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Original Research Article

Diagnostic Accuracy of Tzanakis and Alvarado Scoring Systems Relative to Open Surgery, Ultrasonographic and Histopathological Diagnosis for Acute Appendicitis: A Prospective Observational Study

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Conflict of interest: Nil

Abstract

Background: Acute Appendicitis is a common surgical emergency. Clinical scores may standardize assessment, but their performance varies by setting and threshold. This study compares Tzanakis and Alvarado Scores against Histopathology(HPE).

Methods: Aggregate data for 200 patients, aged 18-75 years, and both sexes were analyzed. Histopathology (HPE) was treated as the reference standard.

Results: Tzanakis ≥8 showed sensitivity 59.09%, specificity 100.00%, PPV 100.00%, NPV 42.20% and accuracy 68.50%. Provisional Alvarado ≥7 results were 53.25%, 73.91%, 87.23%, 32.08% and 58.00%, respectively. Single-threshold AUC approximations were 0.795 and 0.636.The association between Alvarado Score classification and HPE findings was statistically significant ($p = 0.003$).The association between Tzanakis Score classification and HPE findings was statistically significant (Fisher's exact, $p < 0.001$).

Conclusion: Regarding sensitivity, PPV, NPV and diagnostic accuracy, Tzanaki's Score was better. To improve clinical judgment in the precise diagnosis of Acute Appendicitis and to reduce the morbidity, this research supports the use of Tzanaki's Scoring. Tzanakis Scored higher than Alvarado in the current study.

Keywords: Acute Appendicitis; Tzanakis Score; Alvarado Score; Histopathology(HPE); Diagnostic Accuracy; ROC.

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Introduction

Acute Appendicitis is one of the most common causes of acute abdominal pain requiring emergency surgical assessment. Early and accurate diagnosis is important because delayed treatment may lead to complications such as perforation, abscess formation and peritonitis, whereas unnecessary surgery exposes patients to avoidable operative risks, healthcare costs and recovery time. Despite advances in diagnostic imaging and laboratory investigations, diagnosing acute appendicitis can remain challenging because its clinical presentation varies with age, appendix position, disease stage and individual patient characteristics. A combination of clinical assessment, laboratory findings and imaging is therefore commonly used to improve diagnostic confidence and guide management [1,2].

The diagnosis of Acute Appendicitis is based on a careful history and physical examination, supported by investigations such as the complete blood count, inflammatory markers and abdominal imaging. However, individual clinical findings are not sufficiently reliable in every patient and the diagnostic performance of investigations may vary according to local resources, operator expertise and the stage of inflammation. Ultrasonography (USG) is a widely used initial imaging modality because it is non-invasive, does not involve ionising radiation, and can demonstrate features suggestive of Appendiceal inflammation. Nevertheless, its accuracy may be affected by body habitus, bowel gas, appendix position and the experience of the operator. Imaging findings should therefore be interpreted alongside the clinical assessment rather than in isolation [1,2].

Clinical scoring systems have been developed to combine symptoms, signs and laboratory parameters into a structured assessment. These systems may help clinicians stratify patients according to the likelihood of Appendicitis, identify individuals who require further imaging or observation and support decisions regarding surgical intervention. Several scoring systems have been described, including the Alvarado Score, Appendicitis Inflammatory Response (AIR) score, and other diagnostic models. Their usefulness depends on the population in which they are applied, the selected diagnostic threshold and the accuracy of the reference standard used to establish the final diagnosis [3,4]. The Alvarado Score is one of the most widely recognised clinical scoring systems for suspected Acute Appendicitis. It incorporates symptoms, clinical signs and laboratory findings into a numerical score intended to estimate the probability of the disease. Its simplicity and limited resource requirements make it attractive for use in emergency departments and settings where advanced imaging may not be readily available. Published studies have evaluated its diagnostic performance and its potential role in reducing unnecessary Appendectomy. However, sensitivity and specificity vary across studies and the score may perform differently in different patient populations. Consequently, the Alvarado Score should be interpreted as a clinical decision-support tool rather than a definitive substitute for clinical judgement, imaging or histopathological confirmation [5–7].

