Barw Medical Journal | 2024;2(2):44-56
Journal home page: https://barw.krd/index.php/BMJ

Systematic Review

# Thyroid Collision Tumors: A Systematic Review

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Keywords:
PTC and MTC
PTC and FTA
Recurrence
Collision

Received: April 20, 2024
Revised: May 30, 2024
Accepted: June 22, 2024
Published: June 28, 2024



Citation: Abdullah AM, Qaradakhy AJ, Ali RM, Ali RM, Mahmood YM, Omar SS, et al. Thyroid Collision Tumors: A Systematic Review. Barw Medical Journal. 2024 Jun 28;2(2):44-56.
https://doi.org/10.58742/bmj.v2i2.94

## Abstract

### Introduction

Collision tumors in the thyroid gland are exceedingly uncommon, comprising approximately 1.0% of all thyroid malignancies. This study aims to systematically review the presentation and management of collision tumors of the thyroid gland.

### Methods

A systematic review of published studies on thyroid collision tumors was conducted. All studies concerning thyroid collision tumors meeting the following criteria were included: 1) Confirmation of collision tumors via diagnostic methods, surgical exploration, or histopathological examination. 2) Presentation of case details within the study. 3) Tumors located precisely in the thyroid gland.

### Results

In total, 57 studies were compatible with the inclusion criteria. Most cases were female 87 (71.31%), and the remaining 35 (28.69%) were male. The patients' ages were between 12 and 88 years old, with a mean of 49.87 ± 14.48 years. The most commonly presented symptom was neck swelling (45.08%). The most prevalent surgical procedure observed was total thyroidectomy combined with lymph node dissection, performed in 40 cases (32.78%). The predominant histopathological findings consisted of the simultaneous presence of papillary thyroid carcinoma and medullary thyroid carcinoma, identified in 51 cases (41.80%). The recurrence rate was observed in only 10 cases (8.20%).

### Conclusion

Thyroid collision tumors may primarily affect females, with the most frequent collisions being papillary and medullary thyroid carcinoma. Total thyroidectomy with lymph node dissection is the prevalent management option, and the recurrence rate can be lower than 10%.

## 1. Introduction

Collision tumors represent a phenomenon wherein two histologically distinct malignancies, characterized by differing cellular lineages and genetic origins, coexist within the same mass and organ without a discernible transitional zone. This phenomenon frequently manifests in the liver, stomach, adrenal gland, ovary, lungs, kidneys, and colon [1,2].

Collision tumors can arise within the same organ, like renal cell carcinoma alongside transitional cell carcinoma, hepatocellular carcinoma with cholangiocarcinoma, and gastric adenocarcinoma with lymphoma. They can also occur in neighboring organs, such as sigmoid adenocarcinoma with urinary bladder transitional carcinoma. Additionally, they may coincide with systemic malignancies, like renal cell carcinoma with intravascular lymphomatosis, or occur as metastatic occurrences, such as breast carcinoma spreading to meningioma [3]. However, thyroid carcinoma stands as the predominant form of endocrine malignancy, accounting for 2.1% of cases, collision tumors in the thyroid gland are exceedingly uncommon, comprising approximately 1.0% of all thyroid malignancies, most of which are made up of papillary and medullary carcinoma [1,4-6].

Nodules form when growth signals intensify, prompting hyperplasia, or upon acquisition of a new genetic mutation, resulting in self-directed growth. Clinicians focus on discerning a thyroid nodule's benign or malignant nature during evaluation. The preferred diagnostic method is fine needle aspiration biopsy (FNAB). Notably, most thyroid nodules are benign, with malignancy detected in only 9-13% of cases [7,8].

In differentiated thyroid cancers, FNAB is often effective in diagnosing papillary carcinoma. However, its utility is restricted when diagnosing follicular and Hurthle cell tumors. This limitation stems from the fact that distinguishing between adenomas and carcinomas in these cases necessitates evidence of capsule invasion, which can only be detected through histological examination [9]. A frequently observed occurrence among thyroid collision tumors involves the pairing of papillary thyroid carcinoma (PTC) with medullary thyroid carcinoma (MTC) [2].

Managing thyroid collision tumors presents difficulties because of the differences in biological aggressiveness, treatment options, and prognosis among the tumors involved [10]. Decisions regarding treatment plans, such as surgical removal, radioactive iodine (RAI) therapy, chemotherapy, external radiotherapy, and additional supportive treatments, should be tailored to each patient based on the aggressive nature of the tumors involved, as this will ultimately influence the patient's prognosis [11].

This study aims to systematically review the presentation and management of collision tumors of the thyroid gland.

