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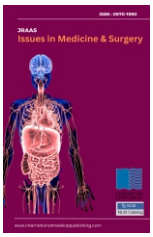

Research Article

Section: Pathology

Histopathological Spectrum of Cutaneous Adnexal Tumours: A Tertiary Care Centre Experience

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HIGHLIGHTS

- Benign adnexal tumors common
- Head and neck predominance
- Follicular differentiation predominant
- Trichilemmal cyst most frequent
- Histopathology confirms diagnosis

Key Words:
Cutaneous adnexal tumors
Histopathology
Follicular differentiation
Trichilemmal cyst
Skin neoplasms
Clinicopathological study

ABSTRACT

Introduction: Cutaneous adnexal tumors (CATs) are a diverse group of neoplasms originating from the adnexal structures of the skin, including hair follicles, sebaceous glands, eccrine glands, and apocrine glands. These tumors demonstrate varied histopathological differentiation and clinical presentations, ranging from benign lesions to rare malignant counterparts. Accurate diagnosis and classification are essential because of their diverse biological behavior and potential association with syndromic conditions. **Aim & Objectives:** To evaluate the clinicopathological spectrum of cutaneous adnexal tumors with respect to age, sex, anatomical site, histological differentiation, and tumor type. **Materials & Methods:** This retrospective descriptive study included 48 histopathologically confirmed cases of cutaneous adnexal tumors. Clinical details were retrieved from medical records. Formalin-fixed, paraffin-embedded tissue sections were stained with hematoxylin and eosin and examined microscopically. Tumors were categorized according to their line of differentiation. Statistical analysis was performed using descriptive statistics and the Chi-square test, with $p < 0.05$ considered statistically significant. **Results:** Most cases occurred in the 21–40 years age group, with a slight male predominance. The head and neck region were the most affected site (64.6%). Follicular differentiation was the predominant histological type (64.6%), followed by eccrine and apocrine differentiation. Trichilemmal cyst was the most common diagnosis, accounting for 37.5% of cases. A statistically significant association was observed between anatomical site and differentiation pattern ($p < 0.05$). Most tumors were benign in nature. **Conclusion:** Cutaneous adnexal tumors are predominantly benign lesions with a strong predilection for the head and neck region and follicular differentiation. Histopathological examination remains the cornerstone for accurate diagnosis and classification of these tumors.

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INTRODUCTION

Cutaneous adnexal tumors (CATs) constitute a heterogeneous group of neoplasms derived from the adnexal structures of the skin, including hair follicles, sebaceous glands, eccrine glands, and apocrine glands. These tumors exhibit diverse histomorphological patterns that reflect their line of differentiation and the pluripotent nature of cutaneous adnexal epithelium [1,2]. From a pathological standpoint, accurate classification of these lesions is essential, as they encompass a broad spectrum ranging from innocuous benign proliferations to rare but locally aggressive or metastatic malignancies [3].

Histopathological evaluation remains the cornerstone for diagnosis, given the considerable overlap in clinical presentation among adnexal tumors and other cutaneous lesions. Clinically, these tumors often present as slow-growing nodules or papules, frequently indistinguishable from epidermal cysts, nevi, or basal cell carcinoma [4,5]. Microscopically, however, they display characteristic architectural patterns, cytological features, and differentiation specific structures such as ductal lumina, keratinization patterns, and sebaceous differentiation, which enable precise categorization [6]. Recognition of these features is critical not only for diagnosis but also for guiding management and prognostication. Adnexal tumors are traditionally classified based on their predominant line of differentiation into follicular, eccrine, apocrine, and sebaceous types. Among these, follicular differentiation is most encountered, with entities such as trichilemmal cyst, pilomatrixoma, & trichoepithelioma being frequently reported [7]. Eccrine tumors, including hidradenoma & poroma, & apocrine tumors such as syringocystadenoma papilliferum, exhibit distinctive histological patterns that aid in their identification [8].

Sebaceous tumors, although less common, are of particular importance due to their association with syndromic conditions such as Muir-Torre syndrome [9].

Epidemiologically, most adnexal tumors are benign and demonstrate a predilection for the head and neck region, especially the scalp, likely due to the high density of adnexal structures in these areas [8,9]. Malignant adnexal tumors, including microcystic adnexal carcinoma, porocarcinoma, and sebaceous carcinoma, are rare but clinically significant because of their infiltrative growth, potential for perineural invasion, and risk of recurrence or metastasis [10,11]. Histological identification of such aggressive features is therefore crucial in routine diagnostic practice.

