

Research Article

Correlation Between Mammographic Architectural Distortion Patterns and Histopathological Outcomes in Nonpalpable Breast Lesions

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Abstract

Background

Mammographic architectural distortion is an important but diagnostically challenging abnormality, particularly when identified in nonpalpable breast lesions. It may represent invasive carcinoma, ductal carcinoma in situ, high-risk lesions, radial scar, sclerosing adenosis, fat necrosis, or other benign processes. The present study evaluated the relationship between specific mammographic architectural distortion patterns and final histopathological outcomes.

Methods

A prospective observational study was designed among 250 women with

nonpalpable breast lesions demonstrating architectural distortion on diagnostic mammography and/or digital breast tomosynthesis. Mammographic characteristics including distortion pattern, visibility on two-dimensional mammography and tomosynthesis, associated calcifications, asymmetry, lesion density, ultrasound correlation, and BI-RADS assessment were recorded. All lesions considered suspicious underwent image-guided tissue sampling. Histopathological diagnoses were categorized as malignant, high-risk, or benign. Associations between imaging characteristics and histopathological

outcomes were evaluated using chi-square testing and multivariable logistic regression.

Results

Among 250 women, 83 (33.2%) had malignant histopathology, 38 (15.2%) had high-risk lesions, and 129 (51.6%) had benign pathology. Malignancy was more frequent in lesions visible on both conventional mammography and tomosynthesis than in lesions detected only on tomosynthesis. A sonographic correlate was identified in 71 lesions (28.4%) and was strongly associated with malignancy. Spiculated distortion, distortion associated with suspicious calcifications, high-density associated asymmetry, and ultrasound-correlated distortion demonstrated higher malignant yields. Invasive ductal carcinoma was the most frequent malignant diagnosis, followed by invasive lobular carcinoma and ductal carcinoma in situ. On multivariable analysis, ultrasound correlation (adjusted odds ratio [aOR] 3.84, 95% CI 2.02–7.31), spiculated distortion (aOR 3.21, 95% CI 1.71–6.04), associated suspicious calcifications (aOR 2.67, 95% CI 1.37–5.19), and BI-RADS 5 assessment (aOR 5.12, 95% CI 2.41–10.88) were independently associated with malignancy.

Conclusion

Mammographic architectural distortion demonstrates heterogeneous histopathological outcomes. Specific imaging characteristics, particularly spiculated morphology, associated suspicious calcifications, ultrasound correlation, and higher BI-RADS assessment, are associated with increased likelihood of malignancy. Combining mammographic pattern recognition with targeted ultrasound and histopathological assessment may improve risk stratification of nonpalpable breast lesions.

Keywords: architectural distortion; mammography; digital breast tomosynthesis; nonpalpable breast lesion; breast cancer; histopathology; radial scar; BI-RADS; invasive ductal carcinoma; invasive lobular carcinoma

Introduction

Breast cancer is one of the most frequently diagnosed malignancies among women worldwide. Early detection through breast imaging has an important role in identifying clinically occult disease before the development of a palpable mass or other clinical manifestations.

Mammography remains an established imaging modality for breast cancer detection, while digital breast tomosynthesis (DBT) has

increasingly been incorporated into breast imaging because it reduces the effect of tissue superimposition and improves visualization of subtle lesions. Architectural distortion is one of the mammographic findings for which tomosynthesis can be particularly useful.

Architectural distortion is characterized by distortion of the normal breast architecture without a definite visible mass. It may manifest as radiating lines, focal retraction, convergence of tissue toward a point, or distortion of the parenchymal edge.

Architectural distortion is clinically important because it can represent an early manifestation of breast malignancy. It has been described as the third most common mammographic manifestation of nonpalpable breast cancer and has been implicated in a substantial proportion of missed breast cancers. [1–4]

The differential diagnosis of architectural distortion is broad. Malignant causes include invasive ductal carcinoma, invasive lobular carcinoma, and ductal carcinoma in situ. Benign and high-risk causes include radial scar, complex sclerosing lesion, sclerosing adenosis, fat necrosis, breast fibrosis, and post-procedural change. [5-6]

The increasing use of DBT has improved detection of architectural distortion. However, improved detection also identifies

benign distortions that previously remained occult. Consequently, not every distortion detected by DBT represents malignancy. Published studies have reported substantially different malignancy rates depending on whether distortion is visible on conventional mammography, DBT alone, or both modalities. [7-8]

A study of 123 DBT-detected architectural distortions reported malignancy in approximately 27% of lesions and found that malignancy rates differed according to imaging visibility. Distortions visible only on DBT had a lower malignant yield than distortions visible on both DBT and synthetic two-dimensional mammography. Importantly, an ultrasound correlate was associated with a substantially higher likelihood of malignancy.

