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Computed tomography measurement of extra-ocular muscle diameters in a population of normal patients in a tertiary hospital in Nigeria

GI Ogbole[1], OA Ogun[2] and D Olusumade[3]
Departments of Radiology and Ophthalmology, College of Medicine, University of Ibadan and Department of Radiology, University College Hospital, Ibadan, Nigeria

Abstract

Background: Measurements of extraocular muscle diameter may be useful in diagnosis and as an outcome indicator in the assessment of treatment options in thyroid-associated ophthalmopathy. Racial differences are known to account for craniofacial variations and orbital sizes.
Objective: To determine the normal diameters of extra-ocular muscles using computed tomography in a homogeneous, group of hospital patients in a tertiary hospital in Nigeria.
Material and Method: The maximum diameters of extra-ocular muscles were measured for 182 normal patients on thin slice reconstructed coronal computed tomography images. The effects of age and sex were determined.
Result: Normal ranges for the diameters (mean + 2 SDs) of extraocular muscles were 4.5 + 1.2 mm for medial rectus, 4.9 + 2.1 mm for lateral rectus, 4.8 + 1.6 mm for inferior rectus and 4.0 + 1.5 mm for the superior group.
The mean diameter of the extra-ocular muscles of male patients was not significantly larger than that of female patients ($p > 0.05$). There was a small but positive correlation between age and diameter of each extra-ocular muscle except in the left medial rectus and right lateral rectus muscles ($P<0.05$).
Conclusion: These normative values may serve as radiological reference values in the assessment of changes in size and suspected enlargement of the extraocular muscles in Nigerian patients. They may also be extrapolated to other Black African patients, until population studies become available.

Keywords: *Extra-ocular muscle, Normal measurement, Computed tomography*

Résumé

Introduction : Les mesures de diamètre du muscle extra oculaire peuvent être utiles dans le diagnostic et comme un indicateur du résultat dans la répartition des options de traitement de l'ophthalmopathie associée à la thyroïde. Les différences raciale sont connues a expliquer les variations cranio-faciales et dimensions orbitales.
Objective : Pour déterminer les diamètres normaux des muscles extra oculaires en utilisant la tomographie supputée dans un groupe homogène de patients d'hôpital d'un hôpital tertiaire au Nigeria.
Matériel et Méthode : Les diamètres maximum des muscles extra oculaires étaient mesurés pour 182 patients normaux sur des tranches légères reconstruites des images coronales de tomographie supputée. Les effets de l'âge et du sexe étaient déterminés.
Résultats : Les rangs normaux pour les diamètres (moyenne + 2SDs) des muscles extra oculaires étaient 4,5 + 1,2 mm pour le rictus médial, 4,9 + 2,1 pour le rictus latéral, 4,8 + 1,6 pour le rictus inferieur et 4,0 + 1,5 pour le groupe supérieur.
Parmi les patients, le diamètre moyen des muscles extra oculaires des hommes n'était de manière significatif plus large que celui des femmes ($p>0,05$). Il y avait une petite mais positive corrélation entre l'âge et le diamètre de chaque muscle extra oculaire hormis dans les muscles du rictus médial gauche et du rictus latéral droit ($p<0,05$).
Conclusion : Ces valeurs normatives peuvent servir de valeurs référentielles radiologiques dans la répartition des changements en dimension et agrandissement soupçonné des muscles extra oculaires des patients nigérians. Elles peuvent aussi être extrapolées aux autres patients Africain Noir, jusqu'à ce que des études basées sur la population deviennent disponible.

Mots Clé : *Muscle extra oculaire, Mesure normal, Tomographie supputée*

Introduction

The orbit provides protection for the eyeball within. It contains muscle, blood vessels, fat, interstitial tissue, the optic nerve and fine fibrous septa which divide it into compartments. The six extra-ocular muscles are responsible for the synchronous movement of the eyeballs and eyelids. Imaging of the extra-ocular muscles may be warranted in the investigation of orbital trauma [1], pathological disorders like Thyroid Associated Orbitopathy (TAO) [2-3] or myositis [4]. Ultrasonography [5], Computed Tomography (CT) [6-7], and Magnetic Resonance Imaging (MRI) [8] have been used to