The Tzanakis Scoring System combines clinical assessment with Ultrasonographic findings and the white blood cell count. By incorporating imaging into a composite score, it aims to improve diagnostic discrimination compared with assessment based solely on clinical findings. The original description of the system and subsequent comparative studies have investigated its ability to identify Acute Appendicitis and its potential value in selecting patients for surgery [2,8–12]. However, reported performance varies according to study design, patient selection, the threshold used to define a positive result and the prevalence of Appendicitis in the study population. These differences make direct comparisons between studies difficult and emphasise the importance of evaluating both scoring systems against the same reference standard.

Several studies have directly compared the Tzanakis and Alvarado Scoring Systems in patients presenting with suspected Acute Appendicitis. Such comparisons are clinically relevant because the systems use different combinations of diagnostic information: the Alvarado Score primarily relies on symptoms, signs and laboratory findings, whereas the Tzanakis Score also incorporates Ultrasonographic assessment. Comparative investigations have explored their diagnostic accuracy and potential usefulness in guiding management [8–18]. Nevertheless, results from individual studies should be interpreted in the context of their sample sizes, study populations, scoring thresholds and methods of confirming Appendicitis. Differences in these factors may explain variation in reported sensitivity, specificity, positive predictive value and negative predictive value. Other scoring systems have also been examined as alternatives or complements to the Alvarado Score. Research evaluating the AIR Score and the RIPASA Score illustrates the broader effort to improve risk stratification and support clinical decision-making in suspected Appendicitis [4,20,21]. Studies have also considered the performance of scoring systems across different age groups, highlighting the importance of assessing whether a diagnostic tool remains reliable in populations with different clinical characteristics [19]. Evidence concerning the Alvarado Score from additional clinical settings further reinforces the need to assess each scoring system within the population in which it is intended to be used [22].

Although previous research has examined these scoring systems, their reported diagnostic performance is not uniform across settings. Differences in the availability and quality of Ultrasonography, patient demographics, clinical presentation and thresholds used to define a positive score may influence the results. Furthermore, comparisons are most informative when both scoring systems are evaluated in the same patients against a consistent reference standard, preferably histopathological examination (HPE) in patients who undergo Appendectomy.

Such an approach allows the diagnostic performance of each system to be assessed within the same clinical cohort.

Tzanakis and Alvarado Scoring Systems were used in 200 patients evaluated for suspected Acute Appendicitis, using histopathological examination as the reference standard.

The study assessed and compared their sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy at the specified scoring thresholds. The findings may help clarify the relative diagnostic utility of these scoring systems in the study population and contribute to evidence-based decision-making in the assessment of suspected Acute Appendicitis.

Aim and Objectives:

Aim: To compare Tzanakis and Alvarado diagnostic performance against Histopathology(HPE).

- Describe demographic characteristics and Appendix Position.
- Calculate diagnostic indices at Tzanakis ≥8 and Alvarado ≥7.
- Compare point estimates of diagnostic performance.
- Report overall USG positivity.
- Explain the limits of ROC analysis using aggregate data.

Materials and Methods

Materials: This study was conducted in the Department of General Surgery, Dr. KNS Memorial Institute of Medical Sciences, Gadia, Barabanki, UP, India. It was Prospective Observational Study. 200 USG positive patients were included in this study. The study was conducted over a year between June 2024 to June 2026.

Index Tests and Reference Standard: Index tests were Tzanakis ≥8 and Alvarado ≥7. HPE was treated as the reference standard.

Inclusion Criteria:

- Patients aged 18 to 75 years, both sexes, diagnosed with Acute Appendicitis undergoing Open Appendectomy during the study period
- Patient willing to participate and give consent for the research

Exclusion Criteria:

- The patient not willing for surgery.
- Appendicular mass.
- Peritonitis secondary to Appendicular perforation

Ethical clearance: Ethical clearance was obtained from Institutional Ethics Committee on 27/05/2024,

Methods

- Informed consent was taken prior to the study
- At the time of admission, each patient had undergone a comprehensive history and a thorough clinical examination and recorded on preformed profoma.
- Relevant investigations were done
- USG Abdomen and pelvis done on admission.
- Prior to surgery and at the time of admission, each patient was administered both the Tzanaki Score and the Alvarado Score.
- Surgery was performed on patients whose scores were below the cutoff points based on clinical judgment and assessment.
- Patients underwent an Open Appendectomy.
- The final diagnosis was validated by the pathologist's Histopathological Examination (HPE) of the specimen.
- The data was compared between the two score systems' diagnostic accuracy for Acute Appendicitis.