Despite their importance, cutaneous adnexal tumors remain relatively underreported, and available data show considerable variation in incidence, distribution, and histological patterns across different populations [12,13]. In the Indian context, studies are limited and often involve small sample sizes, highlighting the need for comprehensive clinicopathological analyses [14,15]. Such studies provide valuable insights into the spectrum of differentiation, anatomical distribution, and biological behavior of these tumors. **Figure 1** shows the histopathological spectrum of cutaneous adnexal tumours and their characteristic microscopic features.

In this context, the present study aims to evaluate the clinicopathological profile of cutaneous adnexal tumors with emphasis on histopathological classification, differentiation patterns, and distribution across demographic and anatomical variables, thereby contributing to improved diagnostic accuracy and a better understanding of their pathological spectrum.

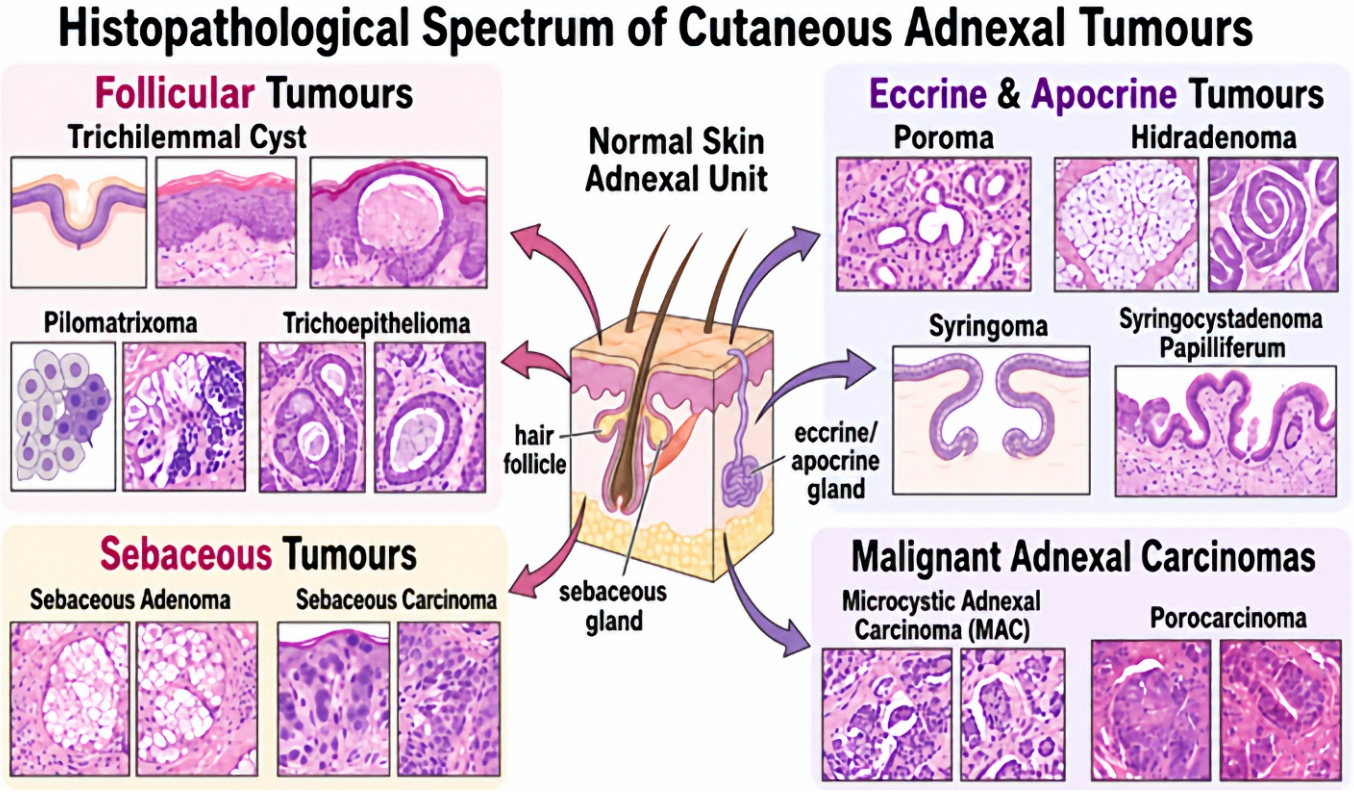

Figure 1: Histopathological spectrum of cutaneous adnexal tumours showing follicular, sebaceous, eccrine, apocrine, and malignant adnexal neoplasms with their characteristic microscopic features.

MATERIALS & METHODS

This was a retrospective descriptive study conducted in the Department of Pathology at a tertiary care center over a period of two years. All cases diagnosed as cutaneous adnexal tumors over a defined study period were included. A total of 48 cases were retrieved from the histopathology records. Relevant clinical details including age, sex, site of lesion, and duration of symptoms were obtained from requisition forms and case records. Formalin-fixed, paraffin-embedded tissue sections were processed and stained with hematoxylin and eosin (H&E). Histopathological evaluation was performed to classify tumors based on their line of differentiation into follicular, eccrine, apocrine, sebaceous, and unclassified types, using standard dermatopathological criteria. Tumors were also categorized as benign or malignant based on established histological features.