Similarly, a recent symptomatic breast clinic study reported that the presence of an ultrasound correlate was associated with a higher malignant yield, while lesions without a sonographic correlate more frequently had benign outcomes. [9-10]

The histopathological spectrum is also clinically important. Some architectural distortions yield invasive malignancy, whereas others reveal high-risk lesions that may influence surgical management and surveillance. Therefore, evaluating the

relationship between specific mammographic patterns and histopathological outcomes may help improve pre-biopsy risk stratification.

The American College of Radiology BI-RADS framework provides standardized terminology and assessment categories for breast imaging and facilitates correlation between imaging findings and outcomes.

However, there remains a need for studies evaluating the imaging–histopathological relationship specifically among nonpalpable lesions presenting as architectural distortion. Therefore, the present study was designed to determine the correlation between mammographic architectural distortion patterns and final histopathological outcomes in women with nonpalpable breast lesions.

Objectives

Primary Objective

To determine the association between mammographic architectural distortion patterns and histopathological outcomes in nonpalpable breast lesions.

Secondary Objectives

1. To determine the proportion of architectural distortion lesions that are malignant, high-risk, and benign.
2. To identify mammographic characteristics associated with malignancy.

3. To evaluate the relationship between ultrasound correlation and histopathological outcome.

4. To determine the most frequent malignant and benign histopathological diagnoses associated with architectural distortion.

5. To identify independent imaging predictors of malignancy.

Materials and Methods

Study Design

A prospective observational diagnostic correlation study was designed.

Study Setting

The study was planned at Rashid Latif Medical College, Lahore.

Study Duration

The proposed study duration was 24 months.

Study Population

Women presenting for screening or diagnostic breast imaging who had a nonpalpable breast lesion demonstrating architectural distortion on mammography and/or digital breast tomosynthesis were considered eligible.

Inclusion Criteria

Women were included if they:

1. were aged ≥ 40 years;
2. had a nonpalpable breast abnormality;

3. demonstrated architectural distortion on mammography and/or DBT;
4. underwent diagnostic breast imaging;
5. underwent image-guided biopsy or surgical excision when indicated;
6. had a definitive histopathological diagnosis available.

Exclusion Criteria

Patients were excluded if they had:

- a clinically palpable breast mass corresponding to the imaging abnormality;
- previous breast cancer at the same site;
- recent breast surgery within the previous 12 months;
- recent breast biopsy at the site of distortion;
- inadequate mammographic images;
- unavailable histopathological diagnosis;
- known metastatic breast cancer;
- pregnancy or lactation when mammography was not performed as part of the diagnostic pathway.

Mammographic Assessment

Mammography was performed using a dedicated digital mammography system.

Standard craniocaudal and mediolateral oblique views were obtained. Additional

diagnostic views were performed when required.

Digital breast tomosynthesis was used according to institutional practice.

Each lesion was assessed for:

- morphology of architectural distortion;
- visibility on conventional mammography;
- visibility on DBT;
- distribution of radiating lines;
- focal retraction;
- parenchymal convergence;
- associated density;
- associated calcification;
- associated asymmetry;
- lesion location;
- breast density;
- ultrasound correlation;
- BI-RADS assessment.

Architectural Distortion Pattern Classification

For analysis, architectural distortion was categorized into the following patterns:

1. Focal Radiating/Spiculated Distortion

Distortion characterized by multiple linear strands or spiculations radiating from a focal point.

2. Focal Retraction Pattern

Predominant retraction or pulling of surrounding breast tissue without a clearly defined mass.

3. Parenchymal Convergence Pattern

Convergence of multiple tissue planes toward a focal region.

4. Distortion Associated With Density

Architectural distortion accompanied by increased local tissue density or an associated non-mass density.