Sonographic Criteria for Appendicitis:

- Appendix non-compressible with AP diameter greater than 6 mm
- Hyperechoic thickened Appendix wall > 2 mm— target sign.
- Appendicolith presence.
- Discontinuity of the sub-mucosal layer.
- “Peri-Appendicular” fluid.

Statistical Analysis: Excel and SPSS software version 26.2 were used for data analysis.

A frequency table was used to present categorical variables. The form for continuous variables was Mean ± SD/Median (Min, Max). The applicability of the Tzanakis Score and Alvarado Score to predict Acute Appendicitis is checked by Logistic regression and Receiver Operating Characteristic (ROC) curves. By simultaneously maximizing the sensitivity and specificity, cutoff values are determined. Statistical significance is indicated by a P-value of 0.05 or less.

Results

Aggregate data for 200 patients, aged 18-75 years and both sexes were analyzed. Out of 200 subjects, 88 (44.00%) were female and 112 (56.00%) were male (Table-1, Figure-1 & 2)

Table 1: Demographic characteristics of study subjects

Variable	Category	n	%
Sex	Male	112	56.0
	Female	88	44.0
Age (years)	18–20	23	11.5
	21–30	81	40.5
	31–40	25	12.5
	41–50	58	29.0
	51–60	9	4.5
	61–75	4	2.0