## 2. Methods

### 2.1. Study design

The current systematic review conformed to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

### 2.2. Data sources and search strategy

A systematic review of all published studies on thyroid collision tumors was conducted utilizing Google Scholar and PubMed. The search incorporated specific keywords: (synchronous OR simultaneous OR collision thyroid cancer OR thyroid tumor OR thyroid carcinoma) AND (thyroid coexisting cancer OR tumor).

### 2.3. Eligibility criteria

Non-English-language studies and those unrelated to humans were excluded before or during the initial screening process. All studies concerning thyroid collision tumors meeting the following criteria were included: 1) Confirmation of collision tumors via diagnostic methods, surgical exploration, or histopathological examination. 2) Presentation of case details within the study. 3) Tumors located precisely in the thyroid gland. Studies published in predatory journals (lacking appropriate peer review) [12], as well as those not meeting the inclusion criteria, were excluded.

### 2.4. Study selection process

Initially, the titles and abstracts of identified studies underwent a preliminary screening, followed by a thorough examination of the full texts to determine eligibility. Various data of information were documented from the selected studies, including study design, participants' age and gender, symptoms, laboratory findings, diagnosis, type and site of the malignancies, treatment approaches, administration of RAI, outcomes, and recurrence rates.

### 2.5. Data item

The gathered data underwent analysis using Statistical Package for the Social Sciences software version 25.0 and were subsequently displayed in terms of frequency and percentages.

## 3. Results

In total, 340 studies were obtained from the resources, 19 of which were removed before any screening due to duplication, non-English language, non-article, and only abstracts. On the initial screening, the titles and abstracts of 247 studies did not match the inclusion criteria, and they were excluded. Overall, 74 studies underwent full-text screening, and 61 were assessed for eligibility. Finally, 57 studies [1- 3, 5- 7, 10, 11, 13- 61] (122 cases) were compatible with the inclusion criteria (Figure 1) (Table 1). Of the included studies, 50 (87.72%) were case reports, and 7 (12.28%) were case series. Most cases were female 87 (71.31%), and the remaining 35 (28.69%) were male. The patients' ages were between 12 and 88 years old, with a mean of 49.87 ± 14.48 years. The most commonly presented symptom was neck swelling (45.08%). Available preoperative

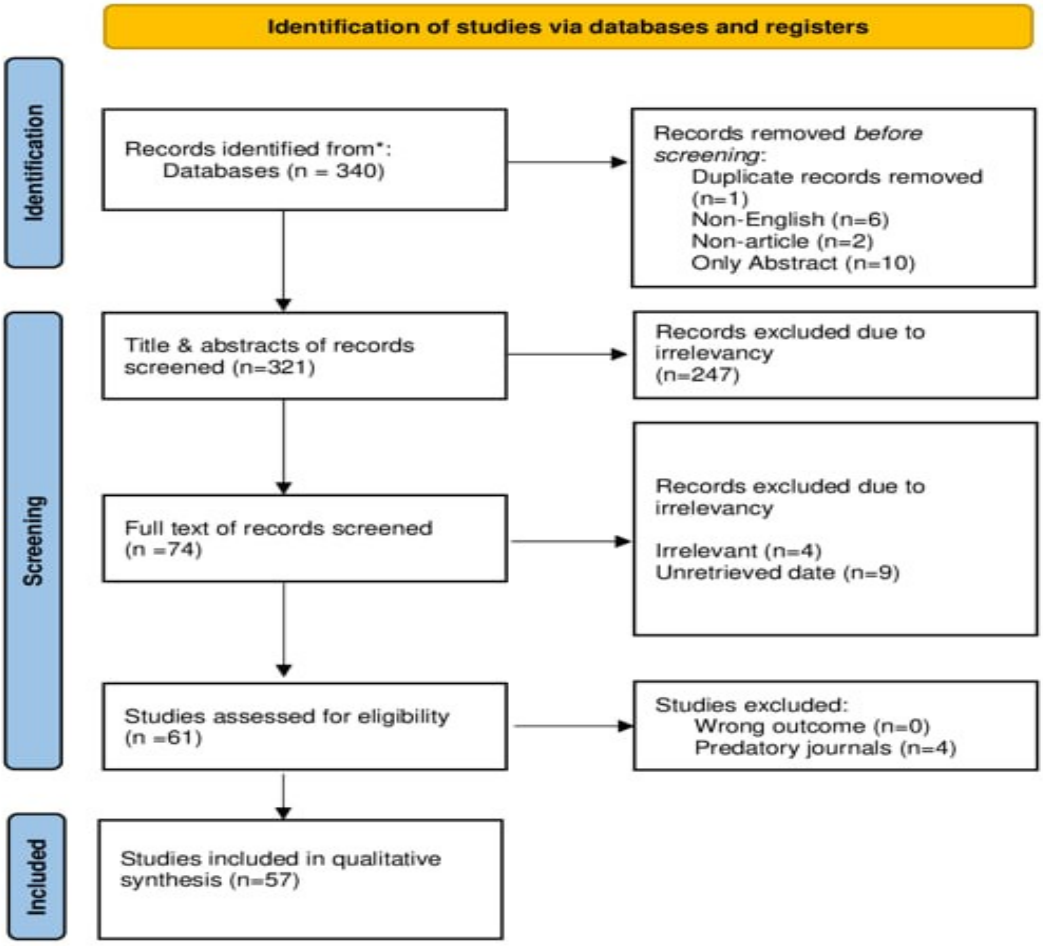


Figure 1. Study selection PRISMA flow chart.

