Original Article

Computed Tomographic Dimensions of the Normal Lacrimal Gland in Adult Thai Population: Any Differences from other Ethnicities?

Varalee Mingkwansook, M.D.*, Sorakrit Athibovonsuk, M.D., Warit Tarathipmon, M.D.

Abstract

Objective: To establish diameters of normal lacrimal gland (LG) on computed tomography (CT) in the Thai population and to compare the results with other ethnicities.

Methods: There were 616 CT images of LGs (308 patients). The maximal dimension of length and width of LGs in Thai adults were measured on axial and coronal orbital CT in patients who were free of orbital disorders. The LG sizes were summarized by using descriptive statistics and analyzed in terms of age, gender and laterality. Comparison between Thai LGs size and other ethnicities from previous literatures were performed.

Results: The mean axial lengths in the right and left LG were 12.61 ± 3.04 mm and 12.31 ± 2.94 mm. Coronal lengths of the right and left LG were 13.38 ± 3.60 mm and 13.51 ± 3.70 mm. Axial widths in the right and left LG averaged 4.30 ± 2.50 mm and 4.25 ± 1.26 mm. Coronal widths in the right and left LG were 4.03 ± 1.42 mm and 4.11 ± 2.40 mm. There was no significant difference in LG size between both sides and genders except for AL which was significantly longer in males. A significant inverse linear relationship was observed between gland size and age. Thai LGs were significantly shorter to those of other ethnicities in some dimensions.

Conclusions: Diameters of normal LGs in the adult Thai population showed significantly different from those of other ethnicities in some dimensions. Knowledge of the normal LG dimensions for a given patient's ethnicity could be helpful in diagnosis.

Keywords: Lacrimal gland, LG, Dimension, Size, Computed tomography

Received: 3 November 2021 **Revised: 28 April 2022** **Accepted: 10 May 2022**

Department of Radiology, Faculty of Medicine, Thammasat University, Pathum Thani, Thailand

***Corresponding author:** Varalee Mingkwansook, M.D., Department of Radiology, Faculty of Medicine, Thammasat University, Pathum Thani, Thailand Email: m.varalee@gmail.com

Introduction

The lacrimal glands (LGs) can be affected by a wide spectrum of orbital pathologies.[1-7] In general, 50% of the diseases affecting the LGs are inflammatory (including autoimmune diseases), 25% of the lesions are lymphoproliferative disorders, and 25% of the lesions are salivary gland type tumors.[1] Some of these conditions present with LG enlargement or atrophy.[1-7] With accurate clinical and preoperative imaging, biopsy can be avoided. Therefore, it is necessary to know the normal dimensions of LGs in order to differentiate between LGs which are healthy and those which are diseased. There were previous literatures reported LG sizes which showed some difference among various ethnicities.[8-13] To the best of our knowledge, the normal dimensions of Thai LGs measured on computed tomography (CT) had not been determined prior to this study.

Objective: To establish normal diameters of lacrimal gland (LG) on computed tomography (CT) in the Thai population and to compare the results with LG dimensions from other ethnicities.

Methods

Study Population

This retrospective study was approved by the Research Ethics Board of our institution. The inclusion criteria were adult patients (age 18 or older) who underwent cranial CT between November 2019 and December 2019. The patients with history of orbital trauma, orbital disorders or known related diseases that might affect LG such as bacterial or viral infection, sarcoidosis, thyroid ophthalmopathy, Sjögren's syndrome, lymphoma, salivary gland tumor and patient with history of head and neck radiation were excluded.

Sample Size

The estimated sample size was calculated by using two-sample comparison of mean LG size from STATA software. Mean LG size and standard deviation (SD) in Korean[9] population were used as references for calculation. The estimated minimum sample size was 199. There were 616 LGs from 308 patients who met inclusion criteria and underwent cranial CT scan at University Hospital between November 2019 and December 2019. One hundred and fifty-four patients were males (50%) and 154 patients (50%) were females. Ages ranged from 19 to 96 years. Age distribution is shown in Figure 2.

