

## ORIGINAL ARTICLE

# Histopathological characteristics analysis of giant melanocytic naevi in children

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## Abstract

**Background:** The major diagnostic criterion for the giant congenital melanocytic nevus (GCMN) is a size larger than 20 cm in diameter. However, the histopathological origin, pathogenesis, and GCMN progression are not yet completely clear. Unlike other medium or small superficial lesions, histomorphological evaluation is significant for GCMN pathological classification, malignant transformation assessment, and early detection of prognosis.

**Aims:** This study aimed to investigate the pathological features of GCMN, including its satellite lesions.

**Patients/Methods:** Twenty-three giant naevi and seventeen "satellite lesions" were collected from children aged 1 to 10 in Shanghai Ninth People's Hospital from 2018 to 2020. A histological study was conducted to evaluate their histological appearance. All the data observed and recorded data were statistically analyzed.

**Results:** In 23 cases of GCMN primary nevus, nevus cells were mainly distributed in the dermal region, with melanocyte proliferation and the presence of nevus nests at the dermal-epidermal junction. However, in satellite nevus, a junctional growth pattern was noted. Additionally, other histopathologic features, including epidermal contour, cell morphology, and architecture disorder also showed significant differences between primary nevus and satellite nevus.

**Conclusions:** We demonstrated that the congenital pattern of the main nevus is more obvious than one of the satellite nevus, suggesting that the satellite nevus and the main nevus may occur slightly later than the main nevus. "Satellite nevus" happens as a result of a separate genetic event.

## KEYWORDS

cluster analysis, GCMN, histological features, primary nevus, satellite nevus

**Abbreviations:** AMN, acquired melanocytic nevus; CMN, congenital melanocytic nevus; GCMN, giant congenital melanocytic nevus.

Wei Chen and Xuewei Jiang contributed equally to this work.

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## 1 | INTRODUCTION

Giant congenital melanocytic nevus (GCMN) is usually defined as the hyperplastic lesions on the skin found at birth, which includes large nevi with a diameter of 20 cm or even giant nevi with a diameter greater than 50 cm in adults.<sup>1,2</sup> The clinical diagnosis is mainly focused on its diameter and location. The appearance of GCMN is mainly shown as flat, papular, or papillary brown lesions with clear boundaries and hair growth. Although GCMN can be found in any area of the body surface, the most common part is the trunk, followed by the limbs and head.<sup>1-5</sup>

Histologically, nevus consists of transformed melanocytes,<sup>6,7</sup> which normally present as highly dendritic cells scattered among the keratinocytes of the epidermal basal layer. Until now, the histopathological studies on nevus have mainly focused on the identification of congenital melanocytic nevus (CMN) and acquired melanocytic nevus (AMN), and most of the samples come from medium and small CMN. In contrast, studies on GCMN are seldom reported.<sup>3,8-10</sup> After observing some cases, in addition to presenting several histological characteristics of CMN, GCMN also shows more complex and diverse histological components and lesion distribution. In these cases, other histological phenotypes, such as neurocytes, blue nevus or Spitz nevus, could also be found. The diversity of histological components in the GCMN in the dermis suggests that these lesions could originate from pluripotent stem cells. The most common epidermal changes in GCMN lesions are prolonged rete ridges with hyperkeratosis and pigmentation and the presence of nests of melanocytes in the basal layer of the epidermis.<sup>11,12</sup> Moreover, giant nevus is often accompanied by a large amount of satellite nevus.<sup>13-15</sup> Based on clinical experience, the differentiation between congenital nevus and acquired nevus, small nevus, and giant nevus is still controversial due to a lack of accurate histological basis.

The objective of this study was to search for the correlation between the clinical features and pathological characteristics of GCMN. We collected pathological specimens of GCMN and analyzed morphological features such as histological distribution, cellular morphology, and architecture characteristics.