laboratory examinations revealed that thyroid-stimulating hormone (TSH) levels were within the normal range in 40 cases (32.79%), while thyroglobulin (TG) levels were elevated in 12 cases (9.84%), and calcitonin levels were elevated in 20 cases (16.39%). The most prevalent surgical procedure observed was total thyroidectomy combined with lymph node dissection, performed in 40 cases (32.78%). Moreover, cervical lymph node metastasis was present in 46 cases (37.70%). The predominant histopathological findings consisted of the simultaneous presence of PTC and MTC, identified in 51 cases (41.80%). This was followed by instances of PTC coexisting with follicular thyroid carcinoma, observed in 24 cases (19.67%). The isthmus exhibited the lowest frequency of malignancies, accounting for 7 cases (5.73%). Radioactive iodine was administered to 44 patients (36.06%). The recurrence rate was observed in only 10 cases (8.20%) (Table 2) (Table 3).

## 4. Discussion

Collision tumors denote the coexistence of two histologically distinct neoplasms within the same anatomical location without intermixing. While the incidence of collision tumors is notably rare across all body regions, their occurrence in the thyroid gland is even more infrequent [3].

The terminology collision tumors of the thyroid have been utilized interchangeably with mixed and composite tumors. These designations denote the presence of multiple synchronous tumors exhibiting parafollicular and follicular-derived cellular elements within the thyroid gland. However, it is crucial to note that these terms are not synonymous, as they denote distinct entities. Within the context of thyroid tumors, a "mixed tumor" is exemplified by the Mixed Medullary and Follicular Tumor of Thyroid. This entity is a malignant tumor demonstrating morphological and immunophenotypical evidence of the coexistence of follicular and parafollicular tumor cells closely admixed within the same lesion [53]. Composite tumors often emerge from a common driver mutation in a neoplastic source, resulting in divergent histology [57]. Conversely, collision tumors represent histologically distinct tumors situated nearby within the same organ [53,62].

Several hypotheses have been advanced to elucidate the occurrence of collision tumors. The chance theory postulates the

Barw Medical Journal | 2024;2(2):44-56 | https://doi.org/10.58742/bmj.v2i2.94

**Table 1:** The raw date of the included studies.

| Author [Reference] | Study Design | No. of Cases | Age | Gender | | Pre op. investigations | | | | | | | | | | | | | | | | | Common Signs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | TSH | | | | CT | | | | | TG | | | | ATPO | | | | | | |
| | | | | M | F | L | E | N | NA | L | E | N | NA | UD | L | E | N | NA | L | E | N | NA | NK pain | NK swelling | N/A |
| Awadalla et al. 2022 [13] | Case report | 1 | 59 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Abdelaal et al. 2020 [14] | Case series | 6 | *49 | 2 | 4 | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 6 | 1 | 4 | 1 |
| Abdullah et al. 2022 [1] | Case series | 8 | *43.1 | 2 | 6 | 2 | 1 | 5 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 2 | 6 | 0 | 2 | 1 | 5 | 1 | 4 | 0 |
| Abdullah et al. 2022 [15] | Case report | 1 | 53 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Adnan et al. 2013 [16] | Case series | 4 | *52.2 | 0 | 4 | 0 | 0 | 2 | 2 | 0 | 3 | 0 | 1 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 4 | 1 | 0 | 3 |
| Alavi et al. 2011 [17] | Case report | 1 | 32 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Al-Mashat et al. 2003 [18] | Case report | 1 | 40 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Alshehri et al. 2023 [19] | Case report | 1 | 45 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Polat et al. 2016 [20] | Case series | 20 | *48.8 | 3 | 17 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 20 | 0 | 20 | 0 |
| Baloch et al. 2001 [21] | Case report | 1 | 72 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Dikbas et al. 2019 [5] | Case report | 1 | 35 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Fallahi et al. 2023 [22] | Case series | 5 | *55.4 | 3 | 2 | 0 | 0 | 0 | 5 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 5 | 0 | 0 | 4 |
| Fatima et al. 2022 [2] | Case series | 3 | *34.3 | 1 | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 | 0 | 3 | 0 |
| Fulciniti et al. 2015 [23] | Case report | 1 | 34 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Brandwein-Gensler et al. 2004 [3] | Case report | 1 | 86 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Giacomelli et al 2007 [24] | Case report | 1 | 50 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Gosavi et al. 2020 [25] | Case report | 1 | 32 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| He et al. 2012 [26] | Case report | 1 | 54 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| He et al. 2020 [27] | Case report | 1 | 71 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Hidangmayum et al. 2022 [28] | Case report | 1 | 59 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |

Barw Medical Journal | 2024;2(2):44-56 | https://doi.org/10.58742/bmj.v2i2.94

**Table 2:** Continued...

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kawasaki et al. 2023 [29] | Case report | 1 | 69 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Kim et al. 2014 [30] | Case report | 1 | 67 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 6 | 1 | 4 | 1 |
| Kobayashi et al. 1995 [31] | Case report | 1 | 63 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 1 | 5 | 1 | 4 | 0 |
| Kösem et al. 2002 [32] | Case report | 1 | 38 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Koufopoulos et al. 2021 [33] | Case report | 1 | 60 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 1 | 0 | 3 |
| Lax et al. 1994 [35] | Case report | 3 | 42 | 1 | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 3 |
| Li et al. 2020 [36] | Case report | 1 | 27 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Liu et al. 2023 [10] | Case report | 1 | 62 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Ma et al. 2023 (37) | Case report | 2 | 50.5 | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Mohammadzadeh et al. 2013 [38] | Case report | 1 | 40 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Nabili et al. 2007 [39] | Case report | 1 | 63 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Palo et al. 2021 [7] | Case report | 1 | 36 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Pishdad et al. 2020 [40] | Case report | 1 | 79 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Plauche et al. 2012 [41] | Case report | 1 | 62 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Rachida et al. 2023 [42] | Case report | 1 | 45 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Rana et al. 2018 [43] | Case report | 1 | 45 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Rekhi et al.2007 [44] | Case report | 1 | 59 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| Rossi et al. 2005 [45] | Case report | 3 | 40.6 | 2 | 1 | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 | 0 | 1 | 1 |
| Ryan et al 2015 [11] | Case report | 1 | 88 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Saharan et al. 2019 [46] | Case report | 1 | 55 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |

Barw Medical Journal | 2024;2(2):44-56 | https://doi.org/10.58742/bmj.v2i2.94

**Table 3:** Continued...

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SamieeRad et al. 2020 [47] | Case report | 1 | 54 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Sribu et al. 2020 [6] | Case report | 1 | 46 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Stenman et al. 2022 [48] | Case report | 1 | 43 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Tasci et al. 2022 [49] | Case report | 1 | 70 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Tanaka et al 1989 [50] | Case report | 1 | 51 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Tarui et al. 2024 [51] | Case report | 1 | 58 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Thomas et al. 2018 [52] | Case report | 1 | 33 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Thomas et al. 2021 [53] | Case series | 21 | *45.4 | 9 | 12 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 21 | 0 | 0 | 21 |
| Toyoshima et al. 2021 [54] | Case report | 1 | 63 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Vlaenderen et al. 2020 [55] | Case report | 1 | 12 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Vlad et al 2021 [56] | Case report | 1 | 56 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Walvekar et al. 2006 [57] | Case report | 1 | 65 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Warman et al. 2011 [58] | Case report | 1 | 84 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| Whitehouse et al. 2020 [59] | Case report | 1 | 83 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Younes et al. 2005 [60] | Case report | 1 | 55 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Ziaolhagh et al. 2021 [61] | Case report | 1 | 62 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Stenman et al. 2022 [48] | Case report | 1 | 43 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Tasci et al. 2022 [49] | Case report | 1 | 70 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |

***M**: Male, **F**: Female, **L**: Low, **E**: Elevated, **N**, Normal, **TSH**: Thyroid-Stimulating Hormone, **CT**: Calcitonin, **TG**: Thyroglobulin, **NK**: Neck, **Pre.op**: Preoperative, *: Mean*