Correspondence: Dr. Olufunmilola A. Ogun, Department of Ophthalmology, College of Medicine, University of Ibadan, Ibadan, Nigeria. E-mail: olufunmiogun@gmail.com

image the extra-ocular muscles and other soft tissues of the orbit. Measurement of the extra-ocular muscle volume or diameter is used to assess and monitor orbital involvement in thyroid disease. Extra-ocular muscle volume assessment requires complex measurements and is prone to overestimation using region grow segmentation parameters on CT while under estimation of true volume occurs with high resolution MRI [8]. It is therefore more suited for research purposes than for routine clinical practice. Normal reference data for extra-ocular muscle diameter are needed to define abnormality for specific populations. There are significant differences in orbital and ocular anthropometry among individuals of different ages, genders and ethnicities [1]. Though there have been some cadaveric studies in other populations [9] and a cadaveric study measuring orbital morphology on dried skulls in Nigeria [10], there is no normal data to the best of our knowledge available for extra-ocular muscle diameters in Nigerians.

This study was therefore designed to obtain the maximum extra-ocular muscle diameters in normal Nigerian patients, using a validated CT-imaging protocol, with a view to defining an acceptable range of reference values for Nigerians.

Materials and Methods

The Computed Tomography (CT) images of patients who underwent Cranial, Craniofacial or Paranasal sinus studies in the department of Radiology, University College Hospital, Ibadan, Nigeria between January 2011 and June 2012 were reviewed. All consecutive patients without intra-orbital abnormality were selected. Patients who had orbital pathology or known endocrine disease were excluded. The CT images with any form of asymmetry were also excluded.

The CT studies were performed using a 64-slice Toshiba Aquillion scanner (Toshiba Medical systems, Europe B.V.; 2009) with 0.5mm slice thickness from the skull base to the vertex. The axial images were acquired as a volumetric dataset parallel to the orbito-meatal plane. Coronal reformats of the volumetric data were generated on a standalone computer workstation using the ClearCanvasDicom viewer (Clearcanvas Workstation 2.0 SP1, a downloadable software at www.clearcanvas.ca) and only non-contrast images were evaluated by two radiologists.

For the measurement of the extra-ocular muscles, a constant window width (350HU) and level (40HU) as well as a constant magnification factor (x4) were used to ensure consistency and uniformity (figure 1). The measurement calliper was operated with a single mouse click at either end of the distance to be measured. The start and end point of the measurement was the margin of the muscle. The measurements were taken on 3 consecutive images to determine the maximal diameter of each of the muscle using the measurement callipers.

The callipers could measure up to a tenth of a millimetre. Both right and left sides were measured. The superior rectus and levatorpalpebrae muscles were measured together as a group- the superior muscle group because each of the muscles could not easily be delineated separately [6].

The lateral and medial rectus muscles as well as the inferior rectus muscles were measured independently. Each muscle was measured at its point of maximum diameter perpendicular to the orbital wall. Vertical diameters were used for the inferior rectus muscle and superior muscle group while horizontal diameters were used for the medial and lateral recti muscles.

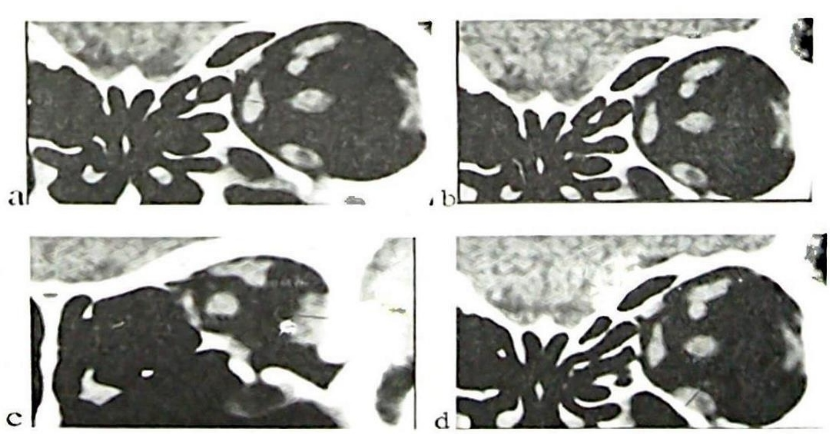

Figure 1

The data obtained was analysed using SPSS for Windows version 17 with the paired sample t-test, independent sample t-test, Chi square test and Pearson correlation. The mean diameter of each muscle was calculated and the presence of any difference in size between muscle groups, gender and side of the body (laterality) within the population was determined as well as the age-specific sizes. Student-t test was used to achieve a comparison of the mean diameters between sexes. All p values were computed from Chi-square tests of contingency. A p-value of <0.05 was considered significant.