## 2 | METHODS

### 2.1 | Patient selection

We derived the patients' characteristics from the Plastic and Reconstructive Surgery division at the Shanghai Ninth People's Hospital, China, from 2018 to 2020. The giant congenital melanocytic lesion was clinically measured to be more than 20 cm in diameter. Up to now, the clear definition of satellite lesions is still unknown. Our study defined the small lesions as near satellites located in the same body part as the main nevus. Distant satellites were defined as the small nevus in other different parts. After microscopic evaluation, traumatized naevi, blue naevi, Spitz and Reed naevi, and naevi with incomplete biopsies were excluded. Finally, 23 GCMN lesions from

23 patients aged 1 to 10 years old were involved in the further analysis.

Each specimen was routinely treated with formalin and paraffin wax to make sections at 4  $\mu$ m thickness and stained with hematoxylin and eosin. The pathological manifestations were subjected to analysis. Accordingly, clinical data such as the size, color, and surface textures of the GCMN from each patient were recorded.

### 2.2 | Histopathological categories and cytological features

The definition of histopathological categories and the grading of cytological atypia complied with the widely accepted standards for naevi.

We identified the location of nevus cells in cutaneous tissue in accordance with Mark's criteria.<sup>11</sup> According to Clemente and Braun-Falco et al., the architecture disorder of a nevus was diagnosed based on basilar proliferation of atypical melanocytes.<sup>16,17</sup> In addition, other features were also evaluated by a histopathologist, including the scattering and nesting of intraepidermal melanocytes, pigmentation, epidermal contour, pagetoid melanocytes, the distribution and growth pattern of melanocytes, bridging of cell nests, and size of junctional nests. These features are shown in the supplemental table.

Cytological atypia was difficultly graded because of poorly reproducible nuclear atypia. Thus, we adopted the reformative scheme from Braun-Falco and Rhodes for GCMN, which indicated the highest degree of multiple melanocytes atypia with more than two rete ridges at the epidermal-dermal junction. Dermal melanocytes were not performed.<sup>17,18</sup>

### 2.3 | Statistical analysis

SPSS Statistics v.21.0 was used for analysis in this study. Independent Student's *t*-test and chi-squared test were respectively used for counting data and categorical data. Pearson correlation analysis was carried out for two variables. R software constructed heatmaps by agglomerative hierarchical clustering to compare the difference in histomorphological variables. All significant difference was defined as  $p < 0.05$ .

## 3 | RESULTS

### 3.1 | Histopathological features of GCMN and its satellite lesions

Giant nevus and its satellite nevus lesions of GCMN patients were compared. In 23 cases of GCMN main nevus, the nevus cells were mainly characterized by dermal distribution, and the dermal-epidermal junction was often accompanied by the proliferation of

melanocytes, and by the formation of nevus nests, showing the common histological types of compound nevus or intradermal nevus. GCMN nevus cells often extend to 2/3 of the reticular layer and are distributed around nerves, blood vessels, sebaceous glands, sweat glands, and other skin appendages. Among the dermal collagen fibers, nevus cells can be infiltrated by a single file. In 17 cases of satellite nevus, epidermal basal melanocyte hyperplasia, pigmentation, and shouldering were more common (Figures 1 and 2).

### 3.2 | Univariate analysis of histomorphological variables between primary nevi and satellite nevi

The statistically significant differences in some histomorphological features were found by microscopic observation and statistical analysis of 23 primary nevus specimens and 17 satellite nevus specimens (Table 1). Dermal growth pattern was dominant in the primary nevus (65.2%), while in the satellite nevus it was the junctional pattern (82.4%;  $p < 0.001$ ). Compared to satellite nevi, the congenital pattern was more common in primary nevi, in which nevus cells were often seen around vascular, adnexal structures, and collagen fibers. Mark type was seen in 19 primary nevi (82.6%) and 2 satellite nevi (11.8%),  $p < 0.001$ . In addition, other histomorphological variables also presented significant statistical differences ( $p < 0.01$ ), including epidermal contour, cell morphology, and architecture disorder.