**Table 2.** Basic characteristics summary of the included studies.

| Variables | Frequency / Percentage |
|---|---|
| Age (mean of means) ± SD | 49.87 ± 14.48 |
| Gender | |
| Female | 87 (71.31%) |
| Male | 35 (28.69%) |
| Pre-operation Investigations | |
| TSH | |
| Low | 6 (4.92%) |
| Elevated | 3 (2.46%) |
| Normal | 40 (32.79%) |
| N/A | 73 (59.83%) |
| Thyroglobulin | |
| Low | 0 (0%) |
| Elevated | 12 (9.84%) |
| Normal | 5 (4.10%) |
| N/A | 105 (86.06) |
| Calcitonin | |
| Low | 0 (0%) |
| Elevated | 20 (16.39%) |
| Normal | 3 (2.46%) |
| Undetectable | 3 (2.46%) |
| N/A | 96 (78.68%) |
| A-TPO | |
| Low | 0 (0%) |
| Elevated | 2 (1.64%) |
| Normal | 1 (0.82%) |
| N/A | 119 (97.54%) |
| Presentation | |
| Neck Swelling | 55 (45.08%) |
| Neck Pain | 7 (5.73%) |
| N/A | 64 (44.26%) |
| Histopathological Findings | |
| PTC and MTC | 51 (41.80%) |
| PTC and FTC | 24 (19.67) |
| PTC and FTA | 8 (6.55%) |
| PTMC and FTC | 7 (5.74%) |
| PTC and HCA | 5 (4.10%) |
| MTC, FTA, and PTMC | 3 (2.46%) |
| PTMC and HCA | 3 (2.46%) |
| PTC and SCC | 3 (2.46%) |
| PTC and HCC | 2 (1.64%) |
| PTC and MALT lymphoma | 2 (1.64%) |
| MTC and FTA | 1 (0.82%) |
| MTC and Melanoma | 1 (0.82%) |
| OC, HPTC, and PDTC | 1 (0.82%) |
| OC and PTMC | 1 (0.82%) |
| Osteosarcoma and PTC | 1 (0.82%) |
| PTC and adenocarcinoma | 1 (0.82%) |
| PTC and MEC | 1 (0.82%) |
| PTC and Liposarcoma | 1 (0.82%) |
| PTC and TA | 1 (0.82%) |
| PTC, FTC, and anaplastic | 1 (0.82%) |
| PTMC and Anaplastic | 1 (0.82%) |
| TVC and HCC | 1 (0.82%) |
| FTC and NIFTP | 1 (0.82%) |
| PTC, FTC, and MTC | 1 (0.82%) |
| Site of malignancy | |
| Right lobe | 56 (45.90%) |
| Left lobe | 53 (43.44%) |
| Isthmus | 7 (5.73%) |
| N/A | 45 (36.88%) |
| Lymph Node Metastasis | |
| Negative | 52 (42.62%) |
| Positive | 46 (37.70%) |
| N/A | 24 (19.68%) |
| Type of operation | |
| Total thyroidectomy and Lymph node Dissection | 40 (32.78%) |
| Total thyroidectomy | 31 (25.40%) |
| Right Thyroid lobectomy | 8 (6.55%) |
| Left Thyroid lobectomy | 6 (4.92%) |
| Partial thyroidectomy | 5 (4.10%) |
| Completion thyroidectomy | 2 (1.64%) |
| Completion of thyroidectomy and Lymph node Dissection | 2 (1.64%) |
| Radio-active iodine (RAI) | |
| Yes | 44 (36.06%) |
| No | 22 (18.04%) |
| N/A | 56 (45.90%) |
| Outcome | |
| No recurrence | 54 (44.26%) |
| Recurrence | 10 (8.20%) |
| N/A | 58 (47.54%) |

*SD: Standard deviation, ATPO: Anti-thyroid peroxidase, NA: Not-available, TSH: Thyroid stimulating hormone, PTC: Papillary thyroid carcinoma, PTMC: Papillary thyroid microcarcinoma, MTC: Medullary thyroid carcinoma, FTC: Follicular thyroid carcinoma, FTA: Follicular thyroid adenoma, HCC: Hurthle cell carcinoma, NIFTP: Non-invasive follicular thyroid neoplasm with papillary-like nuclear features, mMTC: Medullary thyroid microcarcinoma, OC: Oncocytic carcinoma, MEC: Mucoepidermoid carcinoma, SCC: Squamous cell carcinoma, TA: Trabecular adenoma, TVC: Tall cell variant papillary thyroid carcinoma*

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**Table 3:** Management and outcome of collision tumors