Table 1: Mean values of the extra ocular muscles and the correlation of each muscle diameter with age.

Muscle group	Mean ±SD (mm)	Pearson correlation coefficient(r)	p-value	Lower 95%CI	Upper 95%CI
Right SG	3.97±0.75	0.23	0.00	3.86	4.08
Right IR	4.83±0.81	0.15	0.05	4.72	4.94
Right MR	4.59±0.61	0.16	0.03	4.50	4.67
Right LR	4.69±1.04	0.04	0.60	4.54	4.84
Left SG	4.0±0.76	0.26	0.00	3.86	4.08
Left IR	4.72±0.81	0.17	0.02	4.60	4.85
Left MR	4.50±0.61	0.06	0.46	4.41	4.60
Left LR	5.13±1.00	0.26	0.00	4.99	5.27

MR=medial rectus, SG= superior muscle group, LR=lateral rectus, IR= inferior rectus.

Results

Out of 1751computed tomography studies evaluated, 182 cases were eligible for this study. This included 103 males and 79 female patients. Their ages ranged from 16 to 88 years with a mean of 50.3 + 18.2 years.

Table 2: Comparison of the mean extra ocular muscle diameters between the right and left sides

Muscle	Side		Mean difference	±Std. deviation	95% CI		p-value
	Right (mm)	Left (mm)			Lower	Upper	
SG	3.97	3.97	0.00	0.63	-0.09	0.10	.915
IR	4.83	4.72	0.11	0.70	0.01	0.21	.034
MR	4.59	4.50	0.09	0.55	0.01	0.17	.030
LR	4.69	5.13	-0.45	1.14	-0.61	-0.28	.000

MR=medial rectus, SG= superior muscle group, LR=lateral rectus, IR= inferior rectus.

Table 3: Gender comparison of the mean diameters of the extraocular muscles

	Mean		p-value	Mean Difference	95% CI	
	Male (mm)	Female (mm)			Lower	Upper
Right SG	4.14	3.75	0.00	0.39	0.17	0.60
Right IR	4.89	4.76	0.29	0.13	-0.11	0.37
Right MR	4.56	4.63	0.40	-0.08	-0.25	0.10
Right LR	4.81	4.52	0.06	0.29	-0.02	0.59
Left SG	4.12	3.76	0.00	0.36	0.14	0.58
Left IR	4.78	4.64	0.24	0.14	-0.09	0.38
Left MR	4.48	4.52	0.67	-0.04	-0.22	0.14
Left LR	5.22	5.01	0.15	0.21	-0.08	0.51

MR=medial rectus, SG= superior muscle group, LR=lateral rectus, IR= inferior rectus.

The mean values of the diameters of the extra-ocular muscles are given in Table 1.

There was no statistically significant difference (p=0.915) in the mean values between the superior muscle group diameters on the left and right sides However, the inferior, medial and lateral recti showed statistically significant differences in their mean sizes on both sides (p=0.034, p=0.030 and p=0.000 respectively). (Table 2)

The mean diameters of the muscles were larger in male patients for all the muscle groups except the medial recti bilaterally which were slightly larger in female patients. (Table 3)

There was a significant difference in the means of the right superior muscle group (p=0.000) and the left superior muscle groups (p=0.001) between males and females. The remaining extraocular muscles measured, did not show any significant difference in the mean diameters between the male and female genders (Table 3).

There was a small but positive correlation between age and diameter of each extra-ocular muscle (Table 1) except in the left medial rectus and right lateral rectus muscles; in which there was no significant increase in muscle diameter with age (P<0.05).

Discussion

The extraocular muscles are usually long, thin, well defined and extend from the orbital apex to the globe. They usually assume a fusiform shape. Several imaging modalities such as CT [1, 2, 4, 6, 7], ultrasound [5, 11] and MRI [3, 8] can be used to demonstrate their anatomy and architecture. Though the use of ultrasound for the measurement of extraocular muscles has been reported in some echographic studies, and ultrasound is cheaper and more widely available in a developing country like Nigeria, the use of CT imaging is justified because CT clearly defines extraocular muscle outline, separate from the orbital walls and extraocular soft tissue better than ultrasound [11, 12] and therefore offers greater accuracy. Furthermore, the results of studies using ultrasound scanning are less reproducible than CT imaging [12].