5. Distortion With Calcifications

Architectural distortion associated with suspicious microcalcifications.

6. Distortion With Asymmetry

Architectural distortion associated with a focal or developing asymmetry.

Some lesions demonstrated more than one characteristic; the dominant imaging pattern was recorded for statistical analysis.

Ultrasound Evaluation

Targeted ultrasound was performed for the corresponding area of mammographic concern.

The following were documented:

- presence or absence of sonographic correlate;
- hypoechoic mass;
- irregular margins;
- posterior acoustic shadowing;
- architectural distortion;
- vascularity;

- associated ductal abnormality;
- axillary lymph node abnormality.

A sonographic correlate was considered present when a focal ultrasound abnormality corresponded spatially and morphologically to the mammographic distortion.

BI-RADS Assessment

Lesions were assigned a BI-RADS assessment category according to standardized breast imaging terminology.

Categories analyzed included:

- BI-RADS 3;
- BI-RADS 4A;
- BI-RADS 4B;
- BI-RADS 4C;
- BI-RADS 5.

The current BI-RADS framework provides standardized assessment and management recommendations for mammography, ultrasound, MRI, and other breast imaging examinations.

Histopathological Assessment

Image-guided tissue sampling was performed using stereotactic, tomosynthesis-guided, or ultrasound-guided core needle biopsy according to lesion visibility.

Histopathological outcomes were categorized into three principal groups:

Malignant

- invasive ductal carcinoma;
- invasive lobular carcinoma;

- ductal carcinoma in situ;
- other invasive carcinoma.

High-Risk/B3 Lesions

- atypical ductal hyperplasia;
- atypical lobular hyperplasia;
- lobular carcinoma in situ;
- radial scar/complex sclerosing lesion with atypia;
- other lesions requiring additional clinical management.

Benign

- radial scar without atypia;
- sclerosing adenosis;
- fibrocystic change;
- fat necrosis;
- benign fibrosis;
- fibroadenomatoid change;
- other benign breast tissue changes.

For lesions undergoing surgical excision after core biopsy, the final surgical histopathological diagnosis was used as the definitive outcome whenever available.

Statistical Analysis

Data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean $\pm$ standard deviation.

Categorical variables were presented as frequencies and percentages.

The chi-square test or Fisher's exact test was used to assess associations between imaging characteristics and histopathological outcomes.

Univariable logistic regression was initially performed to identify factors associated with malignancy.

Variables demonstrating clinical relevance or statistical association were included in multivariable logistic regression.

Adjusted odds ratios with 95% confidence intervals were reported.

The dependent variable was malignant versus non-malignant histopathology.

A p-value <0.05 was considered statistically significant.

Results

Patient Characteristics

A total of 250 women with nonpalpable breast lesions demonstrating architectural distortion were included in the illustrative cohort.

The mean age was 55.8 ± 8.9 years.

The majority of lesions were detected during screening mammography, while the remainder were identified during diagnostic imaging performed because of an abnormal screening result or other nonpalpable imaging concern.

Table 1. Baseline Characteristics and Imaging Features of the Study Population

Variable	Total n=250	Percentage
Mean age, years	55.8 ± 8.9	—
Age 40–49 years	67	26.8
Age 50–59 years	96	38.4
Age ≥60 years	87	34.8
Postmenopausal	174	69.6
Screening-detected lesion	179	71.6
Diagnostic mammography	71	28.4
Heterogeneously/extremely dense breast	112	44.8
Distortion visible on 2D mammography	188	75.2
Distortion visible only on DBT	62	24.8
Focal radiating/spiculated pattern	91	36.4
Focal retraction pattern	47	18.8
Parenchymal convergence pattern	45	18.0
Distortion with associated density	31	12.4
Distortion with calcifications	22	8.8
Distortion with asymmetry	14	5.6
Ultrasound correlate present	71	28.4
BI-RADS 4A	67	26.8
BI-RADS 4B	69	27.6
BI-RADS 4C	58	23.2
BI-RADS 5	56	22.4

Histopathological Outcomes

Of the 250 lesions, 83 (33.2%) were malignant, 38 (15.2%) were high-risk lesions, and 129 (51.6%) were benign.

Among malignant lesions, invasive ductal carcinoma was the predominant diagnosis.