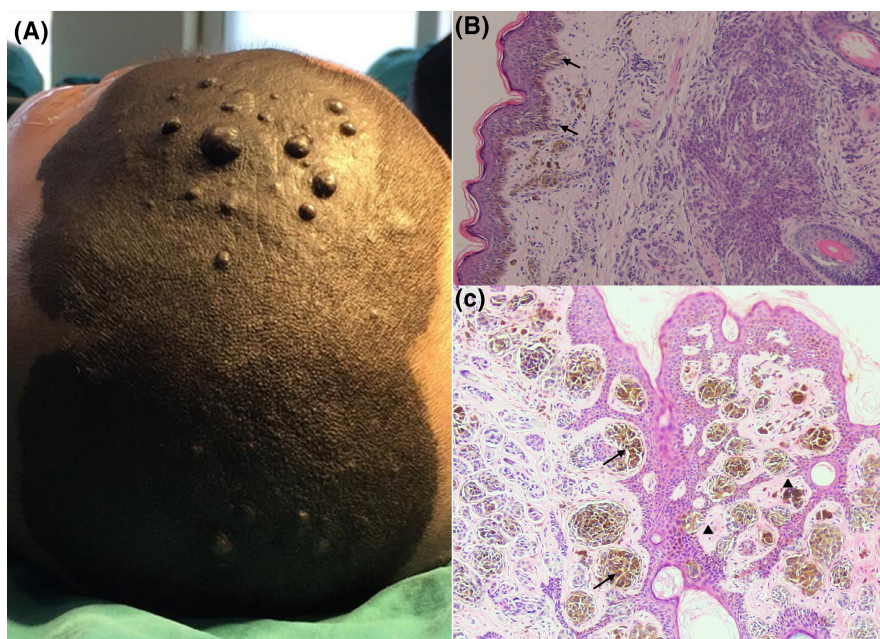
### 3.3 | Analysis of the histomorphological variables of primary nevi and satellite nevi

According to the histomorphological variables, the clustering was carried out by aggregative hierarchical clustering. The values of the variable were from 0 to 5, and the corresponding color scale was from blue to red. Multivariate cluster analysis showed significant differences in growth pattern, epidermis and dermis structure among the groups,  $p < 0.05$  (Figure 3). These results suggested that the histomorphological differences between the main nevus and satellite nevus were growth patterns, and epidermal-dermal structures.

The primary nevi samples were divided into light, medium, and dark according to the pigmentation. After clustering, there was no significant difference in histomorphology among the groups,  $p > 0.05$  (Figure 4).

