

## CT Exophthalmometry: A normal value in adult Thai population

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### Abstract

**Introduction:** Hertel exophthalmometry is the most frequently used tool in evaluation of proptosis but there has been reports of its low reliability and less reproducibility. Since computed tomography (CT) has become a widely used technique for imaging of the orbit, we therefore conducted this study to find normal value of proptosis in Thai people on CT.

**Method:** One hundred fifty-two subjects with normal CT scan of brain during May 1, 2011 - September 30, 2012 were enrolled. Seventy-three were male (age 21 - 74 years) and seventy-nine were female (age 20 - 85 years). Several parameters of exophthalmometry on orbital CT were measured.

**Result:** Mean protrusion value was 17 mm in male group, and 16.45 mm in female group. There was no statistically significant difference in all parameters between right and left eyes.

**Discussion and Conclusion:** Although this study found normal range of proptosis on CT in Thai population, the cutoff value for determining exophthalmos is still not known. In addition, there are several factors that influence the protrusion other than diseases such as height, weight, facial contour. Future study is therefore needed to find the cutoff value. However, the normal range of orbital CT exophthalmometry parameters from this study will still be useful to serve as an available general reference for orbital CT interpretation.

**Key words:** Exophthalmometry, Proptosis, Orbital CT

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## Introduction

Proptosis could be a result of hyperthyroidism, ocular tumors, trauma, systemic diseases, and vascular anomalies, or it may be a normal variant. In diagnosing or differentiating orbital disease, it is important to know a normal range of protrusion that differs according to race, sex and age. There are several methods to evaluate proptosis. Hertel exophthalmometry is the most frequently used tool in evaluation of proptosis but there has been reports of its low reliability and less reproducibility in serial measurement<sup>1,2,3</sup>. Computed tomography (CT) has become a widely used technique for imaging of the orbit since the 1970s<sup>4</sup>. Although normal CT anatomy of the orbital structures is described in many references<sup>2,4,5,6,7</sup> there is no study of normal value of proptosis in Thai population.

The aim of this study was to find normal value of proptosis in Thai people, to compare value between sex, and to see whether there was difference between left and right eyes.

## Method

### Patient population

This retrospective study was approved by the Research Ethics Board of Faculty of Medicine, Thammasat University. We identified 504 patients age 20 years old or more who had normal intracranial findings on brain CT scan performed at Thammasat University Hospital, Pathumthani, Thailand from May 1, 2011 to September 30, 2012. Of these 504 patients, 352 patients were excluded by the following exclusion criteria: (a) clinical evidence or history of endocrine disease, any orbital disorder, or orbital fracture (51 patients, 10.1%); (b) asymmetric scans, scans with artifacts for any reason (dental material, eye motion, etc.)

that may cause errors in orbit measurements (200 patients, 39.7%); (c) CT scans with abnormal orbital findings (e.g., artificial lens implantation, ruptured globe) (101 patients, 20.0%). Among 152 patients included in the study, 73 were male (age 21-74 years) and 79 were female (age 20-85 years).

### Image selection

Images were acquired using 64-detector CT scanner (Brilliance 64; Philips) with 5 mm slice-thickness axial reconstruction. We selected images that revealed the center of the lens, the largest eyeball contour and the optic canal on axial plane of brain CT.

### CT analysis

The parameters of exophthalmometry on orbital CT (Figure 1) were distance between the lateral orbital rims of both eyes (line A), the shortest distance from the corneal center to line A (line B), the distance between the lateral orbital rim and the medial orbital rim (line C), the length of the line passing through the lens center from the apex to line C (line D), the axial length between corneal apex (line E), the distance between the corneal apex and the posterior pole of globe (line F). Line F was parallel to line B and perpendicular to line A. All parameters were measured by two inter-observer consensus. The proptosis value (protrusion value) was line B.

### Statistical analysis

Data were analyzed using SPSS version 15.0 software. Continuous data were presented as mean  $\pm$  standard deviation. Comparisons were made between male and female groups using independent-samples t-test, and between right and left eyes using Pair t-test. A value of  $p \leq 0.05$  was considered significant.



**Figure 1** A: Distance between the lateral orbital rims of both eyes  
 B: Shortest distance from the corneal center to line A  
 C: Distance between the lateral orbital rim and the medial orbital rim  
 D: Length of the line passing through the lens center from the apex to line C  
 E: Axial length between corneal apex  
 F: Distance between the corneal apex and the posterior pole of globe

### Result

The results of measurement of each parameter for male and female groups were shown in table 1. There was a statistically significant difference between the male and female groups for parameters A, B, C, D, and F. ( $p < 0.05$ ) (Table 2)

On comparison of right and left eyes (Table 3), there was no statistically significant difference in all parameters between the right and left eyes ( $p > 0.1$ ).