| Authors | L. Node Met. | | | | Type of operation | | | | | | RAI | | | | Histological Findings | Site of malignancy | | | | outcome | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NA | + | - | TT | TT/LND | RTL | LTL | STT | CTL | CTL/LND | NA | Y | N | NA | | Rt. lobe | Lt. lobe | isthmus | NA | Rec | No. Rec | NA |
| Awadalla et al. 2022 [13] | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTMC+FTC | 0 | 1 PTMC+FTC | 0 | 0 | 0 | 1 | 0 |
| Abdelaal et al. 2020 [14] | 0 | 0 | 6 | 4 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 6 | 3 PTC+FTC<br>3 PTMC+FTC | 3 PTMC+FTC | 3 PTC+FTC | 0 | 0 | 0 | 3 | 3 |
| Abdullah et al. 2022 [1] | 8 | 0 | 0 | 4 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 1 MTC+FTA<br>6 PTC+FTA<br>1 PTC+FTC | 0 | 0 | 0 | 8 | 0 | 6 | 2 |
| Abdullah et al. 2022 [15] | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 MTC+PTMC | 0 | 1 MTC+PTMC | 0 | 0 | 0 | 0 | 1 |
| Adnan et al. 2013 [16] | 0 | 1 | 3 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 PTC+MTC<br>3 MTC+FTA+PTMC | 2 PTC+MTC<br>1 MTC+FTA<br>1 MTC+FTA+PTMC | 1 PTMC<br>1 FTA | 0 | 0 | 0 | 0 | 4 |
| Alavi et al. 2011 [17] | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 PTC+MTC | 1 PTC+MTC | 0 | 0 | 0 | 0 | 0 | 1 |
| Al-Mashat et al. 2003 [18] | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+MTC | 0 | 1 PTC+MTC | 0 | 0 | 0 | 0 | 1 |
| Alshehri et al. 2023 [19] | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+MTC | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Polat et al. 2016 [20] | 0 | 2 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 20 | 2 PTC+FTA<br>10 PTC+FTC<br>5 PTC+HCA<br>2 PTC+HCC<br>1 PTC+TA | 0 | 0 | 0 | 20 | 2 | 18 | 0 |
| Baloch et al. 2001 [21] | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 TVC+HCC | 0 | 1 TVC+HCC | 0 | 0 | 0 | 0 | 1 |
| Dikbas et al. 2019 [5] | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+MTC | 1 PTC+MTC | 0 | 0 | 0 | 0 | 1 | 0 |
| Fallahi et al. 2023 [22] | 0 | 3 | 2 | 0 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 1 mMTC+PTC<br>1mMTC+PTMC<br>3MTC+PTMC | 1mMTC<br>1MTC<br>2PTMC | 1mMTC+PTMC<br>2MTC<br>1PTC<br>1PTMC | 3 | 2 | 0 | 4 | 0 |

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**Table 3:** Continued...

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Giacomelli et al 2007 [24] | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 MTC+PTMC | 1 MTC+PTMC | 0 | 0 | 0 | 0 | 1 | 0 |
| Gosavi et al. 2020 [25] | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 PTMC+FTC | 1 FTC | 1 PTMC | 0 | 0 | 0 | 1 | 0 |
| He et al. 2012 [26] | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 MTC+Melanoma | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| He et al. 2020 [27] | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTMC+FTC | 1 FTC | 1 NIFTP+PTMC | 0 | 0 | 0 | 1 | 0 |
| Hidangmayum et al. 2022 [28] | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 FTC+NIFTP | 1 FTC | 1 NIFTP | 0 | 0 | 0 | 0 | 1 |
| Kawasaki et al. 2023 [29] | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 PTC+FTC | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Kim et al. 2014 [30] | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 PTC+FTC+MTC | 1 PTC+FTC | 1 MTC | 0 | 0 | 0 | 0 | 1 |
| Kobayashi et al. 1995 [31] | 0 | 1 | 0 | 0 | 1 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+MTC | 1 MTC | 1 PTC | 0 | 0 | 0 | 1 | 0 |
| Kösem et al. 2002 [32] | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 mMTC+PTC | 1 mMTC | 1 mMTC+PTC | 0 | 0 | 0 | 0 | 1 |
| Koufopoulos et al. 2021 [33] | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 osteosarcoma and PTC | 0 | 1 osteosarcoma and PTC | 0 | 0 | 1 | 0 | 0 |
| Lalanda et al. 2023 [34] | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+MTC | 1 PTC+MTC | 1 PTC | 0 | 0 | 0 | 1 | 0 |
| Lax et al. 1994 [35] | 1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 3 PTC and MTC | 0 | 0 | 0 | 3 | 1 | 1 | 1 |
| Li et al. 2020 [36] | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 PTC+MTC | 0 | 1 PTC+MTC | 0 | 0 | 0 | 0 | 1 |
| Liu et al. 2023 [10] | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 OC+PTMC | 1 PTMC | 1 OC | 0 | 0 | 0 | 1 | 0 |
| Ma et al. 2023 [37] | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 PTC+MTC<br>1 PTC+FTC | 1 PTC+MTC<br>1 PTC | 1 FTC | 0 | 0 | 0 | 2 | 0 |
| Mohammadzadeh et al. 2013 [38] | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+FTC | 1 PTC+FTC | 0 | 0 | 0 | 0 | 1 | 0 |
| Nabili et al. 2007 [39] | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+ adenocarcinoma | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Palo et al. 2021 [7] | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 PTMC+HCA | 1 PTMC+HCA | 0 | 0 | 0 | 0 | 1 | 0 |
| Pishdad et al. 2020 [40] | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 PTC+FTC | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Plauche et al. 2012 [41] | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 PTC+FTC | 1 PTC+FTC | FTC | 0 | 0 | 0 | 0 | 1 |
| Rachida et al. 2023 [42] | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 PTC+MTC | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Rana et al. 2018 [43] | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTMC+HCA | 1 PTMC+HCA | 0 | 0 | 0 | 0 | 0 | 1 |
| Rekhi et al.2007 [44] | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 PTC+MTC | 0 | 1 PTC+MTC | FVPTC | 0 | 0 | 0 | 1 |
| Rossi et al. 2005 [45] | 2 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 PTC+MTC | 1 PTC+MTC | 0 | 1 PTC | 0 | 0 | 0 | 3 |
| Ryan et al. 2015 [11] | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+SCC | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Saharan et al. 2019 [46] | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 MTC+PTMC | PTMC | MTC | 0 | 0 | 0 | 0 | 1 |

