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The Zuckerkandl's Tubercle: A Useful Anatomical Landmark for Detecting both the Recurrent Laryngeal Nerve and the Superior Parathyroid during Thyroid Surgery

JI-SUP YUN, YONG SANG LEE*, JEONG JOO JUNG*, KEE HYUN NAM*, WOONG YOUN CHUNG*, HANG SEOK CHANG* AND CHEONG SOO PARK*

Department of Surgery, Kangbuk Samsung Hospital, SungKyunKwan University School of Medicine, Seoul, Korea
**Department of Surgery, Yonsei University College of Medicine, Seoul, Korea*

Abstract. Zuckerkandl's tubercle (ZT) is a well-documented anatomical structure. This study evaluated ZT anatomical characteristics in terms of the recurrent laryngeal nerve (RLN) and the superior parathyroid (SP). The study involved 325 (10 with benign tumors and 315 with malignancies) patients who underwent thyroidectomy between February and June 2007. ZTs were classified according to size: Grade 0 (unrecognizable), Grade I (≤5 mm), Grade II (6~10 mm) and Grade III (>10 mm). The incidence and size of the ZT and its positional relationship to the RLN and SP were investigated during thyroid surgery. ZTs were identified in most patients (right 89.3%, left 85.6%). The distribution of ZTs according to grade was as follows: Grade 0, right 10.7% and left 14.4%; Grade I, right 7.9% and left 11.1%; Grade II, right 43.5% and left 38.5%; and Grade III, right 37.9% and left 35.9%. The most common RLN course was in a groove between the ZT and the main body of the thyroid. The majority of SPs were cranial to the ZT which was located at the 1 or 2 o'clock position (96.1%) in the left, and at 10 or 11 o'clock (95.2%) in the right. The smaller the size of the ZT, the greater the distance between the ZT and the SP. There was a constant relationship between the ZT and RLN and SP. Therefore, an identification of ZT and an understanding of the relationship between the ZT and RLN and SP are essential for performing safe thyroid surgery.

Key words: Zuckerkandl's tubercle, Recurrent laryngeal nerve, Superior parathyroid, Anatomical landmark

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IN 1902 the most protruding area of the posterolateral margin of the thyroid was named Zuckerkandl's tubercle (ZT) by Emil Zuckerkandl [1]. Prior to that, Madelung [2] in 1867 had noted this structure for the first time and described it as the "posterior horn of the thyroid". In 1938, Gilmour [3] reported an anatomical relationship between the ZT and the recurrent laryngeal nerve (RLN) and the superior parathyroid (SP). However, the issue of the ZT as an anatomical landmark has largely been of little interest to surgeons [4–9]. Some investigators claimed that the classical exposure of the RLN during thyroid surgery is a prerequisite for its protection [10]. While many studies have reported on the association between the ZT and the RLN, there are no reports detailing the anatomical relationship between the ZT and the SP.

The present study examined whether the ZT is a meaningful anatomical landmark during thyroid surgery and particularly focused on its relationship with the RLN and the SP.

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Correspondence to: Cheong Soo PARK, M.D., Ph.D., Department of Surgery, Yonsei University College of Medicine, 250 Seongsanno, Seodaemun-gu, Seoul 120-752, Korea

Patients and Methods

This study involved 325 patients who underwent thyroidectomy by the same surgeon at the Yonsei University Health System from February 2007 to July 2007. During surgery, the ZT was assessed in terms of

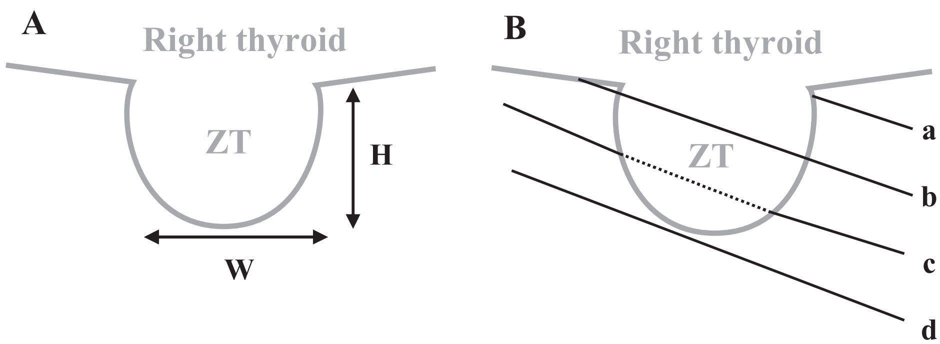

Fig. 1. A–B. The measurement of ZT size (A) and classification of relationship between the ZT and the RLN (B). H = height, W = width, a = Type A (posterior surface of the ZT), b = Type B (anterior surface of the ZT), c = Type C (passes through parenchyma of the ZT), D = type D (lateral to the ZT).