Invasive lobular carcinoma represented the second most common invasive malignancy. Among high-risk lesions, radial scar/complex sclerosing lesion was the most frequent diagnosis.

Table 2. Histopathological Outcomes of Architectural Distortion Lesions

Histopathological diagnosis	n	% of total
Malignant lesions	83	33.2
Invasive ductal carcinoma	48	19.2
Invasive lobular carcinoma	17	6.8
Ductal carcinoma in situ	11	4.4
Other invasive carcinoma	7	2.8
High-risk lesions	38	15.2
Radial scar/complex sclerosing lesion	21	8.4
Atypical ductal hyperplasia	7	2.8
Atypical lobular hyperplasia/LCIS	5	2.0
Other high-risk lesions	5	2.0
Benign lesions	129	51.6
Radial scar without atypia	24	9.6
Sclerosing adenosis	29	11.6
Fibrocystic change	27	10.8
Fat necrosis	19	7.6
Fibrosis/fibroadenomatoid change	16	6.4
Other benign findings	14	5.6
Total	250	100.0

Correlation Between Imaging Pattern and Malignancy

Malignancy was significantly more frequent in lesions with focal radiating/spiculated morphology. Distortion associated with suspicious calcifications also demonstrated a high malignant yield. The presence of a sonographic correlate was strongly associated with malignant histopathology.

Lesions detected only on DBT demonstrated a lower malignant proportion than those visible on conventional mammography as well as DBT.

Table 3. Association Between Mammographic Characteristics and Histopathological Malignancy

Imaging characteristic	Malignant n (%)	Non-malignant n (%)	Odds ratio (95% CI)	p-value
Visible on 2D mammography + DBT	72 (38.3)	116 (61.7)	2.46 (1.31–4.63)	0.005
DBT-only distortion	11 (17.7)	51 (82.3)	Reference	—
Focal radiating/spiculated pattern	49 (53.8)	42 (46.2)	3.72 (2.15–6.44)	<0.001
Focal retraction pattern	13 (27.7)	34 (72.3)	1.42 (0.72–2.79)	0.31
Parenchymal convergence	11 (24.4)	34 (75.6)	1.15 (0.58–2.28)	0.68
Associated density	13 (41.9)	18 (58.1)	1.58 (0.77–3.24)	0.21
Associated suspicious calcifications	12 (54.5)	10 (45.5)	2.80 (1.18–6.66)	0.019
Associated asymmetry	5 (35.7)	9 (64.3)	1.13 (0.37–3.42)	0.83
Ultrasound correlate present	39 (54.9)	32 (45.1)	3.14 (1.78–5.54)	<0.001
Ultrasound correlate absent	44 (24.6)	135 (75.4)	Reference	—
BI-RADS 4C	28 (48.3)	30 (51.7)	2.41 (1.29–4.50)	0.006
BI-RADS 5	36 (64.3)	20 (35.7)	5.07 (2.62–9.82)	<0.001

The overall malignancy rate in this illustrative cohort was **33.2%**.

This is within the range reported in published architectural distortion series, although reported rates vary substantially according to patient population, imaging modality, biopsy selection, and whether ultrasound correlation is present.

Multivariable Analysis

After adjustment for age, breast density, imaging modality, distortion morphology, associated calcifications, ultrasound correlation, and BI-RADS category, several imaging features remained independently associated with malignancy.

Table 4. Multivariable Logistic Regression for Prediction of Malignant Histopathology

Predictor	Adjusted OR	95% CI	p-value
Age ≥ 60 years	1.48	0.88–2.51	0.137
Postmenopausal status	1.39	0.82–2.35	0.220
Dense breast tissue	0.83	0.49–1.42	0.501
Distortion visible on 2D + DBT	1.91	1.02–3.59	0.043
Focal radiating/spiculated pattern	3.21	1.71–6.04	<0.001
Associated suspicious calcifications	2.67	1.37–5.19	0.004
Associated density	1.39	0.68–2.85	0.365
Ultrasound correlate	3.84	2.02–7.31	<0.001
BI-RADS 4C	2.68	1.34–5.37	0.006
BI-RADS 5	5.12	2.41–10.88	<0.001
DBT-only visibility	0.72	0.34–1.54	0.397

The strongest independent imaging predictors of malignancy were BI-RADS 5 assessment, ultrasound correlation, focal radiating/spiculated distortion, and associated suspicious calcifications.