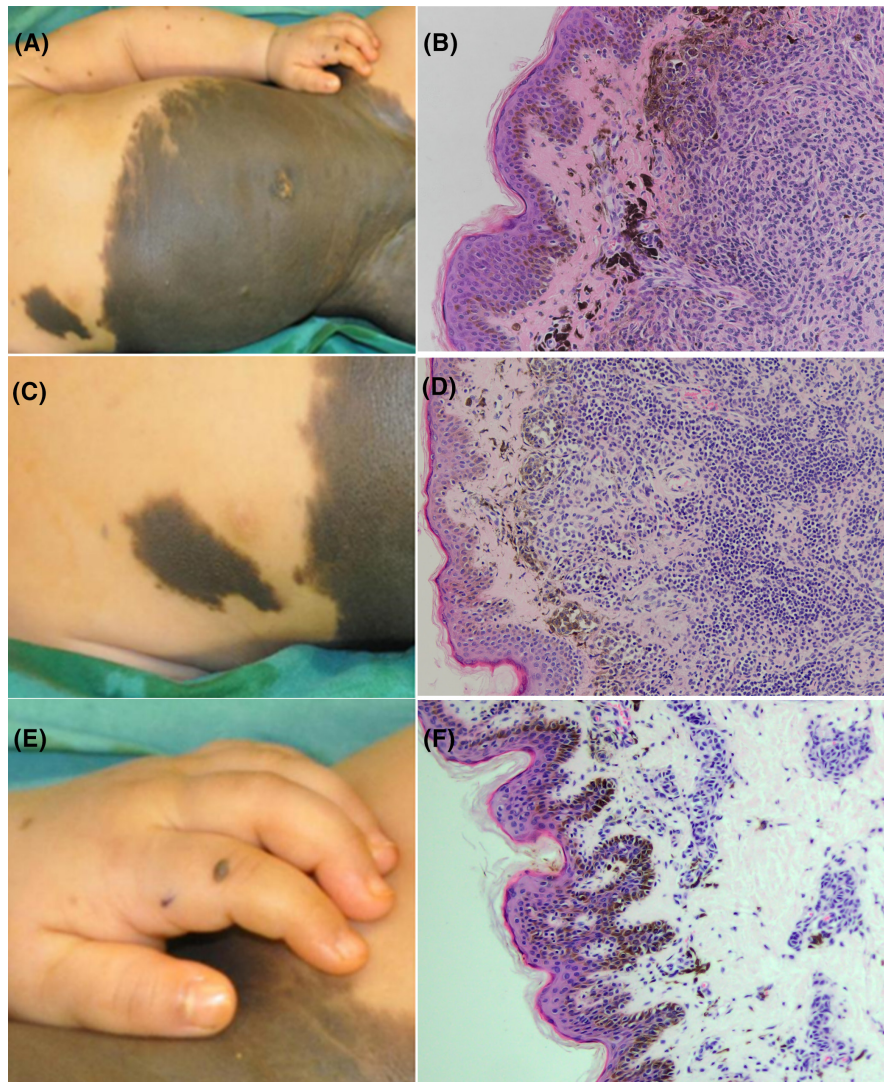
## 4 | DISCUSSION

Giant congenital melanocytic nevus (GCMN) is clinically defined as a nevus with a diameter larger than 20 cm, or at least 2% of the skin surface area.<sup>2,12</sup> Although GCMN is relatively rare, in approximately 1/20000 newborns, the clinical focus and controversies in its treatment are the risk of malignancy and its possible severe



**FIGURE 1** Clinical appearance and HE staining of GCMN in head skin. (A) GCMN in the head, the lesions were highly pigmented with pebbling surface. (B) Pathologic biopsy of the/a lesion with smooth surface by HE staining (100 $\times$ ) at the junctional area and papillary layer of the dermis, deeply infiltrating into the deep layer of the dermis with an involvement of the hair follicles, sebaceous glands, and small blood vessels. Nevus cells were nesting in the epidermal basal layer ( $\uparrow$ ). There was no obvious boundary and histomorphological deference of nevus cells at the junctional area. (C) Pathologic biopsy of the/a lesion with pebbling by HE staining (100 $\times$ ). A large number of nevus cell nests were formed in the basal, junctional and superficial layer of the epidermis, accompanied by moderate architecture disorder. Eosinophilic fibrosis of collagen fibers was observed, and the hyperplasia of collagen fibers surrounded the top of the remaining rete of the epidermis ( $\blacktriangle$ ). The boundary of nevus cell nests between the basal layer of the epidermis and papillary dermis was poorly circumscribed, and there were no obvious collagenous fiber bands in the junctional area, a lesion with a smooth surface being shown.





**FIGURE 2** Different histopathological features of GCMN and its satellite lesions. (A) GCMN in the abdominal area extending to the groin, perineum, and thigh roots, accompanied by various “satellite lesions” in different body parts. (B) 75% of nevus cells were distributed diffusely in the dermis without obvious nesting formation, according to HE staining (100 $\times$ ). (C) The appearance of the satellite nevus in the chest was similar to that of the primary nevus. (D) The histomorphological features of the satellite nevus in the chest near the primary nevus were similar to those of the primary nevus, according to HE staining (100 $\times$ ). (E, F) Satellite lesions in the finger and pathologic biopsy with HE staining (100 $\times$ ): The distribution of nevus cells in the dermal papillary layer was localized, and nevus cells were also seen around the adnexal structures. The melanocytes in the basal layer of the epidermis proliferated, the cytoplasm was stained significantly, and the nucleus was difficult to recognize.

complications. There are only few histopathological studies and reports on GCMN, and most of them only focus on medium and small CMN or only emphasize the histological differentiation between CMN and AMN. We summarized the histopathological characteristics of GCMN and quantified the differences between the primary nevi and the satellite nevi by clustering analysis, which might help to establish the clinicopathological classification standard of GCMN, contributing to its diagnosis, treatment and prognosis judgment.