its presence or absence, size, and association with the RLN and SP. The ZT was exposed by careful capsular dissection using bipolar electrocautery. The size of the exposed ZT was measured based on the height and width by compass (height: apex of ZT~groove between ZT and thyroid lateral margin, width: the longest length between upper and lower margin of the ZT). The ZT grade was based on the classification method of Pelizzo *et al.* [4], in which 0 = unrecognizable, I≤5 mm, II = 6~10 mm, III>10 mm. The running pathway of the RLN in the ZT area was classified as either Type A = posterior ZT surface, Type B = anterior ZT surface, Type C = passing through the ZT parenchyma or Type D = lateral of the ZT (Fig. 1). Type D pathways were further classified as D1 = attached to the apex of the ZT, or D2 = departing from the apex of the ZT. In terms of the SP, the location and distance were classified in terms of clock-face image. Cases where the ZT assessment was difficult were excluded form the study, and these included where the ZT contained tumors, where there were large tumors involving the entire lobe, chronic thyroiditis.

Statistical analysis was performed using SPSS 12.0 software (2003 SPSS Inc. Chicago, Illinois, U.S.A), and comparisons between groups were made using Chi-square and independent sample's t-tests. P values less than 0.05 were considered to indicate significance.

Table 1. Grade of ZT

	Grade (%)				P value
	0	I	II	III	
Right (n = 280)	30 (10.7)	22 (7.9)	122 (43.5)	106 (37.9)	0.127
Left (n = 270)	39 (14.4)	30 (11.1)	104 (38.5)	97 (35.9)	

Results

Clinical and anatomical characteristics of the ZT

There were 41 male and 284 female patients, with a mean age of 47.0 years (range, 17–71 years). Ten cases presented with benign tumors and 315 with thyroid carcinomas. There were 251 total thyroidectomies and 74 less-than total thyroidectomies (33 right-sided and 41 left-side cases). Excepting cases corresponding with the exclusion criteria, ZT was observed in the left side in 95.1% (270/284), and the right side in 96.0% (280/292), and among them, cases showing in bilaterality were 91.2% (229/251). The mean sizes were 8.5 × 5.7 mm for left-sided and 9.5 × 6.8 mm for right-sided ZTs (p = 0.021). For left-sided ZTs, 14.4% (39/270) were Grade 0, 11.1% (30/270) were Grade I, 38.5% (104/270) were Grade II, and 35.9% (97/270) were Grade III. For right-sided ZTs, 10.7% (30/280) were Grade 0, 7.9% (22/280) were Grade I, 43.5% (122/280) were Grade II, and 37.9% (106/280) were Grade III (Table 1).

The relationship between the ZT and the RLN

The study investigated the types of main RLN running pathways after excluding Grade 0 ZTs from the analysis. For left-sided ZTs, main RLN pathways were found to be 90.9% (210/231) Type A, 0.4% (1/

Table 3. Relationship between the ZT and RLN

		ZT height					
		≤5 mm		6~10 mm		>10 mm	
		Right (n = 85)	Left (n = 96)	Right (n = 119)	Left (n = 116)	Right (n = 46)	Left (n = 19)
Type of RLN	A	75 (88.2%)	78 (81.3%)	112 (94.1%)	115 (99.1%)	45 (97.8%)	18 (94.7%)
	B	1 (1.2%)	1 (1.0%)	0	0	0	0
	C	0	0	0	0	0	0
	D1	6 (7.1%)	9 (9.4%)	5 (4.2%)	1 (0.9%)	1 (2.2%)	1 (5.3%)
	D2	3 (3.5%)	8 (8.3%)	2 (1.7%)	0	0	0