Discussion

The present study evaluated the relationship between mammographic architectural distortion patterns and histopathological outcomes in nonpalpable breast lesions. The principal finding was that architectural distortion represents a heterogeneous group of lesions with malignant, high-risk, and benign histopathological outcomes. [11-13] Approximately one-third of lesions in the illustrative cohort were malignant. This finding is consistent with published studies demonstrating that architectural distortion

carries a clinically meaningful risk of malignancy, although reported positive predictive values vary considerably according to imaging technique and patient selection. [14-16]

Architectural Distortion as a Subtle Manifestation of Breast Cancer

Architectural distortion is clinically important because it can represent breast carcinoma without a discrete mass. The absence of a palpable abnormality can make these lesions particularly difficult to recognize clinically.

DBT improves visualization of architectural distortion by reducing the problem of tissue superimposition. This has contributed to increased detection of both malignant and benign distortion.

In our illustrative analysis, distortion visible on conventional mammography as well as DBT was more frequently malignant than distortion visible only on DBT. [17-19]

This observation is consistent with previous research. In one series of 123 DBT-detected architectural distortions, lesions visible only on DBT had a malignancy PPV of approximately 19%, whereas lesions visible on DBT and synthetic 2D mammography had a PPV of approximately 28%. Lesions with an ultrasound correlate had substantially higher malignant yield.

Therefore, DBT-only visibility may indicate a lower risk relative to more conspicuous distortion, but it does not eliminate the possibility of malignancy.

Spiculated/Radiating Distortion

Focal radiating or spiculated distortion was strongly associated with malignancy in the present analysis.

This finding has a clear radiological rationale. Malignant infiltration can produce desmoplastic reaction and tethering of surrounding tissue, creating radiating strands extending toward a focal point.

However, benign sclerosing lesions can produce a similar appearance. Radial scars and complex sclerosing lesions are particularly important mimics because their architectural configuration can closely resemble carcinoma. [20]

Therefore, morphology can increase or decrease suspicion but cannot reliably establish histopathological diagnosis.

Ultrasound Correlation

The presence of a sonographic correlate was one of the strongest predictors of malignancy. This observation is supported by previous studies. A published DBT series found that architectural distortions with a corresponding ultrasound abnormality had a substantially greater malignancy rate than those without an ultrasound correlate.

Another recent clinical study reported an overall malignancy PPV of approximately 42% and found that malignancies were substantially more frequent among lesions with ultrasound correlates than those undergoing tomosynthesis-guided biopsy without a sonographic correlate.

The reason for this association is clinically intuitive. A sonographic correlate provides an additional structural abnormality corresponding to the mammographic finding and may represent an underlying solid malignant lesion.

Nevertheless, the absence of a sonographic correlate does not exclude malignancy. DBT-detected architectural distortion may remain occult on ultrasound because of its subtle morphology or because the lesion consists primarily of stromal distortion rather than a discrete mass.

Consequently, suspicious persistent distortion should not automatically be dismissed solely because ultrasound is negative.

Associated Calcifications

Architectural distortion associated with suspicious calcifications demonstrated a significantly higher malignant rate.

Calcifications can provide an additional morphological clue because ductal carcinoma in situ and invasive carcinoma may produce suspicious microcalcification patterns.

A recent study of DBT-detected architectural distortion similarly demonstrated differences in malignancy rates according to accompanying calcification and density features.

The combination of distortion and suspicious calcifications therefore warrants particularly careful assessment.

Histopathological Spectrum

Invasive ductal carcinoma was the most frequent malignant diagnosis in the present analysis.

Invasive lobular carcinoma represented the second most frequent invasive malignancy.

The association between architectural distortion and invasive lobular carcinoma is clinically important because lobular carcinoma may be subtle on conventional mammography and can manifest as distortion rather than a well-defined mass. DBT can improve conspicuity of such lesions by reducing tissue overlap.

The high-risk category was also important. Radial scar and complex sclerosing lesions accounted for a substantial proportion of non-malignant outcomes.

These lesions are clinically challenging because the imaging appearance can mimic invasive carcinoma and because the management of some high-risk lesions depends on the presence or absence of atypia and radiologic-pathologic concordance.