Data were compiled and analyzed using descriptive statistics, including frequency and percentage. Associations between categorical variables such as site and differentiation were assessed using the Chi-square test, with a p-value <0.05 considered statistically significant. All data were tabulated and presented in appropriate tables and graphical formats for analysis.

RESULTS

A total of 48 cases of cutaneous adnexal tumors were included in the present study. The clinicopathological features were analyzed with respect to age, sex, anatomical site, histological differentiation, and tumor type. The findings are presented below in a structured manner. Cutaneous adnexal tumors in the present study showed a clear predominance in the 21–40 years age group (45.8%), followed by the 41–60 years group (29.2%), indicating that these tumors are more commonly encountered in early to middle adulthood. Both extremes of age (<20 years and >60 years) contributed equally (12.5%), suggesting a relatively lower incidence outside the peak age range. A slight male predominance (54.2%) was observed; however, statistical analysis using the Chi-square test revealed no significant association between age and sex ($\chi^2 = 1.32$, $p = 0.72$). This indicates that the distribution of adnexal tumors across age groups is independent of gender, and the observed variation is likely due to random distribution rather than a true biological difference **(Table 1 & Figure 2)**. Cutaneous adnexal tumors in the present study showed a marked predilection for the head and neck region (64.6%), making it the most involved site, with the scalp being the predominant location. This was followed by extremities (22.9%), while shoulder and back (8.3%) and trunk and abdomen (4.2%) contributed relatively fewer cases. A Chi-square goodness-of-fit test showed that the distribution of tumors across anatomical sites was statistically significant ($\chi^2 = 28.4$, $p < 0.001$), indicating a non-uniform distribution of tumors across anatomical locations. The predominance in the head & neck region can be attributed to the higher density of adnexal structures in this area, supporting its role as the most common site for these tumors **(Table 2 & Figure 3)**.

The distribution of cutaneous adnexal tumors according to differentiation type revealed a clear predominance of follicular differentiation (64.6%), followed by eccrine (16.7%), apocrine (10.4%), and both sebaceous and unclassified types (4.2% each). Statistical analysis using the Chi-square test demonstrated a significant difference in the distribution of differentiation types ($\chi^2 = 30.6$, $p < 0.001$), indicating a non-uniform pattern. The marked predominance of follicular tumors suggests that hair follicle-derived neoplasms constitute the major proportion of adnexal tumors in this cohort, while eccrine and apocrine tumors are comparatively less frequent. This pattern reflects the relative abundance and biological activity of follicular units in the skin **(Table 3 & Figure 4)**. The frequency distribution of histopathological diagnoses revealed that trichilemmal cyst (37.5%) was the most common lesion, followed by pilomatrixoma (20.8 %) and hidradenoma (10.4%). Other tumors such as syringocystadenoma papilliferum (8.3%) and trichoepithelioma (6.3%) were less frequently encountered, while a heterogeneous group categorized as others (16.7%) comprised relatively rare entities. Statistical analysis using the Chi-square test demonstra-ted a significant variation in the distribution of tumor types ($\chi^2 = 24.9$, $p < 0.001$), indicating a non-uniform pattern. The pre-dominance of trichilemmal cyst highlights the high frequency of follicular-derived lesions, particularly involving the scalp, reflecting the underlying adnexal density and biological activity of follicular structures **(Table 4 & Figure 5)**. The correlation between anatomical site and differentiation group demonstrated a predominant localization of follicular tumors in the head and neck region (24/31 cases), followed by extremities (5 cases), indicating a strong site predilection. Eccrine tumors showed a relatively broader distribution across head and neck (4 cases) and extremities (3 cases), while apocrine tumors were sparsely distributed across multiple sites. Sebaceous tumors were few and limited to head and neck and extremities, whereas unclassified tumors were rare and seen in the shoulder–back and trunk regions. Statistical analysis using the Chi-square test revealed a significant association between site and differentiation pattern ($\chi^2 = 18.7$, $p = 0.028$), suggesting that the anatomical distribution of adnexal tumors is dependent on their line of differentiation, with follicular tumors showing a marked predilection for the head and neck region **(Table 4 & Figure 5)**. Representative histopathological features of the various cutaneous adnexal tumors encountered in the present study are illustrated in **Figures 5 & 6**. **Figure 5** demonstrates tumors with follicular differentiation, which constituted the predominant group in this study. Trichilemmal cysts showed well-circumscribed cystic lesions with stratified squamous lining exhibiting abrupt trichilemmal keratinization without a granular layer. Pilomatricoma displayed a biphasic pattern of basaloid cells transitioning into eosinophilic ghost (shadow) cells with areas of keratinization. Trichoblastoma revealed dermal nests of basaloid cells with peripheral palisading and surrounding fibromyxoid stroma, consistent with follicular germinative differentiation. **Figure 6** highlights tumors with eccrine and apocrine differentiation.