**Table 3:** Continued...

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tarui et al. 2024 [51] | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+MALT lymphoma | 1 PTC | 1 MALT lymphoma | 0 | 0 | 0 | 1 | 0 |
| Thomas et al. 2018 [52] | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+FTC | 1 PTC+FTC | 0 | 0 | 0 | 0 | 1 | 0 |
| Thomas et al. 2021 [53] | 0 | 16 | 5 | 2 | 17 | 1 | | 1 | 0 | 0 | 0 | 3 | 18 | 0 | 21 PTC+MTC | 5 MTC<br>6 PTC<br>6 PTC+MTC | 7 MTC<br>5 PTC<br>3 PTC+MTC | 2 MTC<br>2 PTC | 0 | 0 | 0 | 21 |
| Toyoshima et al. 2021 [54] | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 OC+HPTC+PDTC | 1 OC+HPTC+PDTC | 0 | 0 | 0 | 0 | 0 | 1 |
| Fatima et al. 2022 [2] | 0 | 0 | 3 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 PTC+FTC | 0 | 2 PTC+FTC | 0 | 1 | 0 | 3 | 0 |
| Fulciniti et al. 2015 [23] | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+MEC | 0 | 0 | 1 PTC+MEC | 0 | 0 | 0 | 1 |
| Brandwein-Gensler et al. 2004 [3] | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+Liposarcoma | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| SamieeRad et al. 2020 [47] | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 PTC+MTC | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Sribu et al. 2020 [6] | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+MTC | 1 PTC+MTC | 0 | 0 | 0 | 0 | 0 | 1 |
| Stenman et al. 2022 [48] | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 PTC+FTC | 1 PTC+FTC | 0 | 0 | 0 | 0 | 0 | 1 |
| Tasci et al. 2022 [49] | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTMC+HCA | 1 PTMC | 1 HCA | 0 | 0 | 0 | 0 | 1 |
| Vlaenderen et al. 2020 [55] | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+FTC | 0 | 1 PTC+FTC | 0 | 0 | 0 | 0 | 1 |
| Vlad et al 2021 [56] | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 PTMC+Anaplastic | 1 PTMC | 1 Anaplastic | 0 | 0 | 1 | 0 | 0 |
| Walvekar et al. 2006 [57] | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 PTC+SCC | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Warman et al. 2011 [58] | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+SCC | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Whitehouse et al. 2020 [59] | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 PTC+MALT lymphoma | 1 PTC+MALT lymphoma | 0 | 0 | 0 | 0 | 1 | 0 |
| Younes et al. 2005 [60] | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 PTC+MTC | 1 PTC | 1 MTC | 0 | 0 | 0 | 1 | 0 |
| Ziaolhagh et al. 2021 [61] | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 PTC+MTC | 1 MTC | 1 PTC | 0 | 0 | 0 | 0 | 1 |

**LN. Met: Lymph node Metastasis, **TT**: Total thyroidectomy, **TT/LND**: Total thyroidectomy and lymph node dissection, **RTL**: Right thyroid lobectomy, **LTL**: Left thyroid lobectomy, **STT**: Subtotal thyroidectomy, **CTL**: Completion thyroid lobectomy, **CTL/LND**: Completion thyroid lobectomy, **RAI**: Radio-active iodine, **Y**: Yes, **N**: No, Rec: Recurrence, **PTC**: Papillary thyroid carcinoma, **PTMC**: Papillary thyroid microcarcinoma, **MTC**: Medullary thyroid carcinoma, **FTC**: Follicular thyroid carcinoma, **FTA**: Follicular thyroid adenoma, **HCC**: Hurthle cell carcinoma, **NIFTP**: Non-invasive follicular thyroid neoplasm with papillary-like nuclear features, **mMTC**: Medullary thyroid microcarcinoma, **OC**: Oncocytic carcinoma, **MEC**: Mucoepidermoid carcinoma, **SCC**: Squamous cell carcinoma, **TA**: Trabecular adenoma, **TVC**: Tall cell variant papillary thyroid carcinoma*



Barw Medical Journal | 2024;2(2):44-56 | https://doi.org/10.58742/bmj.v2i2.94

independent origin of two tumors, proposing that their co-occurrence is a fortuitous event resulting from de novo local genesis or metastasis adjacent to an unrelated primary tumor [63,50]. Another hypothesis posits that the first tumor alters the microenvironment, thereby fostering the development of a second primary tumor. A third theory suggests that two distinct driver mutations may arise within a common stem cell, leading to the emergence of two separate tumors [64,53].