All 23 GCMN samples in this study were obtained from patients diagnosed with asymptomatic congenital giant nevus. Their pathological manifestations were similar to compound and intra-dermal nevus but showed more complex structures, from the basal layer to subcutaneous tissues. The nevus cells generally showed the distribution trend of nesting in the papillary dermis, diffusing in the sub-papillary layer and band-like distribution in the reticular layer. The primary nevus with papular or pebbling surface showed marked cellular nesting in the upper part of the dermis and junctional area. However, the primary nevus with a smoothing appearance showed a high infiltrating density with Type II nevus cells

under the papilla layer. At the same time, nesting was rarely seen, forming a relatively obvious “acellular zone”, which microscopically consisted of normal collagen fibers. It could be concluded that nevus cell nesting might gradually disappear and degenerate in this layer. Some differences existed in the cellular distribution patterns of GCMN lesions with different clinical appearances. The lesions of giant nevus were mostly concentrated in the dermis. Hyperkeratosis and extension of rete ridges commonly occurred in the epidermis, and were accompanied by a large number of melanocytes that were proliferating in the basal layer to form numerous nevus nests with hyperpigmentation (lentiginous change). According to the pigmentation of lesions, the primary nevus samples are divided into three groups: light, medium, and dark, and there was no significant difference in histomorphology between groups after clustering.

In the previous study, giant nevi are usually accompanied by a number of satellite nevi. The term “satellite lesion” is commonly used in dermatology to describe a minor lesion near the edge of a primary lesion. However, the use of the term “satellite nevus” in GCMN has always been controversial because the term “satellite”

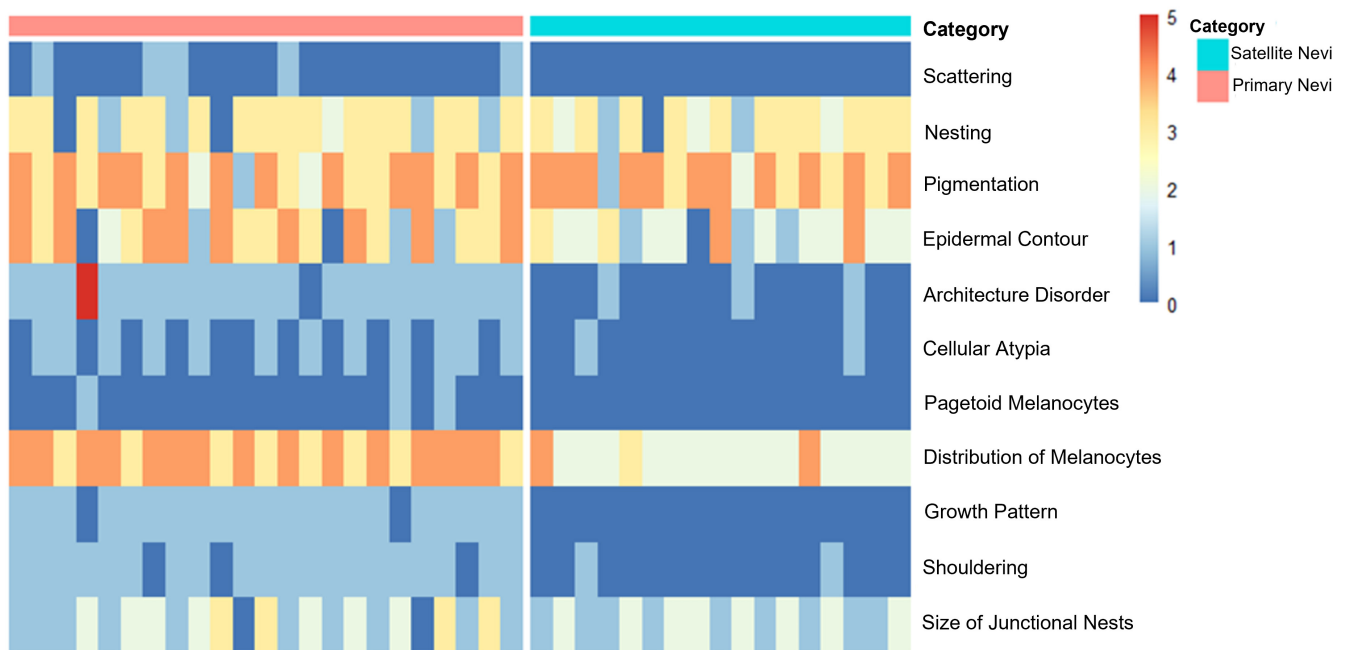
TABLE 1 Univariate analysis of histomorphological variables between primary nevi and satellite nevi.