**Table 1** Comparison of the parameters of exophthalmometry on orbital CT between the right and left eyes of males and females

Patients	Males		Females		p-value
	73		79		
Value (mm)	Mean $\pm$ SD	Range	Mean $\pm$ SD	Range	
A	99.7+/-3.92	88.36 - 107.94	95.69+/-4.43	81.86 - 105.97	< 0.001
BR	16.84+/-2.23	12.26 - 21.28	16.54	9.25 - 21.30	0.157
BL	16.69+/-2.26	11.6 - 21.51	16.53	10.25 - 21.59	0.1
CR	38.18+/-2.52	31.88 - 42.19	36.98	32.67 - 42.04	0.002
CL	37.82+/-2.42	32.33 - 42.15	36.8	32.33 - 42.67	0.003
DR	13.31+/-2.42	8.48 - 19.25	12.78	7.12 - 17.46	0.143
DL	13.34+/-2.35	7.11 - 18.67	12.73	6.64 - 17.58	0.097
E	67.38+/-3.62	57.92 - 76.16	64.02	56.18 - 71.53	< 0.001
FR	25.02+/-0.99	22.42 - 27.97	24.97	22.37 - 28.11	0.037
FL	25.06+/-0.89	22.52 - 27.60	25.06	22.66 - 28.24	0.031

Table 2 Comparison of mean and SD from parameters of exophthalmometry on orbital CT between males and females

Eyes	Males		Females		p-value
	146		158		
Value (mm)	Mean $\pm$ SD	Range	Mean $\pm$ SD	Range	
A	99.7+/-3.92	88.36 - 107.94	95.69+/-4.43	81.86 - 105.97	< 0.001
B	17+/-2.32	11.60 - 21.51	16.45+/-2.09	9.25 - 21.59	0.03
C	38.19+/-2.43	32.33 - 42.21	37.08+/-1.98	32.35 - 42.67	< 0.001
D	13.34+/-2.37	7.11 - 19.25	12.75+/-2.19	6.64 - 17.58	0.037
E	67.38+/-3.62	57.92 - 76.16	64.02+/-3.50	56.18 - 71.53	< 0.001
F	25.21+/-0.98	22.65 - 27.97	24.86+/-1.03	22.37 - 28.24	0.003

Table 3 Comparison of mean and range from parameters of exophthalmometry on orbital CT between the right and left eyes

	Right eye	Left eye	p-value
<b>Eyes</b>	151	151	
A (Average)		97.62+/-4.64	
(Range)		81.86-107.94	
B (Average)	16.76+/-2.26	16.68+/-2.17	0.176
(Range)	9.25 - 21.30	10.25 - 21.59	
C (Average)	37.61+/-2.27	37.62+/-2.28	0.796
(Range)	32.68 - 42.19	32.33 - 42.67	
D (Average)	13.04+/-2.30	13.02+/-2.29	0.704
(Range)	7.12 - 19.25	6.64 - 18.67	
E (Average)		65.63+/-3.93	
(Range)		56.18 - 76.16	
F (Average)	25.01+/-1.05	25.05+/-0.99	0.114
(Range)	22.37 - 28.11	22.52 - 28.24	

## Discussion and Conclusion

Exophthalmos is one of the most common clinical manifestation of various diseases involving the orbit and intraorbital content. For many years, physicians have measured degree of protrusion of the eye globe in relation to the lateral orbital rim using Hertel exophthalmometry. Although Hertel exophthalmometry was used with much appreciated value, it still has some disadvantages including low reliability, low accuracy and inter-observer variability<sup>1,2,3</sup>. These disadvantages may make clinical interpretation of the study using this tool arguably. The study in South Korea by In Tae Kim et al has shown that eye protrusion measurement using CT image is reliable and can be applied for both clinical use and future research study<sup>2</sup>. Eye protrusion can be different according to sex, age, and race. In Thailand there has been no study on normal value of eye protrusion on CT images, therefore we conducted this study to find normal values in adult Thai people.

The results from this study showed that there was no significant difference between both eyes of each patient, corresponding well with the study by In Taek Kim et al. On comparison of the data from our study with the Korean study in the same age groups, we found no statistical significant difference. In this study, the protrusion value was 16.76 mm (9.25-21.30 mm) in right eye, and 16.68 mm (10.25-21.59 mm) in left eye. In the Korean study, the protrusion value was 15.06 mm (10.00-18.57 mm) in right eye, and 15.02 mm (11.02-18.02 mm) in left eye. We also found that the other values (A, C, D) were approximately the same as those of the Korean study. In male patients, we found that all values were more than the values in female patients significantly, unlike the Korean study which no statistical difference was found. We assume that the cause of such difference might be due to larger body built of most of the Thai male population than that of the Thai female.