Prior studies have indicated that the predominant malignancy affecting the thyroid is PTC at 80%, succeeded by follicular thyroid carcinoma at 10%, MTC at 4%, Hürthle cell carcinoma at 3%, and anaplastic carcinoma at 2% [65]. Risk factors associated with PTC include radiation exposure, female gender, smoking, overweight or obesity, excessive dietary iodine intake, alcohol consumption, dietary nitrates, diabetes mellitus, and genetic predisposition [66].

The concurrent presence of both MTC and PTC within the same thyroid gland is a rare phenomenon, typically observed in two primary settings: a mixed tumor displaying dual differentiation or a collision tumor [17]. Rossi et al. suggested that the co-occurrence of MTC and PTC was likely coincidental. They reasoned that RET and BRAF mutations were detected in these tumors, respectively, and these mutations are independent drivers of their respective carcinomas, with a minimal chance of simultaneous occurrence [45]. Nevertheless, certain studies suggest that germline point mutations of the RET gene may play a potential role in the development of both MTC and PTC [67,68]. In the current study, a significant proportion (41.80%) of cases involving MTC and PTC as collision tumors were documented.

Adjuvant treatment, such as RAI, becomes necessary when the PTC component falls within the high or intermediate-risk category based on risk stratification. Biscolla et al. noted that the prognosis of the MTC in collision tumors remains unaffected by the presence of PTC and specific radioiodine treatments [69]. In the current study, adjuvant RAI was administered to 36.06% of the patients.

According to a review conducted by Ryan et al., until 2015, the literature documented merely 33 instances of thyroid collision tumors. Despite the notable increase in the prevalence of thyroid cancer in recent years, the simultaneous presence of multiple tumors within a single thyroid gland remains an infrequent phenomenon [1,30]. In the current study, 122 cases of thyroid collision tumors were recorded.

In a study conducted by Polat et al., 3,700 patients underwent surgery. Histopathological examination revealed benign findings in 2,686 (73%) patients and malignant findings in 1,014 (27%) patients. Among those diagnosed with differentiated thyroid carcinoma, only 20 (1.9%) had an additional neoplasm within the same thyroid gland. The average age of the patients was 48.8±13.2 years, with eighteen of the twenty patients being female and two being male. Lymph node metastasis was found in three patients, accounting for (15%) of the cases [7]. In the present study (71.31%) were female, while (28.69%) were male, and the mean age was 49.87 ± 14.48. However (37.70%) patients were found to have lymph node metastasis.

In another study conducted by Abdullah et al., eight cases of collision tumors were included; four patients (50%) underwent lobectomy, while the remaining four patients underwent total thyroidectomy. These cases presented various symptoms, such as neck swelling, dyspnea, and dizziness [1]. In the current study, neck swelling was the most frequently reported symptom (45.08%). Nevertheless, most of the patients (32.78%) underwent total thyroidectomy and lymph node dissection.

### 5. Conclusion

Thyroid collision tumors may primarily affect females, with the most frequent collisions being papillary and medullary thyroid carcinoma. Total thyroidectomy with lymph node dissection is the prevalent management option, and the recurrence rate can be lower than 10%.

## Declarations

**Conflicts of interest:** The author(s) have no conflicts of interest to disclose.

**Ethical approval:** Not applicable, as systematic reviews do not require ethical approval.

**Patient consent** (participation and publication)**:** Not applicable.

**Funding:** The present study received no financial support.

**Acknowledgements:** None to be declared.

**Use of AI:** AI was not used in the drafting of the manuscript, the production of graphical elements, or the collection and analysis of data.

**Authors' contributions:** BAA and FHK were major contributors to the conception of the study, as well as to the literature search for related studies. HAN, AMS, HOB, and AMA were involved in the literature review, manuscript writing, and data analysis and interpretation. YMM, AJQ, and ASM Literature review, final approval of the manuscript, and processing of the tables. RMA, RMA, SSO, YAS, HMD and ROM were involved in the literature review, the study's design, and the manuscript's critical revision. FHK and HOA Confirmation of the authenticity of all the raw data. All authors approved the final version of the manuscript.

**Data availability statement:** Note applicable.

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