Technique and Measuring Method

Standard CT images of the orbits were recreated from the source images of 1 mm slice thickness cranial CT obtained from Spectral CT (IQon; Philips Healthcare, Cleveland, OH, USA) by using portal IntelliSpace v5.0.1.100050 software. LGs were also displayed and measured on portal IntelliSpace 11. The length and width of LGs were measured in each of the axial and coronal soft tissue series on reformatted images with the axial view parallel to optic nerve and coronal view perpendicular to optic nerve. Forty LGs from 20 patients were randomly selected and measured by a senior radiologist and a third-year radiology resident independently. Agreement of measurement was assessed by using an intra-class correlation coefficient (ICC) with the ICC interpretation described by Landis and Koch.[14] After establishing agreement, the remaining LGs were measured by a third year radiology resident.

The image in which the LG appeared largest was chosen and measured as a single unit as the palpebral and orbital lobes are difficult to be differentiated on CT. We used the same measuring method as a previous study by Tamboli et al.[8] In the axial images, the length was measured from the most anterior to posterior part of the LG. The width of the LG must be perpendicular to the length, measured from the lateral to medial border of the LG in the widest location. On the coronal images, the length was measured from the most superior to the most inferior part of the LG. The width must be perpendicular to the length, measured from the lateral edge to medial edge of the LG at its widest point (Figure 1).

Statistical Analysis

Descriptive statistics was for LG dimensions. The results of LG dimensions were compared between both sides, ages and genders by using 2 sample *t* test. The relation between lacrimal gland dimensions and age was evaluated by using the Pearson correlation Coefficient (r). Comparison between LG dimensions of the Thai population and previously reported LG dimensions from other ethnicities were also calculated by using 2 sample *t* test.

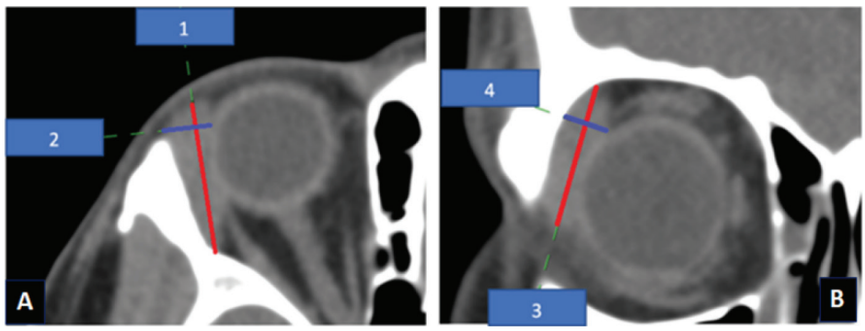

Figure 1 Measuring method: Axial (A) and coronal (B) CT showing the length and width. A the axial length (1) measured from the anterior to posterior and axial width (2) measured from the widest point perpendicular to the length. B the coronal length (3) measured from the superior to inferior tips and coronal width (4) measured from the widest point perpendicular to the length.