Histopathological features	Category	Primary nevi (%)	Satellite nevi (%)	p-value
Mark typing	Mark type	19 (82.6)	2 (11.8)	<0.001
	Non-mark type	4 (17.4)	15 (88.2)	
Scattering	0–25%	18 (78.2)	17 (100)	0.116
	25%–50%	5 (21.8)	0	
	50%–75%	0	0	
	>75%	0	0	
Nesting of intraepidermal melanocytes	0	2 (8.7)	1 (5.9)	0.662
	0–25%	4 (17.0)	2 (11.8)	
	25%–50%	1 (4.3)	3 (17.6)	
	>50%	16 (70.0)	11 (64.7)	
Pigmentation	None	0	0	0.888
	Weak	1 (4.3)	1 (5.9)	
	Medium	2 (8.7)	1 (5.9)	
	High	8 (34.8)	4 (23.2)	
	Strong	12 (52.2)	11 (64.7)	
Epidermal contour	Atrophy	2 (8.7)	1 (5.9)	<0.01
	Thinned	3 (13.0)	3 (17.6)	
	Normal	1 (4.3)	9 (52.9)	
	Thickened	8 (34.8)	2 (11.8)	
	Hyperplasia	9 (39.1)	2 (11.8)	
Architecture disorder	No	2 (8.7)	14 (82.4)	<0.001
	Yes	21 (91.3)	3 (17.6)	
Cellular atypia	0	10 (43.5)	15 (88.2)	<0.01
	Mild	12 (52.2)	2 (11.8)	
	Moderate	0	0	
	Severe	0	0	
Pagetoid melanocytes	No	20 (87.0)	17 (100)	0.122
	Yes	3 (13.0)	0	
Distribution of melanocytes	Junctional	0	0	<0.001
	Most junctional	0	14 (82.4)	
	Compound	8 (34.8)	1 (5.9)	
	Intradermal	15 (65.2)	2 (11.7)	
Growth pattern	Radical growth	2 (8.7)	17 (100)	<0.001
	Vertical growth	21 (91.3)	0	
Bridging	No	20 (87.0)	16 (88.2)	0.851
	Yes	3 (13.0)	2 (11.8)	
Size of junctional nests	None	2 (8.7)	0	0.170
	<33% of epidermis thickness	10 (43.5)	9 (52.9)	
	33%–66% of epidermis thickness	7 (30.4)	8 (47.1)	
	>66% of epidermis thickness	4 (17.4)	0	