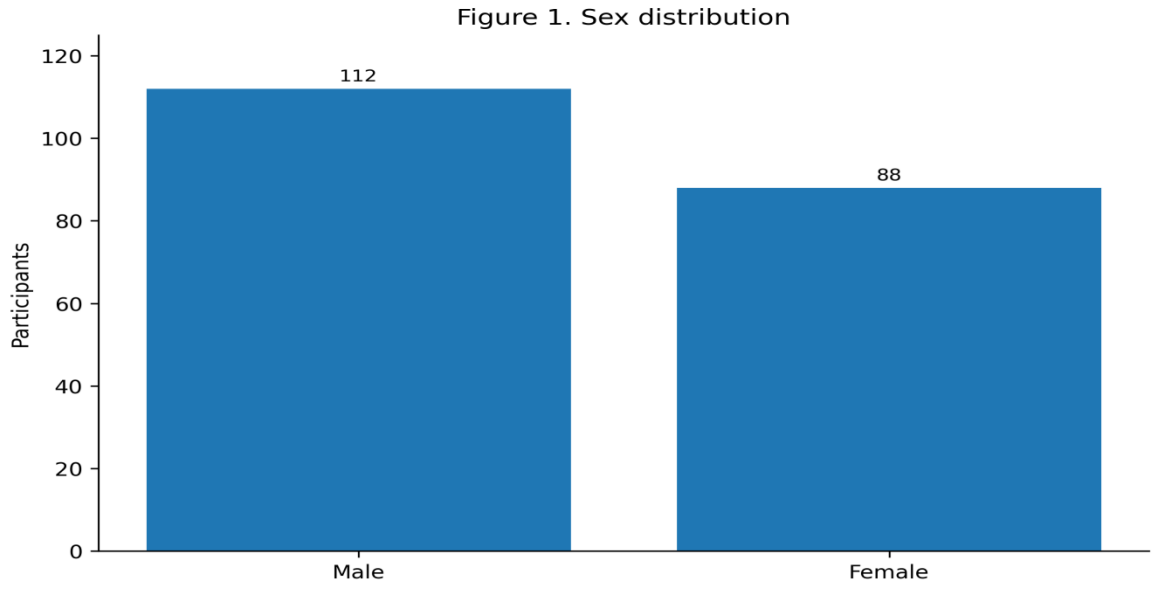


Figure 1: Sex distribution

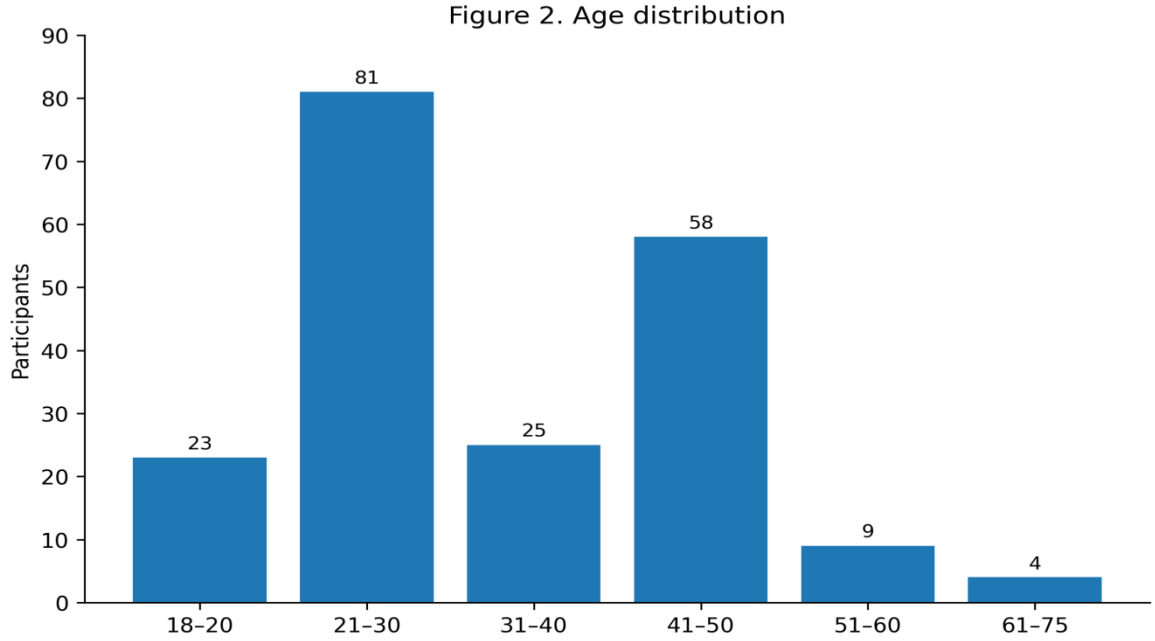


Figure 2: Age distribution

Appendix Position and Ultrasonography: Retrocaecal position was most common (54.0%), followed by pelvic (44.0%) and subcaecal (2.0%).