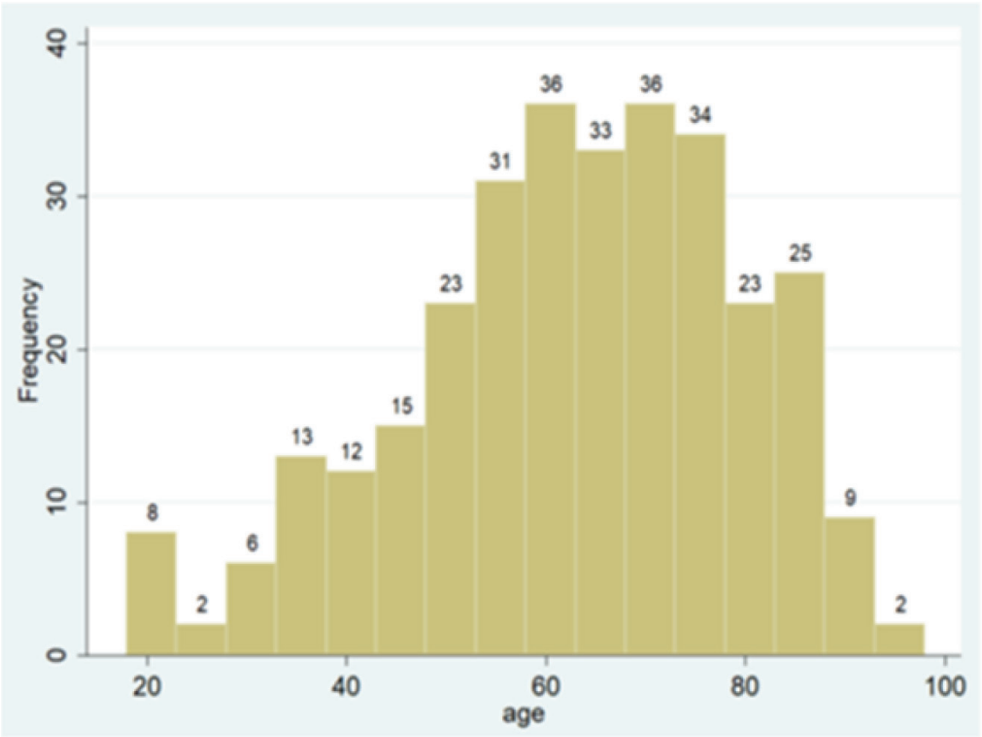

Figure 2 Histogram showing the age distribution of 308 patients.

Results

The mean LG axial length was 12.61 ± 3.04 mm in the right orbit and 12.31 ± 2.94 mm in the left orbit. Coronal lengths averaged 13.38 ± 3.60 mm in the right orbit and 13.51 ± 3.68 mm in the left orbit. Axial width averaged 4.30 ± 2.49 mm in the right orbit and 4.25 ± 1.26 mm in the left orbit. Coronal width averaged 4.03 ± 1.42 mm in the right orbit and 4.11 ± 2.40 mm in the left orbit. Descriptive statistics for the LG dimensions of the right and left orbits are provided in Table 1.

Table 1 Descriptive Statistics of the Lacrimal Glands of Right and Left Orbits in Millimeters

Measurement	Mean	SD	Percentile						
			5%	10%	25%	50%	75%	90%	95%
Right orbit									
AL	12.61	3.04	7.8	8.7	10.55	12.3	14.7	16.9	17.5
AW	4.30	2.49	2.5	2.8	3.2	4	5	5.8	6.3
CL	13.38	3.60	8.4	9.1	10.6	13	15.8	17.8	20
CW	4.03	1.42	2.5	2.8	3.1	3.9	4.6	5.3	5.9
Left orbit									
AL	12.31	2.94	7.7	8.5	10.45	12.1	14.2	16.2	17.6
AW	4.25	1.26	2.7	2.9	3.3	4	5	5.8	6.2
CL	13.51	3.68	8.3	9.2	10.7	13.1	15.5	18.3	20.4
CW	4.11	2.40	2.5	2.8	3.2	3.9	4.6	5.4	5.8

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

There was no statistical difference between the sizes of the right and the left LG with respect to axial width, coronal width, and coronal length (Table 2).

Table 2 Comparison of Right (R) and Left (L) Lacrimal Gland (LG) Dimensions by 2-sample *t* tests ($P < .05$ is significant)

Measurement	Right LG, mean (SD)	Left LG, mean (SD)	*P*-value
AL	12.61 (3.04)	12.31 (2.94)	.21
AW	4.30 (2.49)	4.25 (1.26)	.75
CL	13.38 (3.60)	13.51 (3.68)	.66
CW	4.03 (1.42)	4.11 (2.40)	.61

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

Axial length of male LG was statistically longer than female LG in left orbit by 2-sample *t* test (*P*-value = .04). No difference was found in gland size between male and female in other dimensions (Table 3).

