

# Location of Superior and Inferior Parathyroid Glands in Relation to the Midpoint of Isthmus of Thyroid and Tracheal Rings

\*Romini Niranjana<sup>a</sup> Sivananthini Uthayakumar<sup>b</sup> and Surangi .G. Yasawardene<sup>b</sup>

<sup>a</sup>Department of Anatomy, Faculty of Medicine, University of Jaffna.

<sup>b</sup>Department of Anatomy, Faculty of Medical Sciences, University of Sri Jayewardenepura.

\*rominiranjana@yahoo.com

## ABSTRACT

Knowledge of the anatomical location of parathyroids is essential for thyroid surgeries. The thyroid lobes connected by isthmus in front of 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> tracheal rings (TRs). The aim of the study is to determine the level of location of parathyroids in relation to midpoint of isthmus (MOI). Sixty fresh adult thyroids along with trachea were collected from Judicial Medical Officer, Colombo South Teaching Hospital, Sri Lanka. Level of superior and inferior borders of isthmus (SBI & IBI) to underlying cricoid and TRs was noted. MOI was marked with a pin and TR corresponding to it was noted. SBI extended to 1<sup>st</sup> TR in 76.66% (46/60) and to 2<sup>nd</sup> TR in 18.33% (11/60) of thyroids. IBI extended to 3<sup>rd</sup> TR in 50% (30/60) and to 2<sup>nd</sup> TR in 38.33% (23/60) of thyroids. Common site for SBI was at 1<sup>st</sup> TR and for IBI at 3<sup>rd</sup> TR. Common site for MOI was at 2<sup>nd</sup> TR. A total of 82.08% (197/240) of parathyroids were identified and the level of location of parathyroids to underlying cartilages was noted. Out of them, 0.5% (1/197) were located just above cricoid, 19.28% (38/197) at cricoid, 27.91% (55/197) at 1<sup>st</sup> TR, 5.07% (10/197) at 2<sup>nd</sup> TR, 28.42% (56/197) at 3<sup>rd</sup> TR, 12.18% (24/197) at 4<sup>th</sup> TR, 5.58% (11/197) at 5<sup>th</sup> TR and 1.01% (2/197) were at 6<sup>th</sup> TR level. Parathyroids located above and below the common MOI were considered as superior and inferior parathyroids. A total of 5.07% (10/197) of parathyroids were located at 2<sup>nd</sup> TR could be considered as either superior or inferior. Extension of isthmus is variable. Majority of identified superior parathyroids were located above and inferior parathyroids were below the MOI. Thus MOI helps in identification and differentiation of parathyroids.

**Key words:** Parathyroid location, Tracheal rings, Thyroid isthmus

## 1. INTRODUCTION

Parathyroid glands (PGs) are the small endocrine organs located mostly on the posterior surface of thyroid lobe. Usually parathyroid glands vary in number, size and location. The location of PGs is varying widely as a result of different degree of migration during embryonic development [1]. Both right and left thyroid lobes are connected by the narrow median isthmus. Most of the Anatomy text books describe the isthmus of thyroid to be located in front of second, third and fourth tracheal rings. The posterior surface of the isthmus is firmly adherent to these underlying tracheal rings [2]. Isthmus measures about 1.25 cm transversely as well as vertically [3]. Surgeons face difficulties in identifying and preserving the PGs during the thyroidectomies. Knowledge of anatomical location of superior and inferior PGs is essential for safe thyroid and parathyroid surgeries. This study aimed to determine the level of location of superior and inferior parathyroid glands in relation to

1. Superior and inferior borders of isthmus.
2. Midpoint of isthmus (MOI).

This knowledge would help in identifying both superior and inferior PGs at surgeries.

## 2. MATERIALS AND METHODS

A descriptive study was conducted and a total of sixty fresh normal male and female adult thyroid glands along with trachea were collected during postmortem from Judicial Medical Officer, Colombo South Teaching Hospital, Sri Lanka. Ethical clearance was obtained from Ethics Review Committee, Faculty of Medical Sciences, University of Sri Jayewardenepura. The extension of

the isthmus was studied by noting the level of superior and inferior borders of isthmus to the underlying cricoid cartilage (Cr) and tracheal rings (TRs). Superior border and inferior border of isthmus (SBI & IBI) was identified and the underlying cartilages corresponding to the level of SBI and IBI was noted. The midpoint of isthmus was identified and marked with a pin. The tracheal ring corresponding to the MOI was noted.

Superior and inferior parathyroid glands were identified under the dissecting microscope and similarly the level of location of parathyroid glands to the underlying cartilages was noted. Subsequently the identified parathyroid glands were removed and confirmed by histological methods.

**3. RESULTS AND DISCUSSION**

Extension of isthmus is variable. In most of studied thyroids, superior border of isthmus is at the first tracheal ring and inferior border at third tracheal ring. Common site for the midpoint of isthmus is either at junction of first or second tracheal ring or at second tracheal ring.

Most of identified superior parathyroid glands (100%) were located above and inferior parathyroid glands (88%) were located below the midpoint of isthmus.