Table 2: Appendix Position

Appendix Position	n	%
Retrocaecal	108	54.0
Pelvic	88	44.0
Subcaecal	4	2.0

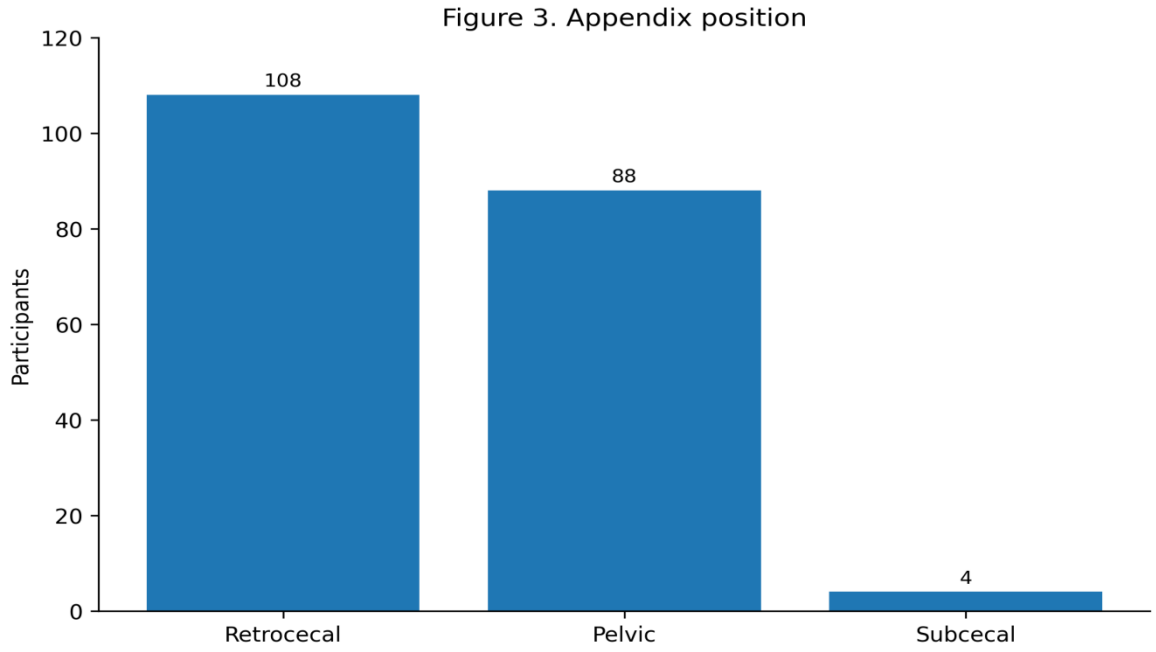


Figure 3: Appendix position

Out of 200 (100%) subjects, 200 (100%) had Right lower quadrant tenderness, 67 (33.5%) had Rebound tenderness, 53 (26.5%) had Migratory right lower quadrant pain, 128 (64.00%) had Nausea/vomiting, 55 (27.5%) had Anorexia, 89 (44.5%) had Fever, 117 (58.5%) had Leucocytosis, 28 (14.00%) had Shift to left. It was observed that USG detected Appendicular inflammation in 159 (79.5%) subjects. 8 (4.00%) were not detected positive in USG.