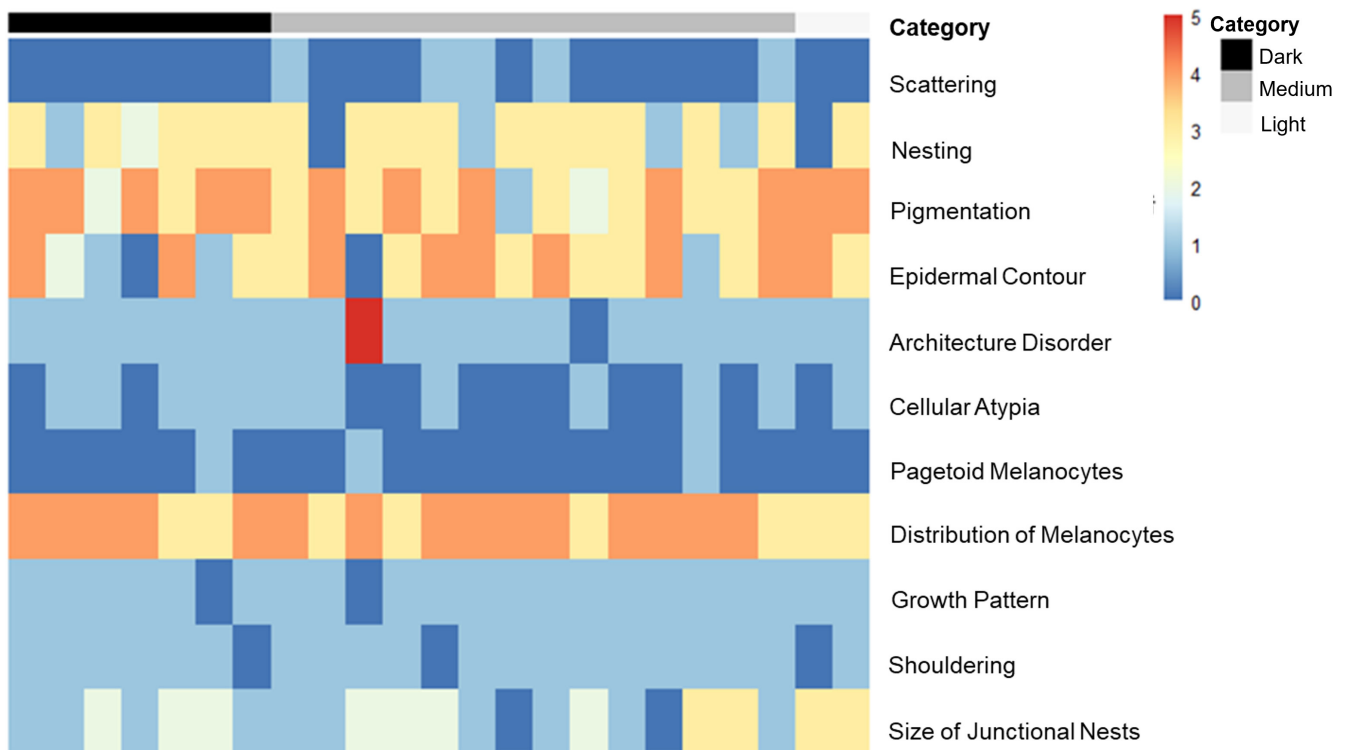
means to some extent that the smaller lesions besides the primary nevus belong to or originate from the largest CMN, which does not help to clarify their true etiology and pathogenesis. Clinically, when most GCMN patients are diagnosed with satellite nevi, these lesions are not necessarily limited to the area at the edge of the primary focus, nor are they obviously smaller.<sup>13,14,19</sup> At present, the origin of

satellite nevus and the relationship between the primary nevus and “satellite nevus” are not clear.

In this study, we still used “satellite nevus” to define the small lesions around or far away from the primary nevus and to observe and analyze their pathological characteristics. The results showed that the histological characteristics of primary nevus and satellite



**FIGURE 3** Heatmap of histomorphological variables between primary nevi and satellite nevi. The samples were divided into two groups: the primary nevus and the satellite nevus, agglomerative hierarchical clustering according to the tissue morphological variables, with the variable values ranging from 0 to 5, corresponding to the order of color from blue to red.