Table 3 Comparison of Male and Female Lacrimal Gland Dimensions

Measurement	Male, mean (SD)	Female, mean (SD)	*P*-value
Right orbit			
AL	12.95 (3.08)	12.27 (2.97)	.05
AW	4.35 (3.18)	4.25 (1.52)	.72
CL	13.54 (3.63)	13.23 (3.57)	.45
CW	3.95 (1.04)	4.11 (1.42)	.32
Left orbit			
AL	12.66 (3.06)	11.96 (2.78)	.04
AW	4.22 (1.09)	4.28 (1.41)	.71
CL	13.66 (3.56)	13.36 (3.80)	.48
CW	4.02 (1.06)	4.20 (2.40)	.53

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

A significant inverse linear relationship was observed in both orbits between gland size and age in every dimension, with exception of axial width in the right orbit and coronal width in the left orbit (*P*-value = .21 and .07, respectively) (Table 4).

Table 4 Relationship Between Lacrimal Gland Dimension and Age by Pearson Correlation Coefficient (*P* < .05 is significant)

Measurement	***r***	***P*-value**
Right orbit		
AL	-0.47	< .001
AW	-0.07	.21
CL	-0.41	< .001
CW	-0.14	.01
Left orbit		
AL	-0.48	< .001
AW	-0.23	< .001
CL	-0.41	< .001
CW	-0.10	.07

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

There was excellent agreement between two separate inspectors in random 40 LGs (ICC = 0.89).

LG dimensions, subject number, modality used, difference of LG dimensions between both orbits, genders and age from the previously published reports were summarized and compared to Thai data as shown in Table 5.

Table 5 Comparison of LG dimensions between Thai LG dimensions and other ethnicities by 2-sample *t* tests ($P < .05$ is significant)

	Present study 2021 (Thai)	**Nawaz et al 2020 (Pakistan)**	***P*-value**	**Bulbul et al 2016 (Turkish)**	***P*-value**	**Lee et al 2013 (Korea)**	***P*-value**	**Tamboli et al 2011 (Caucasian)**	***P*-value**
N (M/F)	308 (154/154)	108 (75/33)		200 (113/87)		180 (90/90)		282 (N/A)	
Modality	CT scan (2.0-mm slice thickness)	CT scan (N/A slice thickness)		CT scan (0.5-mm slice thickness)		CT scan (2.0-mm slice thickness)		CT scan (2.0-mm slice thickness)	
AL (R, L)	12.61 ± 3.04, 12.31 ± 2.94	13.53 ± 1.80, 13.35 ± 1.72	< .001 < .001	16.2 ± 2.0, 16.0 ± 2.0	< .001 < .001	14.9 ± 2.2, 14.7 ± 2.2	< .001 < .001	14.7 ± 19, 14.51 ± 18.7	.069 .052
AW (R, L)	4.30 ± 2.50, 4.25 ± 1.26	4.20 ± 0.81, 4.05 ± 0.93	.538 .083	4.1 ± 0.7, 4.0 ± 0.7	.186 .004	4.1 ± 0.8, 4.3 ± 1.1	.196 .647	5.1 ± 1.6, 4.8 ± 3	< .001 .005
CL (R, L)	13.38 ± 3.60, 13.51 ± 3.70	15.46 ± 1.97, 15.26 ± 1.87	< .001 < .001	18.3 ± 2.3, 18.3 ± 2.3	< .001 < .001	20.9 ± 2.7, 20.7 ± 2.6	< .001 < .001	17.7 ± 3, 16.9 ± 3.1	< .001 < .001
CW (R, L)	4.03 ± 1.42, 4.11 ± 2.40	3.99 ± 0.80, 3.86 ± 0.81	.720 .113	4.1 ± 0.7, 4.1 ± 0.7	.461 .945	3.6 ± 0.7, 3.8 ± 0.8	< .001 .038	5.2 ± 1.6, 5.2 ± 1.8	< .001 < .001
Laterality	No difference	No difference		No difference except for AW		Slightly larger on the left (AW, CW)		No difference except for CL	
Gender	No difference except for AL	Smaller in female		No difference		No difference		No difference	
Age	Decreased size with age	Decreased size with age		Decreased size with age		Decreased size with age except for AW		Decreased size with age	

R, right; L, left; AL, axial length; AW, axial width; CL, coronal length; CW, coronal width

Coronal length of Thai LGs was significantly shorter than other ethnicities in both orbits (P value < .001). Axial length of bilateral LGs in Thai population was also significantly shorter than other ethnicities (P value < .001) except for Caucasians. Coronal width of bilateral LGs in Thai orbits was significantly shorter than Korean (P value < .001 on the right and 0.04 on the left) and Caucasians (P value < .001 in both orbits). Axial width of Thai LG was significantly shorter than Caucasian in both orbits (P value < .001 on the right and .01 on the left) and Turkish in left orbit (P value < .001).