In majority of thyroids, superior PGs were located either at the cricoid cartilage or 1<sup>st</sup> tracheal ring level.

**Borders of isthmus**

In 76.66% (46/60) of thyroid glands, the superior border of isthmus was extending up to first TRs and in 18.33% (11/60) of thyroids SBI was extending up to the second TRs (Table 1). Thus first TR was considered as common site for superior border of isthmus (CSBI).

In 50% (30/60) of thyroids, the inferior border of isthmus was extending up to third TR and in 38.33% (23/60) of thyroids extending up to second TR (Table 2). Thus third TR was considered as common site for inferior border of isthmus (CIBI).

In this study, the extension of the isthmus of thyroid from superior border at 1<sup>st</sup> TR and inferior border at 2<sup>nd</sup> TR was observed in 35% (21/60) of thyroid glands. Isthmus extending as superior border lying on 1<sup>st</sup> TR and inferior border lying on 3<sup>rd</sup> TR was observed in 36.66% (22/60) of thyroids.

Another 10% (6/60) of thyroids had isthmus extension from superior border on 2<sup>nd</sup> TR to inferior border on 3<sup>rd</sup> TR. Remaining thyroids have shown other types of isthmus extension in less percentage (Table 3).

**Midpoint of isthmus:**

In majority of thyroids, the superior border of isthmus extends up to first TR and inferior border extends up to third TR. Considering these facts then the second TR was considered as the common point for the midpoint of isthmus (CMOI).

It was also observed that in most of studied thyroids, the midpoint of isthmus was located either at junction of first and second tracheal rings 38.33% (23/60) or at second tracheal ring 40% (24/60) (Table 4).

**Table -1** Extension of Superior border of isthmus in relation to the underlying cartilages:

Level of superior border of isthmus of thyroid	No of thyroid glands
Cricoid level	2
First TR level	46
Second TR level	11
Third TR level	1
<b>Total</b>	<b>60</b>

**Table -2** Extension of inferior border of isthmus in relation to the underlying cartilages:

Level of inferior border of isthmus of thyroid	No of thyroid glands
Second TR level	23
Third TR level	30
Fourth TR level	6
Fifth TR level	1
<b>Total</b>	<b>60</b>

**Table -3** Extension of isthmus

Number of thyroid glands	Extension of isthmus	Percentage
2	Cr,1,2,3	3.33%
21	1,2	35%
2	2	3.33%
22	1,2,3	36.66%
6	2,3	10%
2	1,2,3,4	3.33%
1	1,2,3,4,5	1.66%
3	2,3,4	5%
1	3,4	1.66%
<b>Total (60)</b>		

**Location of parathyroid glands:**

Total of 197 parathyroid glands were identified. Considering four parathyroids are normally found in each thyroid gland, a total of 82.08% (197/240) of PGs were identified.

Out of identified PGs, 0.5% (1/197) of PGs, located just above the cricoid level, 19.28% (38/197) of PGs were at cricoid level, 27.91% (55/197) of PGs at 1<sup>st</sup> TR, 5.07% (10/197) at 2<sup>nd</sup> TR, 28.42% (56/197) at 3<sup>rd</sup> TR, 12.18% (24/197) at 4<sup>th</sup> TR, 5.58% (11/197) at 5<sup>th</sup> TR, 1.01% (2/197) were at 6<sup>th</sup> TR level (Table 5).

**Table -4** Midpoint of isthmus of thyroid gland in relation to the underlying cartilages:

Level of MOI of isthmus of thyroid	No of thyroid glands
Junction of first and second TR level	23 (38.33%)
Second TR level	24 (40%)
Junction of second and third TR level	8 (13.33%)
Third TR level	4 (6.66%)
Junction of third and fourth TR level	1 (1.66%)
<b>Total</b>	<b>60</b>

**Table -5** Location of PGs in relation to the underlying cartilages:

Cartilage level	Left	Right
Above cricoid	1	0
Cricoid	24	14
First TR	25	30
Second TR	3	7
Third TR	24	32
Fourth TR	12	12
Fifth TR	4	7
Sixth TR	1	1
Seventh TR	0	0
<b>Total (197)</b>	<b>94</b>	<b>103</b>

Total of 47.71% (94/197) of PGs were located above the common midpoint of isthmus and were considered to be superior PGs and 47.20% (93/197) of PGs located below the common MOI were considered to be inferior PGs. A total of 5.07% (10/197) of PGs were located at the second TR could be considered as either superior or inferior PGs.

It was observed that most of superior PGs, nearly 19.28% were located at the level of cricoid cartilage and 27.91% at first TR (Table 5).

A total of 28.42% (56/197) of inferior PGs were located at the level of third TR and 12.18% (24/197) at fourth TR (Table 5).