The normal CT anatomy of the orbit has been well published in several racial populations using various imaging tubes techniques but no study has been done to provide normative CT data in a black African population [6, 7, 13-14].

Due to the universal availability and accessibility to CT in most African nations, the authors opted to use a high-resolution multi-slice CT to evaluate the extraocular muscles among normal Nigerian subjects.Similar to previous research, fixed window setting was used for all imagin reviews based on the understanding that ever change in the window level and with settings cou result in different values with respect to muscle siz

A constant window width (350HU) and lev (40HU) with a magnification factor of 4 was used all evaluations. And to further increase the sensitivi and minimize errors, only the maximal diameter 3 consecutive measurements of both eyes were use Precautions were taken in this study to ensure th all artefacts that could substantially affect ima quality were identified and excluded such as moti and asymmetry. Unlike previous studies, this stu used a 0.5 mm reconstruction interval for ima acquisition. However, direct coronal scans were r done, as the reconstructed images provid sufficiently sharp coronal reconstructior According to the present study, the mean diamete of the extra ocular muscles were significantly larg in males for all muscle groups except the media re which were slightly larger in females. This kind pattern has not been previously described. Also, c findings for the ranking of the thickness of the ext ocular muscles are different from previous wor [6, 13 – 15].

In most studies, the pattern found w Inferior > superior > medial > lateral, howev our study showed rather different pattern: Latera Inferior> Medial> Superior group.The reason f this may not be immediately evident but may due to the shape of the orbit in Nigerians who a of a Negroid extraction as compared with the studies, which were carried out among Caucasia and Asians. This may also be responsible for t disparity of the sizes between the left and rig sides as the lateral rectus was significantly larg on the left side and the inferior and medial rect were larger on the right.The prominent faci feature of the male may also be responsible f the significant larger size of the extraocular musc bilaterally [16].

Differences between diameters of healt contralateral extraocular muscles may also helpful in understanding the pulley system a orientation of the extraocular muscles. In tl present study, the mean sum of the diameters all muscles (18.0 mm) was different, and larg than studies from Asia, by Lerdlum et al. (15mr [13] and Jong Soo Lee et al (14.0 mm) [7] b was similar to measurements recorded in Weste studies (16.9- 19.7 mm) [6]. It is possible that the differences may be related to ethnicity, differenc in craniofacial proportions, socio-economic ar nutritional differences between Oriental and western populations. However we observe that these dimensions appear closer to the extreme of the western population.

Every change in the window level and width settings results in different values with respect to the muscle size. This means that window settings should be the same to accurately compare the muscle sizes between different patients as well as between different CT examinations of the same patient.

For this reason, our normative data would be valid for specified window and level of 350 and 40 HU, respectively. In the present study, we also suggest that the extraocular muscles can be well visualized using a bone algorithm for screening paranasal sinuses provided the optimal window width and window level are used.

The authors propose to correlate extraocular muscle size and Biparietal diameter/head circumference in future studies. The present study revealed that the mean diameters of the extraocular muscles are slightly larger in males than females, though this was not statistically significant. This may be due to a larger head size usually found in male patients. In relation to age, there was only a weak positive correlation with the mean diameters of the extraocular muscles.

A retrospective study had suggested that, to prevent extraocular muscle contraction during a scan, the patient may be asked to maintain a forward gaze and gentle eye closure; this was not the routine practice in our centre [17]. However, patients for routine cranial scan are asked to close their eyes during scanning or positioning to avoid the effect of the laser light. Another limitation is the relatively small sample size, which however, compares well, with previous works of other authors [6, 7, 11]. Biochemical and hormonal profile of patients were not evaluated for evidence of endocrine disorder; this study relied on the clinical history.

In conclusion, this study established a normative reference for extraocular muscle diameters in a subset of normal hospital patients in a Nigerian Teaching Hospital. Furthermore, a difference in extraocular muscle diameters between these black Africans and other racial groups, was observed. These normative values may be used by both, radiologists and ophthalmologists for accurate radiological assessment of changes in size and enlargement of, the extraocular muscles in black African populations.

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