Discussion

Although LG tumors invading the orbits are easily recognized in orbital CTs, the scans provide less precise information regarding the enlargement of LGs in other pathologies, including idiopathic inflammations, Sjögren's syndrome, Wegener granulomatosis, and orbital sarcoidosis.[15] Knowing the normal size of LGs could be helpful in diagnosis or exclusion of some diseases.

Magnetic resonance imaging (MRI) and CT scan are the primary imaging modalities for evaluating LG.[6-9,15,16] In this study, we measured LG size on CT scan as this method is more widely used, less expensive, and usually the initial imaging for orbital examination. Two-dimensional (2D) measurement is a reliable parameter reflecting LG size. It is easy to perform and more practical than volume (3D) measurement.

Tamboli et al,[8] who firstly published the LG size in Caucasian orbits, found no significant difference in size of LG between right and left orbits, except coronal length, which was slightly longer in the right eye. Lee et al[9] described LG size in Korean populations. They found the LG size was slightly larger in the left orbit, with respect to axial width and coronal width. Bulbul et al[12] measured LG dimensions in a Turkish population. They found similar bilateral LGs sizes; only axial width was statistically different. Nawaz et al[13] reported similar bilateral LGs sizes in Pakistani adults. Volumetric measurements of LGs by Bingham et al[10] found no bilateral difference. In contrast, Bukhari et al[11] found gland volumes on the right to be larger than those on the left. In our study, the LG sizes were similar on both sides. 2-dimensional measurements of LGs reported by Lee et al,[9] Tamboli et al,[8] and Bulbul et al[12] did not detect any differences between genders. However, Nawaz et al[13] found significantly smaller LG sizes in females with respect to axial length of both LGs, and coronal length and coronal width of the right LG. In this study, we found similar LG dimensions in both genders except for the axial length, which significantly longer in males.

Our study corroborates a previously reported trend of decreasing LG size with age.[8, 9,12,13] There was a significant inverse relationship between gland size and age with respect to the axial length and coronal length in both orbits, coronal width in the right orbit and axial width in the left orbit in this study.

There have been other studies of LG sizes in different ethnicities.[10-13] Bukhari[11] published a study of interracial variation of LG volume. The largest and smallest average LG volumes were in Asians and Middle Easterners, respectively. Dimensions of LGs from various ethnicities were gathered in a study by Nawaz[13] which found the longest axial length of bilateral LGs in a Turkish population and the widest axial width in Caucasians (Table 5).

In our Thai population, we found significantly shorter coronal length in both orbits compared with that of other ethnicities (P < .001). Axial lengths of both orbits in our Thai population were also significantly shorter than in other ethnicities except for Caucasians, which could be due to the high SD of the mean axial length in the study of Tamboli (14.7 ± 19 mm on the right and 14.51 ± 18.7 mm on the left).[8] We expected the similar LG dimensions between Thai and Korean as they both are Asian, however, coronal width of Thai LG was significantly narrower than Korean in both eyes (P value < .001 on the right and .04 on the left) for unknown reason. Coronal width of Thai LG was also significantly narrower for Caucasians (P value < .001 in both orbits). Axial widths of Thai LGs were not significantly different from others except that they were narrower than Caucasian LGs in the both orbits (P < .001 on the right and 0.01 on the left) and Turkish LGs in the left orbits (P < .001). None of the dimensions of Thai LGs were significantly larger than in any other ethnicity studied (Table 5).

The limitations in our study were due to retrospective nature with difference CT slice

thickness between prior reports and our study. This might affect LG measurement and size comparison. We measured LGs in the wide age range which probable affect overall LG dimensions as there was significant inverse relationship between LG size and with age.