Table 3: Ultrasonography Results

USG result	n	%
Positive	192	96.0
Negative	8	4.0

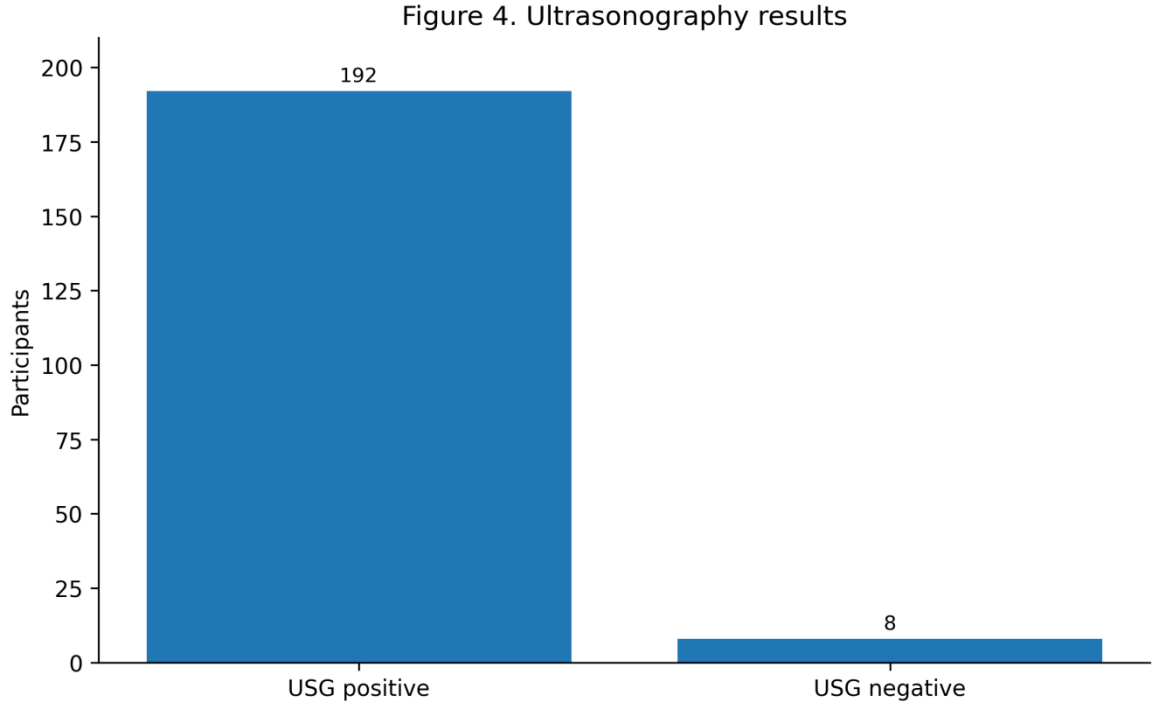


Figure 4: Ultrasonography results

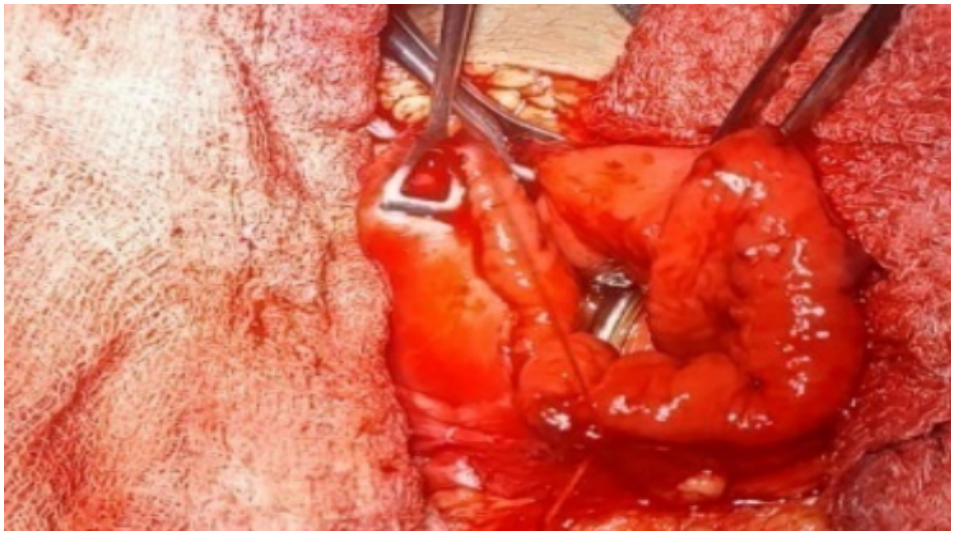


Figure 5: Showing inflamed Appendix during intra - operative Open Appendicectomy

Table 4: Tzanakis Score versus HPE

Tzanakis category	HPE +	HPE −	Total
≥8	91	0	91
<8	63	46	109
Total	154	46	200
(Fisher's exact): p-value			p < 0.001

Sensitivity 59.09% (95% CI 51.20–66.54%); specificity 100.00% (95% CI 92.29–100.00%); PPV 100.00% (95% CI 95.95–100.00%); NPV 42.20% (95% CI 33.35–51.58%); accuracy 68.50% (95% CI 61.77–74.54%). Zero false positives gives a 100% specificity point estimate but does not prove perfect population specificity. The association between Tzanakis Score classification and HPE findings was statistically significant (Fisher's exact, p < 0.001).

Table 5: Alvarado Score versus HPE — provisional reconciliation

Alvarado category	HPE +	HPE −	Total
≥7	82	12	94
<7	72	34	106
Total	154	46	200
p-value			0.003

Provisional sensitivity 53.25% (95% CI 45.38–60.95%); specificity 73.91% (95% CI 59.74–84.40%); PPV 87.23% (95% CI 79.00–92.54%); NPV 32.08% (95% CI 23.95–41.45%); accuracy 58.00% (95% CI 51.07–64.63%).The association between Alvarado Score classification and HPE findings was statistically significant (Pearson chi-square (x^2 =8.81\), p = 0.003).

Table 6: Comparative performance

Metric	Tzanakis ≥8	Alvarado ≥7
Sensitivity	59.09% (51.20–66.54%)	53.25% (45.38–60.95%)
Specificity	100.00% (92.29–100.00%)	73.91% (59.74–84.40%)
PPV	100.00% (95.95–100.00%)	87.23% (79.00–92.54%)
NPV	42.20% (33.35–51.58%)	32.08% (23.95–41.45%)
Accuracy	68.50% (61.77–74.54%)	58.00% (51.07–64.63%)
LR+	Not finite (zero false positives)	2.041
LR−	0.409	0.633
Single-threshold AUC	0.795	0.636
Association with HPE	p < 0.001*	p = 0.003†