Hidradenoma and nodular hidradenoma exhibited well-circumscribed dermal tumors with solid and cystic architecture composed of polygonal and clear cells, along with ductal differentiation. Chondroid syringoma demonstrated epithelial and myoepithelial elements arranged in ducts and tubules embedded in a chondromyxoid stroma.

Cylindroma showed the characteristic "jigsaw puzzle" arrangement of basaloid cell nests surrounded by thick eosinophilic hyaline basement membrane material. These morphological features aided in confirming the line of differentiation and supported the predominance of follicular tumors, followed by eccrine and apocrine types in the present study.

Table 1: Age and Sex Distribution of Cutaneous Adnexal Tumors (n = 48)

Variable	Category	Frequency (n)	Percentage (%)
Age Group	<20 yrs	6	12.5
	21–40 yrs	22	45.8
	41–60 yrs	14	29.2
	>60 yrs	6	12.5
Sex	Male	26	54.2
	Female	22	45.8

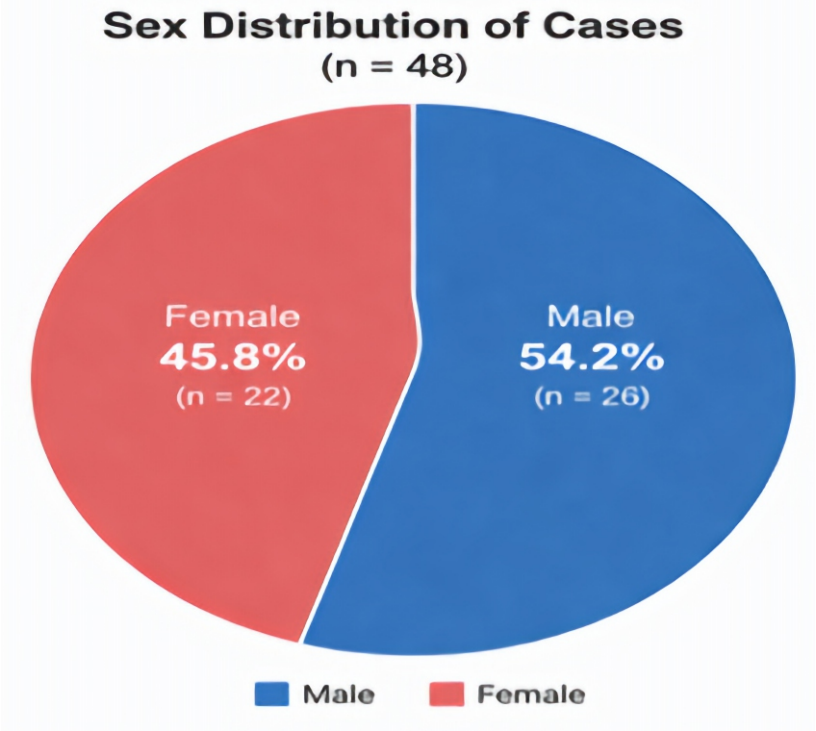

Figure 2: Pie chart depicting sex distribution of cases showing slight male predominance.

Table 2: Site-wise Distribution of Cutaneous Adnexal Tumors

Site	Frequency (n)	Percentage (%)
Head & Neck	31	64.6
Extremities	11	22.9
Shoulder & Back	4	8.3
Trunk & Abdomen	2	4.2
Total	48	100

