Computed Tomographic Dimensions of the Lacrimal Gland in Normal Nigerian Orbits

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***Abstract*- PURPOSE:** To determine the normal range of lacrimal gland dimensions in healthy orbits of Nigerian subjects from brain CT.

METHODS: A retrospective study of patients who had visited the Jos University Teaching Hospital and had undergone brain computed tomographic scan. One hundred twenty seven Nigerians (82 men and 45 women) who were 18 years and above without orbital disease were included. Patients with trauma to the orbits or any known lacrimal gland disease were excluded. The length and width of the lacrimal gland were measured in axial and coronal sections using the largest image. The primary outcome was a descriptive analysis of the distribution of dimensions in normal orbits. The results were analyzed and identified associations with age, sex, and laterality and compared the results with previous studies carried out elsewhere.

RESULTS: The mean lacrimal gland axial length in the right orbits was 14.6 mm (10.9 mm and 18.3 mm) and 14.5 mm in the left orbits (10.3 mm and 18.3 mm). Coronal length averaged 20.7 mm in right eyes (13.9 mm and 21.8 mm) and 20.8 mm in left eyes (12.8 mm and 20.8 mm). The axial width was 4.1mm in the right orbit and 4.1mm in the left orbit. The coronal width was 2.9mm in the right orbit and 3.0mm in the left orbit. A statistically significant inverse linear relationships was observed in both orbits between gland size and age in all dimensions, with the exception of coronal width. No statistically significant difference in all dimensions was found in both orbits between genders.

CONCLUSION: Lacrimal gland size decreases with age, and no gender difference exists. This range can aid in differentiating diseased and non-diseased lacrimal glands, especially when correlated with physical examination. This may be useful in clinical trials that involve lacrimal gland size.

***Index Terms*-** Computed tomography, lacrimal gland, Nigerian orbits.

I. INTRODUCTION

The lacrimal gland is an almond-shaped, eccrine secretory gland for tear production. It is located in the superior-lateral aspect of the orbit, abutting the superior rectus and lateral rectus muscles. The lacrimal gland consists of an orbital lobe and a palpebral lobe, which are separated anatomically by the lateral horn of the aponeurosis of the levator palpebrae muscle. The orbital lobe is located posterior and superior to the levator palpebrae aponeurosis, and the palpebral lobe is situated anterior and inferior to it. The orbital lobe is larger and the site of most lacrimal gland epithelial neoplasms.[1] (1)

The lacrimal glands are unique structures possessing both epithelial and lymphoid tissue and may fall prey to an unusually wide range of pathologies including various neoplastic, infective, infiltrative, inflammatory and structural processes ranging from benign adenomas, adenocarcinomas, histiocytosis, benign dacrocysts and lymphomas to sarcoidosis.[2] (2)Swelling and enlargement of one or both lacrimal glands remain the common denominator of most of these pathologies, suggesting size is an important factor in assessing the integrity of the lacrimal glands on most imaging studies.[3] (3)Aging has been shown to decrease lacrimal gland (LG) function, with a resultant increase in the incidence of dry eye, affecting 15 to 25% of people over the age of 65 years.[4] (4)

Imaging techniques, such as ultrasound and MR, have become important in detecting and monitoring disease in people and in distinguishing lacrimal gland origin disease from other disorders of the orbit. Additional potential uses of advanced imaging include measuring response to therapy and targeted imaging with labeled therapeutics. (5,6).[5,6]

On CT, the lacrimal gland is isodense to the muscle. The medial border is outlined by orbital fat and the lateral border by orbital bone. Calcifications and bony changes are well seen on CT, and normal glands show symmetric contrast enhancement. The superior resolution of MRI permits better assessment of the extent of glandular and periglandular involvement.[1] (1)

George *et al*[7] (7)emphasized the importance of careful evaluation of lacrimal gland imaging by the ophthalmologist in personally reviewing both axial and coronal views of CT scans; even the scans were interpreted as normal by radiologists. No established dimensions of the normal lacrimal glands of normal Nigerian orbits as imaged by CT, which is the most widely used orbital imaging modality.

Hence, in this study, we evaluated the normal range of lacrimal gland dimensions in normal Nigerians using computed tomography and their association with age, sex, and laterality and compared our results with other studies of the normal lacrimal gland dimensions carried out in different parts of the world.