In the Korean study<sup>2</sup>, the values measured by CT were more than those measured by a Hertel exophthalmometry. These differences were also found in this study. In Thailand, there are two studies on normal proptosis

using instrument for exophthalmometry. The first one is the study of proptosis using Hertel exophthalmometry in Thailand by Vangveeravong S. et al, the proptosis value was 14.38 mm in male, 14.16 mm in female, 14.26 mm in right eye, and 14.27 mm in left eye<sup>8</sup>. The second one is the study using Luedde exophthalmometry by Sarinnapakorn V. et al, the proptosis value was 11.84 mm in male, and 11.44 in female<sup>9</sup>. We think that the differences occur by the fact that in Hertel and Luedde exophthalmometry, the protrusion is measured with skin and subcutaneous soft tissue included to the lateral orbital rim. But in CT exophthalmometry, the protrusion is measured from lateral orbital bone only, not with the covering soft tissue and skin.

Although this study found normal range of proptosis on CT in Thai population, the cutoff value for determining exophthalmos is still not known. In addition, there are several factors that influence the protrusion other than diseases such as height, weight, facial contour, future study is therefore needed to find the cutoff value. However, the normal range of orbital CT exophthalmometry parameters from this study will still be useful to serve as an available general reference from orbital CT interpretation. The upper values in the range from our study can also help in evaluation of a patient with normal Hertel exophthalmometry but having exophthalmos appearance.

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### บทคัดย่อ

การศึกษาภาพเอกซเรย์คอมพิวเตอร์เพื่อหาค่าปรกติการยื่นออกมาทางด้านหน้าของลูกตาจากกระดูกเบ้าตาในคนไทย  
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ภาควิชารังสีวิทยา คณะแพทยศาสตร์ มหาวิทยาลัยธรรมศาสตร์

**บทนำ:** การยื่นออกมาทางด้านหน้าของลูกตาที่มากผิดปกติหรือที่เรียกว่า “ตาโปน” สามารถพบได้จากหลายสาเหตุ ปัจจุบันการวัดค่าการยื่นของลูกตาใช้เครื่อง Hertel exophthalmometer เป็นตัววัด ซึ่งวิธีการนี้มีงานวิจัยบางฉบับ รายงานว่ามีค่าคลาดเคลื่อนจากการวัดได้ซึ่งมีผลต่อการวินิจฉัยโรคและการตรวจติดตามผู้ป่วย ในปัจจุบันโรคทางจักษุวิทยาบางโรคผู้ป่วยจะถูกส่งมาทำเอกซเรย์คอมพิวเตอร์ก่อนให้การรักษา ซึ่งการจะวินิจฉัยให้ได้ว่าผู้ป่วยมีการยื่นของลูกตาที่มากผิดปกติหรือไม่นั้น จำเป็นจะต้องทราบค่าที่ปรกติก่อน ทั้งนี้ยังไม่เคยมีการศึกษาค่าปรกติการยื่นของลูกตาในคนไทยจึงทำให้ทางผู้วิจัยสนใจทำการศึกษาในเรื่องนี้ วัตถุประสงค์เพื่อหาค่าปรกติการยื่นออกมาทางด้านหน้าของลูกตาจากกระดูกเบ้าตาด้วยภาพเอกซเรย์คอมพิวเตอร์และเทียบค่าความแตกต่างระหว่างสองตาและเพศ

**วิธีการศึกษา:** เอกซเรย์คอมพิวเตอร์สมองที่ผลปรกติของผู้ป่วย ๑๕๒ คน ที่ทำการตรวจตั้งแต่ ๑ พฤษภาคม พ.ศ. ๒๕๕๔ ถึง ๓๐ กันยายน พ.ศ. ๒๕๕๕ โดยเป็นเพศชาย ๗๓ คน (อายุระหว่าง ๒๑ - ๗๔ ปี) และเพศหญิง ๗๙ คน (อายุระหว่าง ๒๐ - ๘๕ ปี) ภาพเอกซเรย์คอมพิวเตอร์ในท่าตัดขวางจะถูกนำมาวัดค่าตามที่กำหนด

**ผลการศึกษา:** ค่าเฉลี่ยการยื่นของลูกตาในผู้ชายและผู้หญิงเท่ากับ ๑๗ มิลลิเมตร และ ๑๖.๔๕ มิลลิเมตร ส่วนค่าอื่นที่วัดได้เมื่อเทียบกับระหว่างตาด้านซ้ายและขวาไม่แตกต่างกันอย่างมีนัยสำคัญทางสถิติ

**วิจารณ์ และสรุปผลการศึกษา:** ค่าที่ได้จากการวิจัยนี้มีประโยชน์สำหรับใช้เป็นเกณฑ์อ้างอิงเพื่อประกอบการแปลผลการยื่นออกมาทางด้านหน้าของลูกตาจากกระดูกเบ้าตาของคนไทยด้วยภาพเอกซเรย์คอมพิวเตอร์ แต่อาจจะยังไม่สามารถนำมาเป็นเกณฑ์การวินิจฉัยภาวะตาโปนได้ เพราะยังมีปัจจัยอีกหลายประการที่ส่งผลต่อการยื่นของลูกตาซึ่งควรมีการศึกษาต่อไป

**คำสำคัญ:** ตาโปน, ตาโปนข้างเดียว, ภาพเอกซเรย์คอมพิวเตอร์กระดูกเบ้าตา