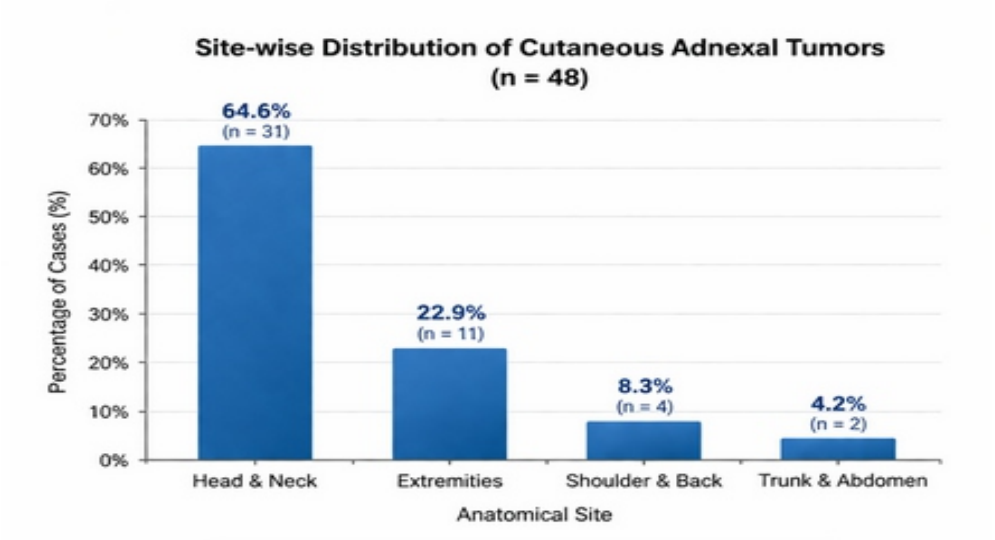

Figure 3: Bar diagram illustrating site-wise distribution of tumors, showing predominance in the head and neck region.

Table 3: Distribution of Tumors According to Differentiation Group

Differentiation Type	Frequency (n)	Percentage (%)
Follicular	31	64.6
Eccrine	8	16.7
Apocrine	5	10.4
Sebaceous	2	4.2
Unclassified	2	4.2
Total	48	100

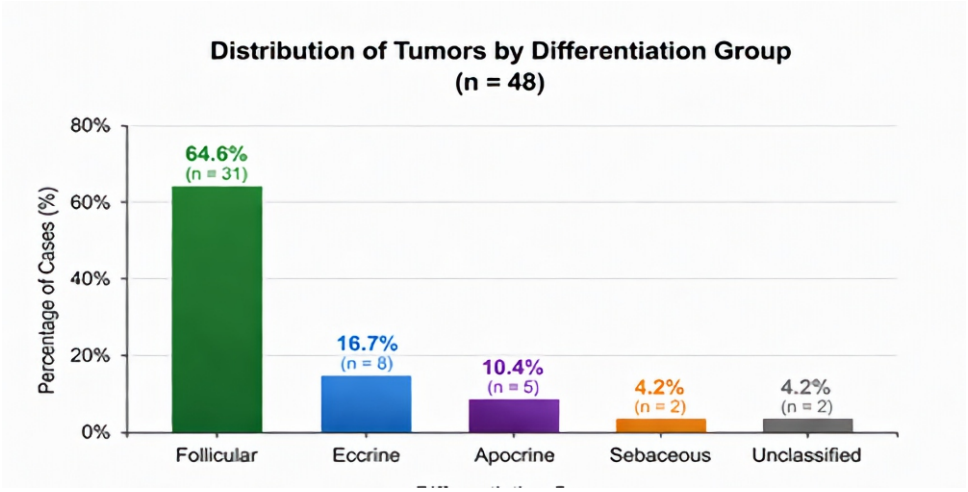

Figure 4: Bar diagram showing distribution of tumors according to differentiation group, highlighting predominance of follicular tumors.

Table 4: Frequency Distribution of Histopathological Diagnosis

Diagnosis	Frequency (n)	Percentage (%)
Trichilemmal cyst	18	37.5
Pilomatrixoma	10	20.8
Hidradenoma	5	10.4
Syringocystadenoma papilliferum	4	8.3
Trichoepithelioma	3	6.3
Others	8	16.7
Total	48	100

Table 5: Correlation Between Anatomical Site and Differentiation Group

Site ↓ / Differentiation →	Follicular	Eccrine	Apocrine	Sebaceous	Unclassified	Total
Head & Neck	24	4	2	1	0	31
Extremities	5	3	2	1	0	11
Shoulder & Back	2	1	0	0	1	4
Trunk & Abdomen	0	0	1	0	1	2
Total	31	8	5	2	2	48