Table 2. Type of RLN

	Type (%)					P value
	A	B	C	D1	D2	
Right (n = 250)	232 (92.8)	1 (0.4)	0	12 (4.8)	5 (2.0)	0.787
Left (n = 231)	210 (90.9)	1 (0.4)	0	12 (5.2)	8 (3.5)	

231) Type B, 0% (0/231) Type C, 5.2% (12/231) Type D1 and 3.5% (8/231) Type D2. For right-sided ZTs, the pathways were found to be 92.8% (232/250) Type A, 0.4% (1/250) Type B, 0% (0/250) Type C, 4.8% (12/250) Type D1 and 2.0% (5/250) Type D2 (Table 2). Analysis of main RLN running pathways and the ZT height showed that the smaller height of the ZT, the more common was the Type D pathway (p<0.001) (Table 3).

The relationship between the ZT and SP

The study examined the clock-face location of the SP associated with ZTs higher than Grade I, where the tracheoesophageal groove was considered the axis. For left-sided ZTs, 13.4% (31/231) of SPs were in the 1 o'clock position, 82.7% (191/231) were in the 2 o'clock position, and 3.0% (7/231) were in the 3 o'clock position. In 0.9% (2 cases) of cases the SP was concealed behind the ZT. For right-sided ZTs, 0.8% (2/250) of SPs were in the 8 o'clock position, 2.8% (7/250) were in the 9 o'clock position, 81.6% (204/250) were in the 10 o'clock position, 13.6% (34/250) were in the 11 o'clock position, 0.8% (2/250)

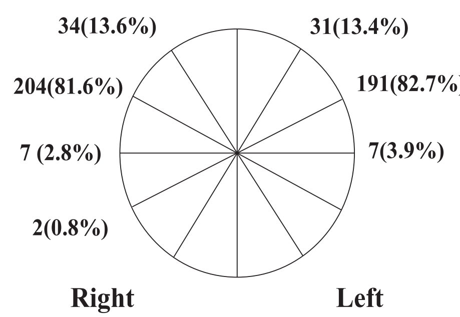

Fig. 2. Clock-face location of the SP. (4 cases behind the ZT (Right: 2, Left: 2) and 1 case on the anterior surface of the ZT (Right) were excluded from this figure).

Table 4. Distance between the ZT and the SP

	Distance (%)			P value
	0 mm	<5 mm	≥5 mm	
Right (n = 250)	219 (87.6)	26 (10.4)	5 (2.0)	0.483
Left (n = 231)	206 (89.2)	19 (8.2)	6 (2.6)	

were detected on the posterior surface of the ZT, and 0.4% (1/250) was detected on the anterior surface of the ZT (Fig. 2).

The study examined the distance between the ZT and the SP. The SP was adhered to the ZT in 89.2% (206/231) of left-sided and 87.6% (219/250) of right-sided cases, was within 5 mm of the ZT in 8.2% (19/231) of left-sided and 10.4% (26/250) of right-sided cases, and was more than 5 mm away in 2.6% (6/231) of left-sided and 2.0% (5/250) of right-sided cases (Table 4). Analysis showed that there was an inverse

Table 5. Relationship between the ZT and the SP

		ZT width					
		≤5 mm		6~10 mm		>10 mm	
		Right (n = 21)	Left (n = 30)	Right (n = 123)	Left (n = 104)	Right (n = 106)	Left (n = 97)
Distance	0	11 (52.4%)	14 (46.7%)	109 (88.6%)	99 (95.2%)	100 (94.4%)	92 (94.8%)
	<5 mm	9 (42.8%)	10 (33.3%)	11 (9.0%)	4 (3.9%)	5 (4.7%)	5 (5.2%)
	≥5 mm	1 (4.8%)	6 (20.0%)	3 (2.4%)	1 (0.9%)	1 (0.9%)	0

Table 6. Incidences of Zuckerkandl's tubercle (n: sides)

	Pelizzo *et al.* [4]	Hisham & Aina [22]	Yacin *et al.* [9]	Present study
Grade 0	24/104 (23%)	19/96 (19.8%)	11/80 (13.8%)	69/550 (12.5%)
Grade I	9/104 (8.6%)	–	17/80 (21.2%)	52/550 (9.5%)
Grade II	56/104 (53.8%)	24/96 (25.0%)	42/80 (52.5%)	226/550 (41.1%)
Grade III	15/104 (14.4%)	53/96 (55.2%)	10/80 (12.5%)	203/550 (36.9%)

relationship between width of the ZT and its distance from the SP (Table 5).