II. MATERIALS AND METHODS

This was a retrospective study conducted over the period of six months from December 2014 to May 2015 at the Jos University Teaching Hospital involving 127 patients (82 men and 45 women) who had undergone axial pre and post contrast brain CT scans with a 2.5mm slice thickness at the skull base and 5mm

at the remaining skull to the vertex using a Bright Speed 4-slice scanner (GE healthcare USA). A 1.25mm reconstruction of the images was done in coronal plane. Patients were included if they were Nigerians and aged 18 and older and had no prior orbital disease. Patients with brain injury, trauma to the orbit or any known lacrimal gland disease were excluded. The length and width of both lacrimal glands were measured in axial and coronal sections and recorded for both lacrimal glands in each patient. The palpebral and orbital lobes of the lacrimal gland are difficult to distinguish on CT, hence, the lacrimal gland was treated as one structure.

The patients were divided evenly into six age groups (≤29, 30-39, 40-49, 50-59, 60-69 and ≥70). We subsequently analyzed the results and identified associations with age, sex, and laterality and compared the results with previous studies of normal Korean and Caucasian lacrimal gland dimensions.[8,9] (8,9)

In each of the axial and coronal soft tissue series, the image in which the lacrimal gland appeared the largest was chosen. Two measurements of the lacrimal gland were made on the selected images. The same method of measurement as used in a previous study by Tamboli et al.[9] (9)In the axial images, the long dimension was measured from the most posterior tip of the lacrimal gland to the most anterior tip. The width was measured from the lateral edge to the medial edge of the gland at its widest location, perpendicular to the first measurement. On the coronal images, the long dimension was measured from the superior tip of the lacrimal gland to the inferior tip. The width was measured from the lateral edge to the medial edge of the lacrimal gland at its widest point, perpendicular to the long measurement (Figs. 1 and 2). The normal distributions for each dimension in millimeter (axial length and width and coronal length and width) was evaluated using SPSS version 20.0 (SPSS Inc, Chicago, Ill). The associations between the dimensions of the lacrimal gland and laterality and sex were compared using t test. The association between the lacrimal gland dimensions and different age groups was evaluated using analysis of variance (ANOVA). Pearson correlation analysis was used to determine the correlation between lacrimal gland dimensions and age.

III. RESULTS

A total of 254 orbits were reviewed on 127 scans (127 right orbits and 127 left orbits) comprising of 82 males (65%) and 45 females (35%) as shown in figure 3. The mean age was 49.51±16.52 years with the range of 18–88 years (table 1).

The mean lacrimal gland axial length was 14.6 mm in the right orbit and 14.5 mm in left orbit. Coronal lengths averaged 20.7 mm in the right orbit and 20.8 mm in the left orbit. The axial width was 4.1mm in the right orbit and 4.1 mm in the left orbit. Coronal width mean was 2.9 mm in the right orbit and 3.0 mm in the left orbit.

There was no statistically significant difference between the sizes of the right and left lacrimal gland in any dimension by t-test (Table 2).

No difference was found in gland size between men and women for any dimension by t test ($p>0.05$ for each) as shown in table 3. A statistically significant inverse linear relation was observed in both orbits between gland size and age in every dimension, with the exception of coronal width. For coronal lengths, the P values were 0.01; r= -350 and r= -374, respectively. For axial lengths, the r=-242; p= 0.06 for right eyes and r= -264; p=0.03 for left eyes. With respect to axial widths, the P=0.04; r= -254 for the right orbit and p=0.04; r= -288 for the left orbit, whereas no significant correlation in coronal widths (p=0.72; r= -0.32 for the right and p=0.46; r= -0.66 for the left) (Table 4).

IV. DISCUSSION

The lacrimal gland though located in the orbit, little attention is paid to it during imaging evaluation of the orbit except when it is diseased. Enlargement of the lacrimal gland is seen in both benign and malignant conditions. Examples include idiopathic inflammation, specific inflammations like Sjo¨gren syndrome, Wegener granulomatosis, sarcoidosis, and both benign and malignant neoplasms. (10).[10]

The lacrimal gland dimensions recorded in our report (table 2) is comparable to the CT dimensions of lacrimal gland in healthy Korean's orbit documented by Joon *et al*.[8] (8)In that study, the mean lacrimal gland axial length was 14.9 mm for the right orbit and 14.7 mm for the left. Coronal length averaged 20.9 mm and 20.7 mm for the right and left orbits, respectively. Axial width mean 4.1mm and 4.3 mm for right and left orbits, respectively. Coronal width in the right orbit was 3.6 mm and was 3.8 mm in the left orbit. The lacrimal gland dimensions (coronal lengths) in Caucasians were smaller when compared to the lacrimal gland dimensions documented in our study. While the axial and coronal width dimensions in the Caucasians were higher than the values documented in our study[9] (9) (table 5). This means that lacrimal gland dimensions varies with geographical location especially between America and Nigeria with respect to the axial width, coronal width and the coronal length.

