. *Singapore Medical Journal* 2009**; 50** (5): 525-528. DOI:https://www.researchgate.net/publication/26265881
18. Kharbanda O.P, Sidhu S.S and Sundrum K.R. Vertical Proportions of face: A Cephalometry Study. *Int. J. Orthod*1991. Fall- Winter; **29** (3- 4): 6 – 8.
19. Pandey A. K. Cephalo-facial variation among Onges. *Kamla – Raj Anthropologist*, 2006.;**8**(4): 245 – 249.
20. Olotu J, Eroje A, Oladipo G and Edibamode E. Anthropometric study of the facial and nasal length of Adult Igbo ethnic group in Nigeria. *The Internet Journal of Biological Anthropology* 2009; **2** (2).
21. H. Jagadish Chandra, M. S. Ravi, S. M. Sharma and B. Rajendra Prasad. Standards of Facial Esthetics: An Anthropometric Study *J. Maxillofac. Oral Surg*2012;**11**(4):384–389. DOI 10.1007/s12663-012-0355-9
22. V. Kaplanoglu, et al. Anthropometric measurements of the orbita and gender prediction with three-dimensional computed tomography images. *Folia Morphol*2014;**73**(2):149–152. DOI:10.5603/FM.2014.0022
23. Salah M, Higzi MAI, Ali RW and Naini FB. The Sudanese female face: Normative craniofacial measurements and comparison with African American and North American White females. *Journal of Cranio-Maxillofacial Surgery 2014*; Vol**42**:(8). https://doi.org/10.1016/j.jcms.2014.06.003
24. Zacharopoulos GV, Manios A, Kau CH, Velagrakis G, Tzanakakis GN and Bree, ED.Anthropometric Analysis of the Face. *Journal of Craniofacial Surgery*2016; **27** (1):71-5. http://www.ncbi.nlm.nih.gov/pubmed/26703056
25. Dharap A et al.). Facial Anthropometry in an Arab Population. *Bahrain Medical Bulletin* 2013;**35** (2).
26. G Julie, C Khristina. Gender Differences in the Growing, Abnormal, and Aging Jaw. *Dent Clin AnAm* 2013;**57** (2): 263–280. DOI: https://doi.org/10.1016/j.cden.2013.01.005
27. Macho GA. Is sexual dimorphism in the femur a population specific phenomenon 1990. *Z Morphol Anthropol.* 1990;78(2):229-42.PMID: 2077774