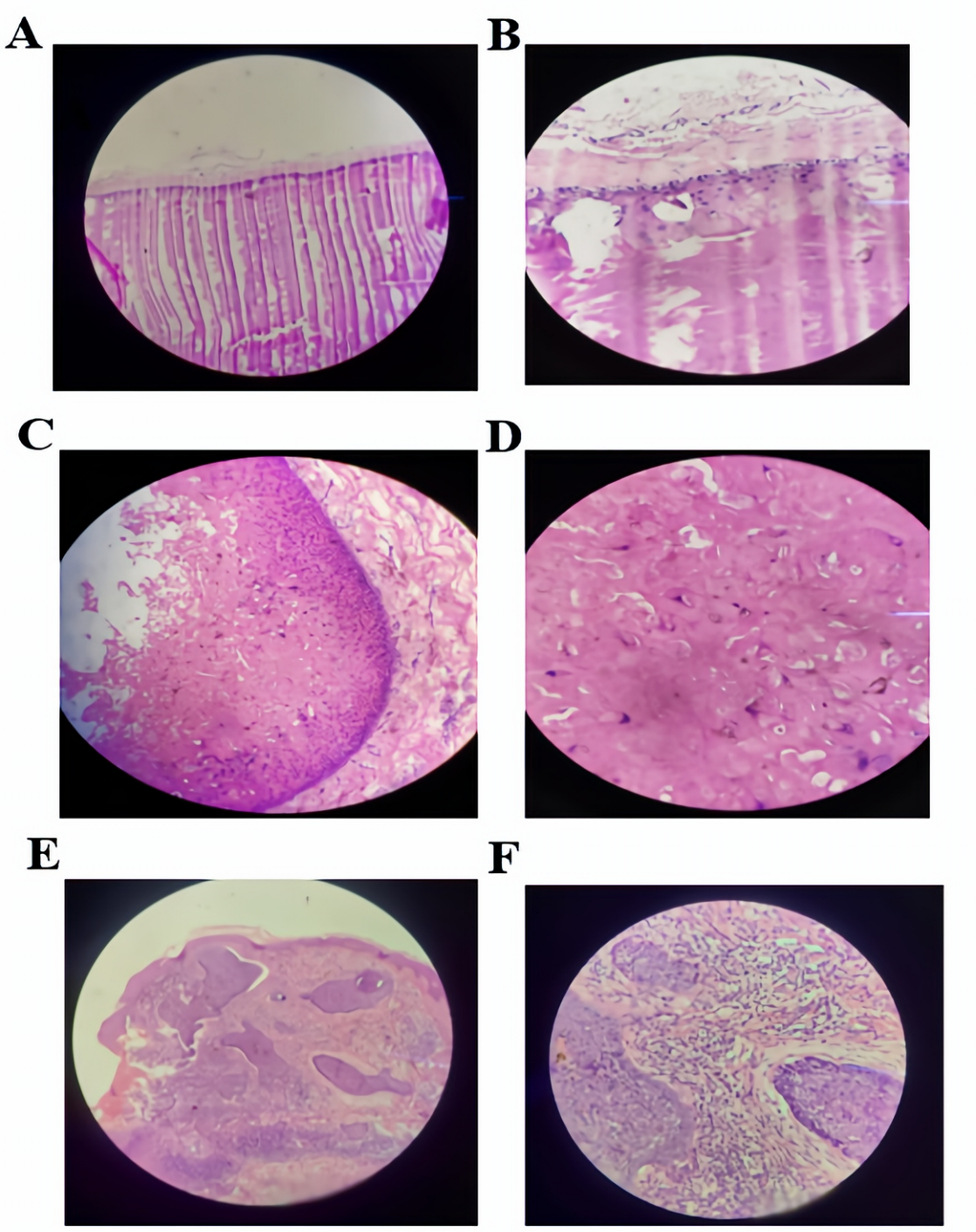

Figure 5: Representative histopathological features of follicular cutaneous adnexal tumors. (**A–B**) Trichilemmal cyst showing a well-circumscribed cyst lined by stratified squamous epithelium with abrupt trichilemmal keratinization lacking a granular layer (**A:** low power; **B:** high power). (**C–D**) Pilomatricoma demonstrating basaloid cells transitioning to eosinophilic ghost (shadow) cells with areas of keratinization (**C:** low power; **D:** high power). (**E–F**) Trichoblastoma exhibiting dermal nests of basaloid cells with peripheral palisading and surrounding fibromyxoid stroma (**E:** low power; F: high power). (Hematoxylin and eosin stain; original magnifications ×40 and ×400).