Discussion

The major concern during thyroidectomy is preservation of the RLN and parathyroid since injury to these sites results in a lower quality of life [11]. Therefore, safe thyroid surgery requires a sufficient understanding of normal anatomy and anatomical variation associated with the thyroid.

Embryologically, the thyroid originates from the median and lateral anlages. The median anlage is composed of follicular cells, and originates from epithelial cells of the foramen cecum located at the base of the tongue, descends along the cervical midline, and forms the median thyroid which constitutes most of the thyroid [12]. The lateral anlage originates from the 4th or the 5th branchial cleft bilaterally, forms the ultimobranchial body, and fuses with the median thyroid in the neck at approximately 5 weeks of gestation [13]. At that time, the ultimobranchial body is located in the posterolateral area and forms the lateral thyroid. The lateral thyroid comprises 1–30% of the weight of the entire thyroid and consists of parafollicular C cells that originate from the neural crest [14]. The lateral thyroid formed in such a manner is the ZT.

The RLN in the neck is located underneath the pretracheal fascia, and runs towards the cephalad. The RLN appears in the medial side of the carotid artery near the thoracic inlet, passes through the groove between the ZT and the main body of the thyroid, and transits into the larynx in the area below the cricopharyngeal muscle [6]. The classic manner to minimize RLN injury is to trace the RLN by dissecting along the entire cervical RLN [15, 16]. However, excessive exposure of the nerve may induce temporary neuropraxia by blocking the vasa nervorum [7]. To apply Simon's triangle as an anatomical landmark to preserve the RLN during surgery, numerous investigators have reported the relationship between structures such as the inferior thyroidal artery, the ligament of Berry, thyroid cartilage and the ZT [4, 5, 11, 17–20]. However, reports regarding the ZT are not abundant, and there is no detailed classification of the relationship with the RLN. This situation highlights the importance of classifying the RLN running pathways in the ZT area, as undertaken in the present study (Fig. 1).

Embryologically, the SP is originates from the 4th branchial cleft adjacent to the ultimobranchial body, and thus the ZT and the SP have a constant anatomical relationship [4]. Chevallier *et al.* [21] emphasized the ZT as an anatomical landmark for the preservation of the SP. The SP is generally located in the cranial portion behind the RLN and inferior thyroidal artery, and the inferior parathyroid is located in the caudal portion of the ZT in front of the RLN and inferior thyroidal artery [5, 21]. In the clock-face classification used to describe SP location in the present study, 96.1% of left SPs and 95.2% of right SPs were located in the ZT cranial portion (left side was 1 and 2 o'clock, while right side was 10 and 11 o'clock), indicating a constant relationship as reported in previous studies.

The present study found that 87.5% of ZTs were higher than Grade I (Table 6), consistent with the findings of others. Prior to using the ZT as an anatomical landmark in thyroid surgery, the ZT capsule shoud first be dissected finely particularly at the cranial and caudal portions of the ZT as the areas are adjacent to the RLN and SP. The present study found that 92.1% RLNs (443/481) were type A, and height of the ZTs greater than 6 mm comprised 65.5% (290/443) of type A RLNs. Therefore, for cases where the ZT is more than 6 mm in height, the initial exposure of nerves should involve dissecting the groove between the inferior portion of the ZT and the main body of the thyroid. For non-A or non-B type patients, the exposed ZT is less than 10 mm in height, and the possibility of being type D is 94.4% (34/36), in which case, nerves should be sought in the vicinity of the ZT apex. In 95.6% (460/481) of cases, the SP was located between the 1~2 o'clock or 10~11 o'clock positions, and should therefore be sought in the cranial portion of the ZT. The present study found that wider ZTs were either adhered to or within 5 mm of the SP, while narrower ZTs greater than 5 mm away ($p<0.001$). Therefore, if the exposed ZT was greater than 6 mm in width, preservation of the SP should be considered from the time of ZT capsular dissection.

Conclusions

ZTs were greater than Grade I in 85.6%–89.3% of cases. ZTs maintained a constant anatomical relationship with the RLN and the SP. Therefore, it appears that the ZT can be used as an anatomical landmark to assist in preservation of the RLN and the SP during thyroid surgery.

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