**Table -6** Location of PGs in relation to the borders of the isthmus of thyroid glands:

Location of PGs in relation to the borders of isthmus	Number of PGs	
	Left	Right
Above SBI	30	21
At the level of SBI	20	22
Within the extension of isthmus	4	5
At the level of IBI	17	25
Below the IBI	23	30
<b>Total</b>	<b>94</b>	<b>103</b>

A total of 47.20% (93/197) of PGs were located at or above the level of SBI and 48.22% (95/197) were located at or below the IBI (Table 6).

In this study most of identified superior parathyroid glands were located at the level or above SBI. Similarly identified inferior parathyroid glands were located at the level or below the IBI. Only 4.56% (9/197) PGs were found within the isthmus extension. It is cleared that majority of thyroids, superior PGs were located above the MOI and inferior PGs were below the MOI.

It was also noted that in each thyroid, identified parathyroid glands were located at different cartilage levels. Also identified PGs in each thyroid gland were not similar in size or its location.

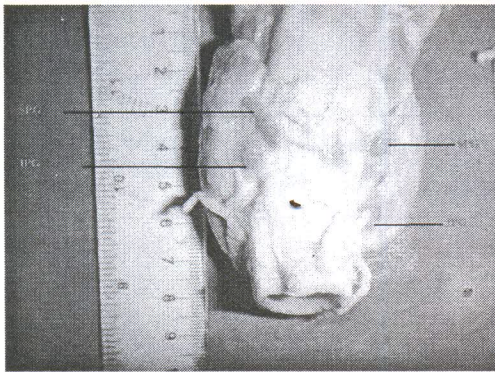
Parathyroids mostly found among the fatty tissues along the posterior border or posterior surface of thyroid glands.

By multivariate analysis and considering 2<sup>nd</sup> TR as the reference point, it was observed the statistical significance between the upper border of isthmus at 1<sup>st</sup> TR and the location of superior PG at the cricoid level ( $p = .004$ ) and similarly upper border at the 2<sup>nd</sup> TR and the location of superior PG at the 1<sup>st</sup> TR ( $p = .002$ ).

It was also observed that the correlation between the isthmus extension 1,2,3 and location of superior PGs

either at cricoid cartilage or 1<sup>st</sup> TR.

It was identified that 100 % of superior PGs and 88% of inferior PGs were located above and below the tracheal ring corresponding to the MOI by using the statistical compute variable analysis. In this case remaining 12% of inferior glands were exactly located at the same tracheal ring corresponding to the MOI.



**Fig-1** Posterior surface of the thyroid gland. Left and right superior parathyroid glands were located at first tracheal ring and inferior parathyroid glands on left was at second tracheal ring and on the right at fourth tracheal ring.

The thyroid gland develops as a median thickening of endoderm on the floor of the pharynx between the first and second pharyngeal pouches.

Embryologists observing the thyroid gland during the embryonic period have observed that gradual lowering of thyroid primordium position in relation with the developing pharynx and other pouches.

Thyroid gland acquires its characteristic two lobe structure with centrally situated isthmus at the end of second month of intrauterine period [4]. Thyroid isthmus is the main remainder of thyroid primordium [4].

The wide variability in the position of isthmus might be due to either failure of descent or excessive descent of thyroid during the embryonic period [3].

Study done by Seheli et al on both thyroid glands with presence of isthmus (68.3%) and without isthmus (31.7%), they observed more frequent location of isthmus was documented at 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> (18.3%) and 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> (18%) tracheal rings in the Bangladesh people [3], which is more or less similar to our results.

In this study, most of the identified superior parathyroid

glands were located at the level or above SBI and inferior parathyroid glands were located at the level or below the IBI. Also most of identified superior glands, which located within the isthmus extension were found to be placed above the MOI and inferior glands were placed below the MOI. Only 1 thyroid with the MOI at 2<sup>nd</sup> TR, both superior and inferior were found at the 2<sup>nd</sup> TR level. It pointed out that there must be some embryological relationship between the borders of isthmus of thyroid and the migration path of the developing parathyroids.

Superior PGs develop from the fourth pharyngeal pouch and inferior PGs from the third pharyngeal pouch.

Typically there are four parathyroid glands, but number may vary from two to seven [5].

Although there are documented studies on the level of location of superior and inferior parathyroid glands, studies on the location of parathyroid glands within the thyroid tissue is lacking and this would be useful to the surgeon at the time of surgery.

The parathyroids located high in the neck are considered as superior and low in the neck were considered as inferior [6].

Normal PGs are soft and pliable in consistency. This helps in differentiating a parathyroid from the lymph node or thyroid nodule [1].

Cricothyroid junction is the most common site for the superior parathyroid glands and inferior parathyroid are more variable in location [6].

Inferior PGs usually situated below inferior thyroid artery near lower pole. The next most common site for inferior is within 1 cm of the lower pole of the thyroid gland [7].

#### 4. CONCLUSION

Thus both the borders of isthmus and the midpoint of isthmus are good guide lines in the identification and differentiation of parathyroid either as superior or inferior glands and preserving PGs at thyroid or parathyroid surgeries it also minimize the time spent on searching the superior and inferior parathyroid glands at the time of surgeries.

Further, large scale studies needed to revalidate our findings.

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