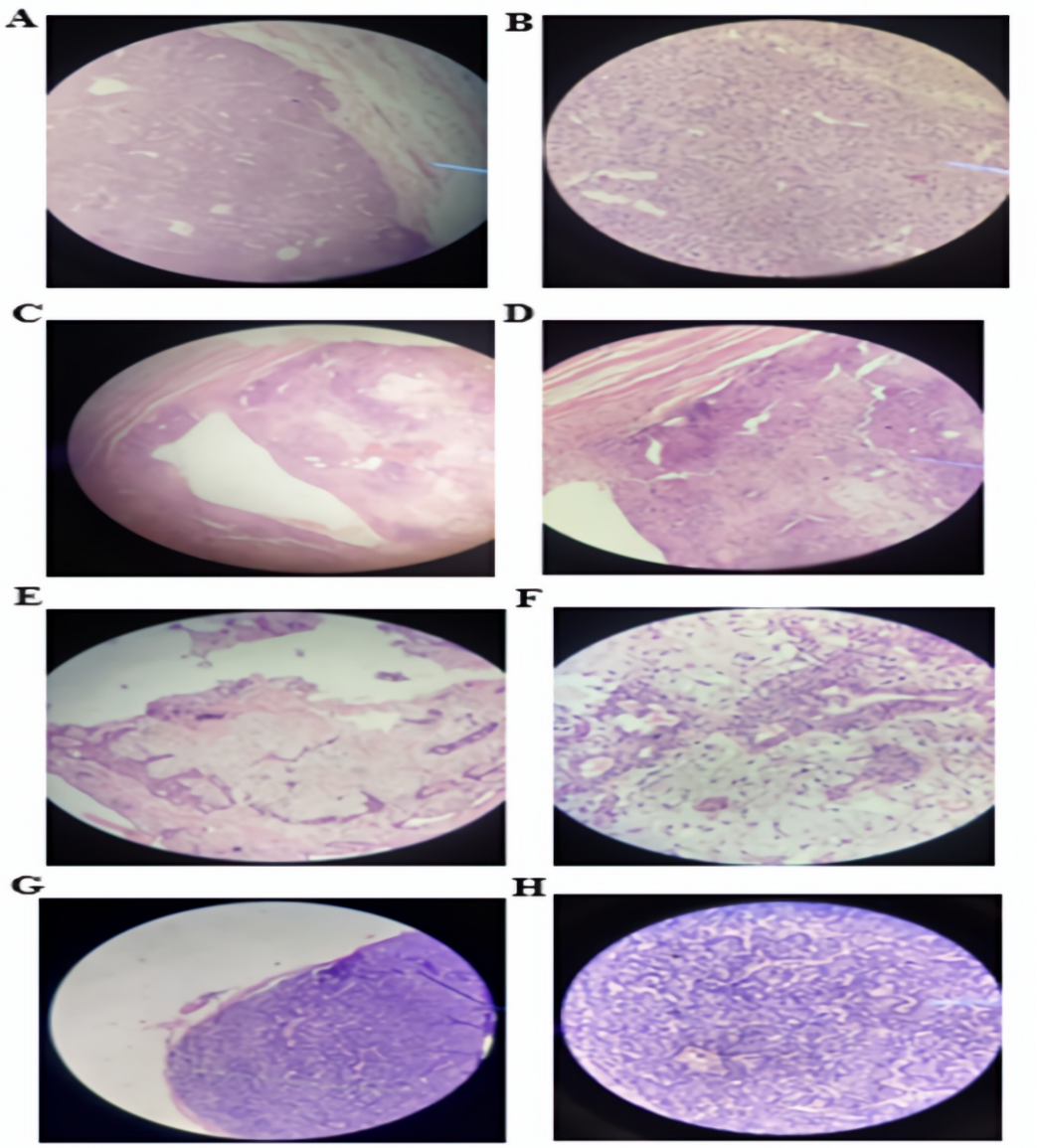

Figure 6: Histopathological spectrum of eccrine and apocrine cutaneous adnexal tumors. **(A–B)** Hidradenoma showing a well-circumscribed dermal tumor with solid and cystic areas composed of polygonal and clear cells with ductal differentiation (**A:** low power; **B:** high power). **(C–D)** Nodular hidradenoma demonstrating lobulated architecture with solid nests and cystic spaces containing eosinophilic secretions (**C:** low power; **D:** high power). **(E–F)** Chondroid syringoma revealing epithelial and myoepithelial components arranged in ducts and tubules embedded within a chondromyxoid stroma (**E:** low power; **F:** high power). **(G–H)** Cylindroma exhibiting characteristic "jigsaw puzzle" arrangement of basaloid cell nests surrounded by thick eosinophilic hyaline basement membrane material (**G:** low power; **H:** high power). Hematoxylin and eosin stain; original magnifications ×40 and ×400).

DISCUSSION

Cutaneous adnexal tumors represent a heterogeneous group of lesions with diverse histopathological differentiation, and their accurate classification relies predominantly on microscopic evaluation. In the present study, most cases were observed in the 21-40 years age group, which is consistent with findings reported by **Radhika et al.** and **Saha et al.**, who also noted a peak incidence in early to middle adulthood [3,6]. However, unlike some studies that demonstrate female predominance, such as **Nair et al.**, our study showed a slight male predominance, though not statistically significant, indicating variability across populations [9].

The **head and neck region (64.6%)** were the most involved site, particularly the scalp. This finding correlates well with studies by **Sharma et al.** and **Saha et al.**, who attributed this predilection to the higher density of adnexal structures in this region [6,10]. Similar observations have been reported by **Pujani et al.**, reinforcing that adnexal tumors commonly arise in areas rich in pilosebaceous units [14].