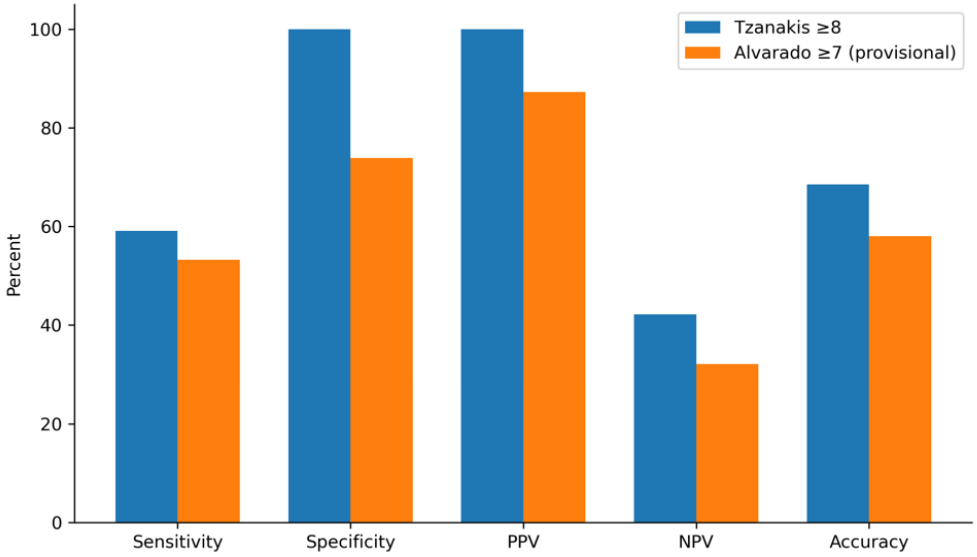


Figure 6: Diagnostic performance

Figure 6: Illustrated, Diagnostic performance; Alvarado estimates were provisional.

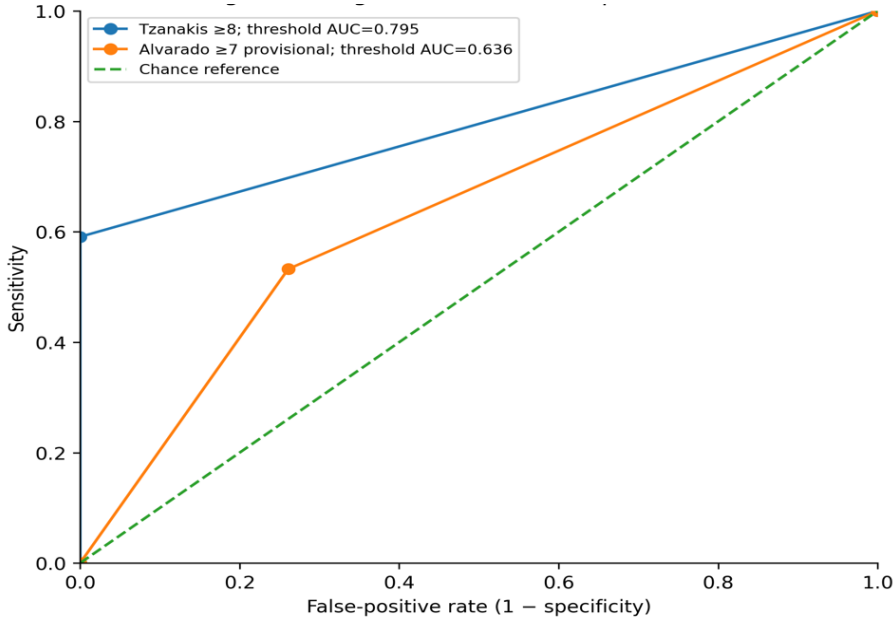


Figure 7: Single-threshold ROC representation

Discussion

Acute Appendicitis remains a common cause of acute abdominal pain requiring emergency surgical evaluation. Accurate diagnosis is essential to reduce delays in treatment and avoid unnecessary Appendectomy. Clinical scoring systems may support decision-making by combining symptoms, physical signs, laboratory parameters and in some systems, imaging findings. The present study compared the diagnostic performance of the Tzanakis and Alvarado Scoring Systems using Histopathological Examination (HPE) as the reference standard. Previous studies have also evaluated these systems as practical tools for the diagnosis of Acute Appendicitis, although their reported diagnostic performance varies between populations and clinical settings [2, 8–18]. The study included 200 patients, of whom 112 (56%) were male and 88 (44%) were female. The largest age group was 21–30 years, comprising 81 patients (40.5%), followed by the 41–50-year group, comprising 58 patients (29.0%).