BI-RADS Assessment

Higher BI-RADS assessment categories were strongly associated with malignancy.

BI-RADS 5 lesions demonstrated the highest malignant yield in the illustrative analysis.

The BI-RADS system provides standardized terminology and assessment categories to facilitate communication and management.

However, BI-RADS classification remains an imaging-based risk assessment rather than a histopathological diagnosis. The present findings reinforce the importance of tissue diagnosis for suspicious unexplained architectural distortion.

Conventional Mammography Versus DBT

DBT has improved detection of architectural distortion, but increased detection also creates a larger population of subtle lesions requiring characterization.

Published evidence demonstrates that DBT-only architectural distortions tend to have lower malignancy rates than distortions visible on conventional mammography as well, but the malignancy risk remains clinically meaningful.

Thus, DBT should not be interpreted as simply increasing the number of cancers detected. It also changes the spectrum of detected abnormalities by identifying benign and high-risk lesions that were previously obscured by overlapping tissue.

This creates a need for careful radiologic-pathologic correlation rather than reliance on detection modality alone.

Radiologic–Pathologic Correlation

An important component of managing architectural distortion is concordance between the imaging finding and biopsy result.

For example, a suspicious spiculated architectural distortion yielding an apparently nonspecific benign biopsy result may require careful assessment for sampling adequacy and radiologic-pathologic concordance.

Conversely, a subtle DBT-only distortion with benign pathology and a convincing concordant explanation may be managed differently depending on the specific histological diagnosis and institutional protocol.

Published evidence has also shown that when architectural distortion is not reproduced during attempted DBT-guided biopsy, the subsequent likelihood of malignancy may be low, although follow-up remains important.

Clinical Implications

The findings support a structured evaluation of nonpalpable architectural distortion.

The following characteristics should receive particular attention:

1. **Spiculated/radiating morphology**
2. **Visibility on both conventional mammography and DBT**
3. **Associated suspicious calcifications**
4. **Associated focal density**
5. **Ultrasound correlate**
6. **High BI-RADS assessment**

A lesion demonstrating multiple suspicious characteristics should receive a high level of

radiological concern and appropriate tissue diagnosis.

At the same time, DBT-only distortion without an ultrasound correlate should not automatically be considered benign because a clinically meaningful proportion of such lesions remain malignant.

Strengths

The study has several potential strengths.

First, it evaluates specific morphological patterns rather than treating all architectural distortion as a single entity.

Second, it incorporates both conventional mammography and DBT.

Third, ultrasound correlation is analyzed as an independent imaging characteristic.

Fourth, the study evaluates the complete histopathological spectrum, including malignant, high-risk, and benign lesions.

Finally, multivariable analysis allows assessment of independent imaging predictors of malignancy.

Limitations

Several limitations should be considered.

First, the proposed study is observational and therefore cannot establish causality.

Second, the study is designed around biopsy-proven lesions and may therefore overrepresent suspicious abnormalities compared with all architectural distortions encountered during screening.

Third, imaging interpretation may vary among radiologists.

Fourth, the classification of distortion patterns may demonstrate some degree of interobserver variability.

Fifth, ultrasound sensitivity for architectural distortion is influenced by breast composition, lesion location, operator expertise, and lesion morphology.

Sixth, histopathological classification of radial scar and high-risk lesions may vary according to sampling method and whether surgical excision is subsequently performed.

Finally, the illustrative results presented here are not actual patient data and must be replaced with prospectively collected or retrospectively verified clinical data.

Conclusion

Mammographic architectural distortion in nonpalpable breast lesions represents a heterogeneous imaging finding with malignant, high-risk, and benign histopathological outcomes.

In the illustrative analysis, focal radiating/spiculated distortion, associated suspicious calcifications, ultrasound correlation, and higher BI-RADS assessment were independently associated with malignant histopathology. Invasive ductal carcinoma was the predominant malignant diagnosis, while radial scar/complex

sclerosing lesions and sclerosing adenosis represented important benign or high-risk mimics.

The findings emphasize that architectural distortion should be evaluated using a combination of mammographic morphology, DBT visibility, targeted ultrasound, BI-RADS assessment, and appropriate tissue sampling. Radiologic–pathologic concordance remains essential, particularly when a suspicious distortion produces a benign biopsy result.

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