In conclusion, this study has revealed the diameters of normal LGs in adult Thai population. We found that some dimensions of Thai LGs differ from those of other ethnicities. Therefore, LG dimensions should be interpreted relative the dimensions typical of the patient's ethnicity. We hope our results will enhance interpretation of enlargement or atrophy of LGs as an aid in diagnosis.

Abbreviations

LG: lacrimal gland; CT: computed tomography

Acknowledgements

Financial support. None reported.

Conflicts of interest. All authors report no conflicts of interest relevant to this article.

References

1. Cunnane M, Sepahdari A, Gardiner M, Mafee M. Pathology of the eye and orbit. *Head and neck imaging.* 2011;5:591-756.
2. Rabinowitz MP, Halfpenny CP, Bedrossian Jr EH. The frequency of granulomatous lacrimal gland inflammation as a cause of lacrimal gland enlargement in patients without a diagnosis of systemic sarcoidosis. *Orbit.* 2013;32(3): 151-155.
3. Hughes GK, Miszkiel KA, editors. Imaging of the lacrimal gland. Seminars in Ultrasound, CT and MRI; 2006: Elsevier.
4. Izumi M, Eguchi K, Uetani M, et al. MR features of the lacrimal gland in Sjögren's syndrome. *AJR American journal of roentgenology.*1998;170(6):1661-1666.
5. Barbosa AP, Oliveira FRd, Rocha FJd, Muglia VF, Rocha EM. Lacrimal gland atrophy and dry eye related to isotretinoin, androgen, and prolactin: differential diagnosis for Sjögren's syndrome. *Arquivos Brasileiros de Oftalmologia.* 2021;84:78-82.
6. Harris MA, Realini T, Hogg JP, Sivak-Callcott JA. CT dimensions of the lacrimal gland in Graves orbitopathy. *Ophthalmic Plastic & Reconstructive Surgery.* 2012;28(1):69-72.
7. Ferreira TA, Saraiva P, Genders S, Buchem M, Luyten G, Beenakker J. CT and MR imaging of orbital inflammation. *Neuroradiology.* 2018;60(12):1253-1266.
8. Tamboli DA, Harris MA, Hogg JP, Realini T, Sivak-Callcott JA. Computed tomography dimensions of the lacrimal gland in normal Caucasian orbits. *Ophthalmic Plastic & Reconstructive Surgery.* 2011;27(6):453-456.
9. Lee JS, Lee H, Kim JW, Chang M, Park M, Baek S. Computed tomographic dimensions of the lacrimal gland in healthy orbits. *Journal of Craniofacial Surgery.* 2013;24(3):712-715.
10. Bingham CM, Castro A, Realini T, Nguyen J, Hogg JP, Sivak-Callcott JA. Calculated CT volumes of lacrimal glands in normal Caucasian orbits. *Ophthalmic Plastic & Reconstructive Surgery.* 2013;29(3):157-159.
11. Bukhari AA, Basheer NA, Joharjy HI. Age, gender, and interracial variability of normal lacrimal gland volume using MRI. *Ophthalmic Plastic & Reconstructive Surgery.* 2014; 30(5):388-391.
12. Bulbul E, Yazici A, Yanik B, Yazici H, Demirpolat G. Evaluation of lacrimal gland dimensions and volume in Turkish population with computed tomography. *Journal of Clinical and Diagnostic Research: JCDR.* 2016;10(2):6.
13. Nawaz S, Lal S, Butt R, Ali M, Shahani B, Dadlani A. Computed tomography evaluation of normal lacrimal gland dimensions in the adult Pakistani population. *Cureus.* 2020;12(3).
14. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics.* 1977:159-174.
15. Voyatzis G, Chandrasekharan L, Francis I, Malhotra R. The importance of clinicians reviewing CT scans in suspected lacrimal gland disease causing eyelid swelling, even if radiologists previously interpreted them as normal. *The Open Ophthalmology Journal.* 2009;3:26.
16. Jung WS, Ahn KJ, Park MR, et al. The radiological spectrum of orbital pathologies that involve the lacrimal gland and the lacrimal fossa. *Korean Journal of Radiology.* 2007;8(4): 336-342.