**FIGURE 4** Heatmap of histomorphological variables of primary nevi. The primary nevus samples were divided into light, medium, and dark groups according to the pigmentation and agglomerative hierarchical clustering based on the tissue morphological variables, with variable values ranging from 0 to 5, corresponding to the color scale from blue to red.

nevus on the surrounding margins were similar: the nevus cells were diffusely infiltrated in the dermis without obvious nest formation; the lesions extended to the reticular layer and subcutaneous

fat surrounding the hair follicle, sweat gland and other appendages; the depth of the satellite nevus was more superficial than that of the primary nevus, with an involvement of the hair follicle

and sebaceous gland, diffusely distributing in the upper layer of the reticular dermis.

Different pathological features between the primary nevus and distant satellite lesions were analyzed. A large number of nevus cells formed multiple cellular nests at the dermo-epidermal junction in GCMN lesions, with obvious eosinophilic fibrosis and extension of the rete ridges. Nevertheless, there was no obvious nesting in the dermis of the satellite nevus. The nevus cells are usually distributed band-like in the upper dermis; hyperplasia of melanocytes in the basal layer of the epidermis could also be seen with shouldering and severe pigmentation. Histologically, the satellite nevus adjacent to the primary nevus showed similar pathological changes with the primary lesions, while the distant satellite nevus showed remarkable differences in pathological features.

From the analysis of the differences and correlations in pathological features between GCMN and satellite nevi, we could infer the histopathological origin of GCMN and its satellite nevi. "Satellite nevus" is a melanocytic nevus; it may occur as a single genetic event due to the different pathological features that we observed. According to Kinsler et al, the size of CMN is related to its occurring time, and the number of CMN depends on the genetic susceptibility, multiple CMNs exist at the same time or GCMN occurs with a highly related "satellite", which are all independent and have a high genetic susceptibility. It was emphasized that the number and size of "satellites" have clinical significance in predicting the risk of complications.<sup>20</sup> Pathologically, a small nevus in the distance cannot be categorized as a "satellite" nevus, which is more like AMN or occurs later than the main nevus. It just presented as genetic susceptibility of nevus in an individual.

Nonetheless, our research has the following limitations: (1) The small sample size limits the interpretation of the histological difference between GCMN and satellite nevi in generalization. (2) Further molecular or immunohistochemical data are required to confirm our findings visually, explore the potential mechanism, and make a more clear definition of satellite nevus. To investigate the relevance between the clinical features and pathological specificity of GCMN, we will collect more clinical follow-up information.

## 5 | CONCLUSION

After identifying and analyzing the histopathological differences between GCMN and its satellite nevus by cluster model and directly showing them in the heatmap, we discovered that the satellite nevus is heterogeneity and inferred that it might appear later than the main nevus. In addition, our study provided a methodological reference for a pathological model of this rare superficial neoplasm disease.

## AUTHOR CONTRIBUTIONS

Wei Chen and Xuewei Jiang had full access to all of the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis. Qun Zhang and Wei Cai were involved in the study concepts and design. All authors were involved in the acquisition, analysis, and interpretation of data. Wei Chen, Xuewei

Jiang, and Nan Chen finished the analysis and drafted the manuscript. All authors read, critically revised, and approved the manuscript. All the named authors meet the International Committee of Medical Journal Editors (ICMJE) criteria for authorship for this article and take responsibility for the integrity of the work as a whole and have given their approval for this version to be published.

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No funding was received for the work presented in this article.

## CONFLICT OF INTEREST STATEMENT

This study has no competing financial interests exist.

## DATA AVAILABILITY STATEMENT

The datasets generated and/or analyzed during the current study are not publicly available due to privacy and ethics but are available from the corresponding author on reasonable request.

## ETHICS STATEMENT

This study was approved by the Ethics Committee of Shanghai Ninth People's Hospital and have been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

## CONSENT

Informed consent was obtained from all individual participants included in the study.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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