Our study established the right and left mean lacrimal gland dimensions on CT imaging. These measurements show no statistical significant difference between right and left sides in all dimensions. On the contrary, *Tamboli et al*[9] (9) found a statistically significant difference (p=0.025) in Caucasian's mean coronal length between the right and left eyes. They suggested that the difference may represent a type 1 error because they did not adjust their significance level for multiplicity of testing. *Joon et al*[8] (8) also found a statistically significant difference in the mean axial (p=0.001) and coronal width (0.012) between the right and the left eyes.

The current study corroborates the previously reported trend of decreasing lacrimal gland size with age. In our study, the decrease with age was statistically significant in all dimensions ($p<0.05$) except for the coronal widths. This decrease in size of the lacrimal gland with age may be due to the various morphological changes that increases with age, especially periductal fibrosis, which is speculated to be related to the decrease in tears outflow seen with aging.[11] (11) Tamboli *et al*[9] (9) and Joon *et al*[8] (8) in separate studies in Caucasians and Koreans, observed a significant inverse linear relationship between gland size and age with respect to the coronal length, coronal width, and axial length of the gland in both orbits. Ueno and colleagues.[12] (12)

We found no significant differences in lacrimal gland dimensions between the sexes which was in agreement with the findings by Joon *et al*[8] (8) and Tamboli *et al*[9] (9) This differs from previous reports by Lorber and Vidic´.[13] (13) Their study showed significant gender differences in all the dimensions they measured.

Various imaging modalities were used by different researchers to study and evaluate both the normal and pathologies lacrimal gland. MRI and ultrasound are useful, high-resolution CT is the most used radiologic modality for orbital evaluation.[10,14] (10,14) Although normal lacrimal gland dimensions are published, these are of limited clinical use because they are largely based on small cadaveric measurements made after embalming and disruptive dissection.[13] (13)

CT scans are the most frequently used radiologic modality for orbital evaluation. Therefore, it is important to be able to interpret lacrimal gland changes on CT scan images.[10,14] (10,13) There have been some cases of lacrimal gland disease being missed by consulting radiologists. However, a slight enlargement of the lacrimal gland was noted by the oculoplastic surgeon. This suggests the importance of careful review of existing imaging and emphasizes the importance of evaluating coronal and axial CT views for suspected lacrimal gland disease.

Our study was limited to Nigerian who presented in our hospital. A future multicenter study could expand these results to include other ethnicities and geographic locations. Future studies may also include in vivo volume measurements, correlation of CT with MRI, comparison of diseased and non-diseased lacrimal glands. The soft tissue density similarities between the lacrimal gland and surrounding orbital structures may make it challenging in measuring the lacrimal gland on CT images.

In conclusion, CT is excellent for visualizing and measuring the lacrimal gland. This study presents a normal range of Nigerian lacrimal gland dimensions as measured on CT. This range can aid in differentiating diseased and non diseased lacrimal glands, especially when correlated with physical examination. The data may also be useful in clinical trials that involve lacrimal gland size.

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Table 1: Number and mean age distribution of patients

		Age	
Gender	Number	Mean SD	Range
Male	82	50.21±15.85	21-88
Female	45	48.28±17.75	18.87
Total	127	49.51±16.52	18-88

Table 2: Comparison of Right and Left Lacrimal Gland Dimensions by t Tests (P< 0.05 Is Significant)

Measurement	R vs L t test	Significance

AL	t=1.10	P=0.27
AW	t=1.43	P=0.16
CL	t=1.34	P=0.18
CW	t=1.59	P=0.11

AL- axial length; AW- axial width; CL- coronal length; CW- coronal width

Table 3: Comparison of Male and Female Lacrimal Gland Dimensions by t test (p<0.05 is significant)

Parameters	**AL**	**AW**	**CL**	**CW**
Right orbit				
Male mean	14.46±2.04	4.17±0.46	20.96±3.08	2.99±0.55
Female mean	14.76±1.87	4.08±1.41	20.31±3.23	2.83±0.48
P value	0.43	0.42	0.26	0.09
Left orbit				
Male mean	14.44±1.98	4.15±0.42	20.98±3.06	3.02±0.55
Female mean	14.71±1.89	4.05±0.46	20.44±3.28	2.87±0.53
P value	0.44	0.23	0.37	0.16

AL - axial length; AW - axial width; CL - coronal length; CW - coronal width

Table 4: Correlation between lacrimal gland dimensions and age by Pearson correlation (p<0.05 is significant)

Lacrimal gland size	**Correlation coefficient (r)**	**P**
Right orbit		
AL	-242	0.01
AW	-254	0.00
CL	-264	0.00
CW	-288	0.72
Left orbit		
AL	-350	0.00
AW	-032	0.00
CL	-374	0.00
CW	-066	0.46

AL-axial length; AW-axial width; CL-coronal length; CW-coronal width

Table 5: Comparism of lacrimal gland dimensions among Nigerians, Koreans and the Caucasians