With respect to histological differentiation, follicular tumors (64.6%) constituted the largest group in the present study. This predominance agrees with studies by **Radhika et al.** and **Parvati et al.**, where follicular differentiation was the most frequent subtype [3,15]. The high proportion of follicular tumors may be explained by the biological activity & abundance of hair follicle structures in the skin, particularly in the scalp region. Eccrine & apocrine tumors were less common, which is consistent with observations by **Obaidat et al.**, who emphasized the relatively

lower frequency of sweat gland tumors compared to follicular lesions [5,7].

Among individual diagnoses, trichilemmal cyst (37.5%) was the most common tumor, followed by pilomatrixoma and hidradenoma. This finding is comparable to studies by **Radhika et al.** and **Pujani et al.**, where trichilemmal cysts were also reported as the predominant lesion [3,14]. The frequent occurrence of trichilemmal cysts in the scalp further supports the site predilection observed in this study.

A statistically significant association was observed between anatomical site and differentiation pattern ($p < 0.05$). Follicular tumors were predominantly localized to the head and neck region, whereas eccrine and apocrine tumors showed a relatively wider distribution. Similar correlations have been described by **Kamyab-Hesari et al.**, who highlighted that the distribution of adnexal tumors is influenced by the anatomical density and type of adnexal structures [13].

Malignant adnexal tumors were rare in the present study, with only a single case identified. This finding is consistent with reports by **Blake et al.** and **Kazakov et al.**, who emphasized the low incidence but significant clinical importance of malignant adnexal neoplasms due to their aggressive behavior [11,12].

Overall, the findings of the present study are largely in concordance with existing literature, reinforcing that cutaneous adnexal tumors are predominantly benign, commonly involve the head and neck region, and most frequently exhibit follicular differentiation. The observed clinicopathological patterns highlight the importance of histopathological evaluation in accurate diagnosis and classification of these tumors.

CONCLUSION

The present study highlights that cutaneous adnexal tumors are predominantly benign lesions with a wide spectrum of histopathological differentiation. A clear predilection for the head and neck region, particularly the scalp, was observed, likely reflecting the high density of adnexal structures in this area. Follicular differentiation emerged as the most common subtype, with trichilemmal cyst being the most frequent diagnosis, underscoring the predominance of hair follicle-derived tumors.

A statistically significant association between anatomical site and differentiation pattern emphasizes the role of site-specific adnexal distribution in tumor development. Although malignant tumors were rare, their identification remains crucial due to potential aggressive behavior and need for timely management.

Overall, the findings reinforce the importance of histopathological examination as the gold standard for accurate diagnosis and classification of adnexal tumors. Comprehensive clinicopathological evaluation is essential for appropriate management, prognostication, and recognition of rare or syndromic associations. Further large-scale studies are recommended to better understand the epidemiological and biological behavior of these tumors.

LIMITATIONS & FUTURE PERSPECTIVES

The present study is limited by its retrospective design and relatively small sample size from a single institution. Larger multicenter studies are required to better understand the epidemiological and clinicopathological spectrum of these tumors. Future studies should incorporate multicentre designs with larger populations to enhance validity, assess long-term outcomes, and investigate advanced diagnostic & management approaches. Such efforts will improve overall patient care and help minimize complications.

CLINICAL SIGNIFICANCE

The clinical significance of this study lies in its potential to bridge the gap between research findings and practical healthcare applications. It emphasizes the importance of trans-lating scientific observations into meaningful improve-ments in patient care, diagnosis, and treatment outcomes. By highlighting real-world relevance, the study contributes to evidence-based medical practice and supports informed clinical decision-making. Ultimately, the findings aim to enhance patient quality of life, optimize therapeutic strategies, and promote better disease management in clinical settings.

ABBREVIATIONS

CATs: Cutaneous adnexal tumors
H&E: Hematoxylin and eosin
FFPE: Formalin-fixed paraffin-embedded

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AUTHOR CONTRIBUTIONS

All authors significantly contributed to the study conception and design, data acquisition, or data analysis and interpretation. They participated in drafting the manuscript or critically revising it for important intellectual content, consented to its submission to the current journal, provided final approval for the version to be published, and accepted responsibility for all aspects of the work. Additionally, all authors meet the authorship criteria outlined by the International Committee of Medical Journal Editors (ICMJE) guidelines.

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CONFLICT OF INTEREST
Authors declared that there is no conflict of interest.

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All necessary consent & approval was obtained by authors.

CONSENT FOR PUBLICATION
All necessary consent for publication was obtained by authors.

DATA AVAILABILITY
All data generated and analyzed are included within this research article. The datasets utilized and/or analyzed in this study can be obtained from the corresponding author upon a reasonable request.

USE OF ARTIFICIAL INTELLIGENCE (AI) & LARGE LANGUAGE MODEL (LLM)
The authors confirm that no AI & LLM tools were used in thewriting or editing of the manuscript, and no images were altered or manipulated using AI & LLM.

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