PARAMETERS	**AL**	**AW**	**CL**	**CW**
Right orbit				
Nigerians	14.6	4.1	20.7	2.9
Koreans	14.9	4.1	20.9	3.6
Caucasians	14.7	5.1	17.7	5.2
Left orbit				
Nigerians	14.5	4.1	20.8	3.0
Koreans	14.7	4.3	20.7	3.8
Caucasians	14.5	4.8	16.9	5.2

AL-axial length; AW- axial width; CL-coronal length; CW-coronal width

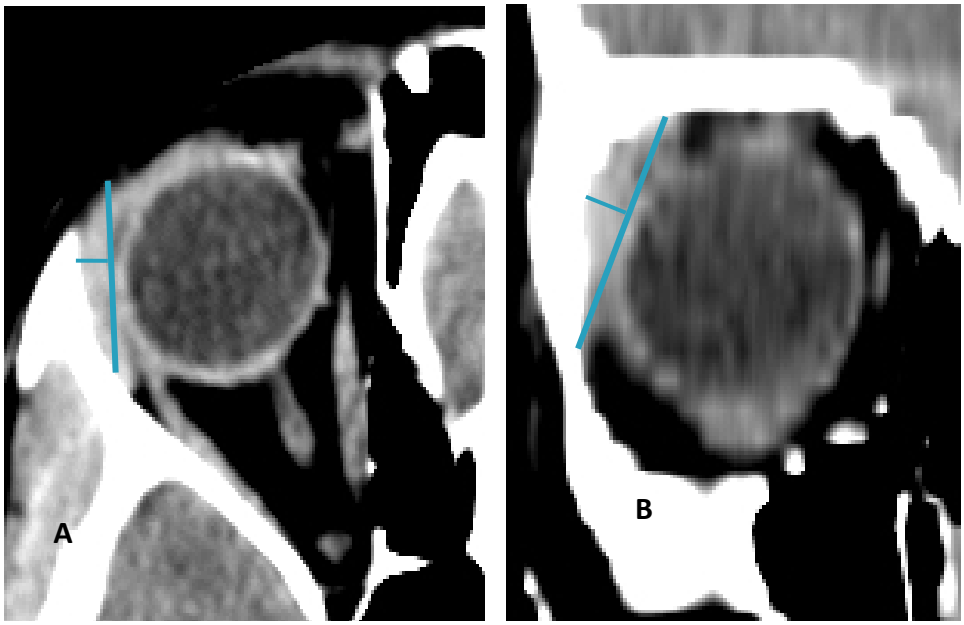

Figure 1: Axial and coronal CT showing the length (blue solid thick line) and width (blue thin line). A, showing the axial length (blue solid thick line) measured from the anterior to posterior tips and axial width (blue thin line) measured from the widest point perpendicular to the length. B, showing the coronal length (blue solid thick line) measured from the superior to inferior tips and coronal width (blue thin line) measured from the widest point perpendicular to the length.

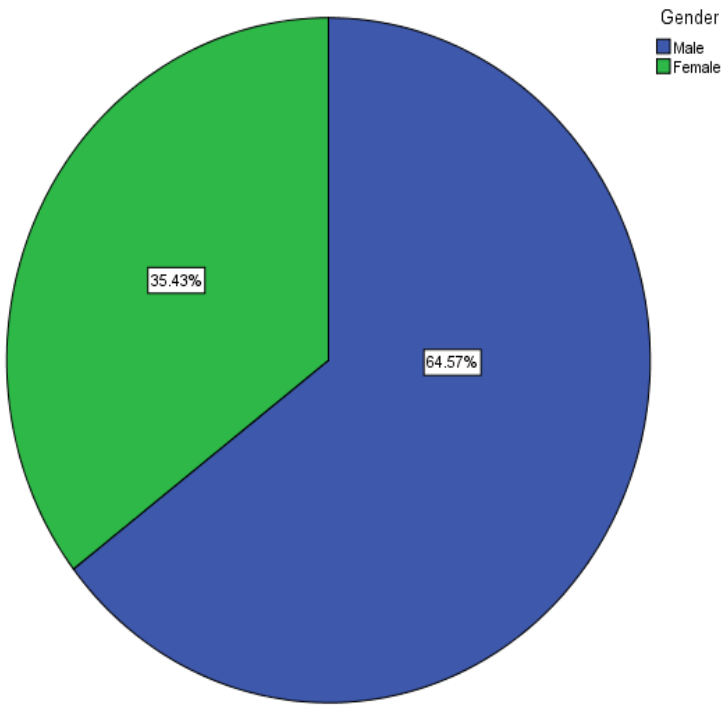

Figure 2: Percentage distribution of patients according to gender