This distribution demonstrates that a substantial proportion of the study population consisted of young and middle-aged adults. Age and clinical presentation can influence the performance of Appendicitis Scoring Systems and previous research has examined whether diagnostic accuracy varies across age groups [19]. However, the present aggregate data do not establish whether either scoring system performed differently according to age or sex; such conclusions would require subgroup-specific diagnostic analyses.

Regarding anatomical position, the Appendix was retrocaecal in 108 patients (54%), pelvic in 88 (44%) and subcaecal in 4 (2%). Appendix position may influence the clinical manifestations and the visibility of the Appendix on Ultrasonography. Imaging studies have highlighted the importance of technical factors and anatomical variation when evaluating suspected Appendicitis [1]. Ultrasonography was reported as positive in 192 patients (96%) and negative in 8 (4%). This high proportion of positive examinations suggests that Ultrasonography was quite supportive of the clinical diagnosis in this cohort. However, the proportion of positive scans alone does not establish diagnostic accuracy. Sensitivity, specificity and predictive values for Ultrasonography require a comparison of USG findings with HPE results for each patient. The role of imaging in Appendicitis assessment and the influence of operator and patient factors have been discussed in the imaging literature [1]. Consequently, the USG positivity rate should be interpreted as a descriptive finding rather than evidence that USG achieved 96% accuracy.

Diagnostic performance of the Tzanakis Scoring System: In the originally supplied Tzanakis table, 91 patients with HPE-positive findings had a score above 8, while 63 HPE-positive patients had a score below 8. No HPE-negative patients were classified as positive by this threshold, whereas 46 HPE-negative patients were classified as negative. Based on these counts, the sensitivity was 59.09%, specificity 100%, positive predictive value (PPV) 100%, negative predictive value (NPV) 42.20% and overall accuracy 68.50%.

The observed specificity of 100% indicates that no false-positive results occurred in this sample at the selected threshold. However, this estimate is based on only 46 HPE-negative patients and should not be interpreted as proof that the Tzanakis Score has perfect specificity in other populations. The relatively low sensitivity indicates that a substantial proportion of patients with histologically confirmed Appendicitis fell below the selected threshold. Similarly, the NPV of 42.20% suggests that a score below the threshold could not reliably exclude Appendicitis in this cohort.

The Tzanakis Scoring System incorporates Ultrasonographic findings alongside clinical and laboratory parameters. Its potential advantage is the inclusion of imaging information within a composite assessment. The original description of the system and subsequent comparative investigations have examined its usefulness in diagnosing Acute Appendicitis [2, 8–18]. However, its performance in the present study should be interpreted in light of the selected threshold, the high reported rate of positive Ultrasonography and the distribution of HPE findings. The results support further evaluation of the score using large sample size.

Diagnostic Performance of the Alvarado Scoring System: According to the originally supplied Alvarado table, 82 patients with HPE-positive findings had a score above 7, while 74 HPE-positive patients had a score below 7. Twelve HPE-negative patients were classified as positive and 32 were classified as negative. Based on these counts, the sensitivity was 52.56%, specificity 72.73%, PPV 87.23%, NPV 30.19% and overall accuracy 57.00%.

These results indicate moderate specificity but limited sensitivity at the stated threshold. The PPV was relatively high, whereas the NPV was low. A high PPV in this cohort means that most patients classified as positive by the score were HPE-positive; it does not necessarily mean that the score will have the same PPV in a population with a different prevalence of Appendicitis. Predictive values are influenced by disease prevalence, whereas sensitivity and specificity are also affected by case selection, diagnostic thresholds and study methods.

The Alvarado Score is a widely studied clinical tool that combines symptoms, physical signs and laboratory findings. Published investigations have evaluated its diagnostic accuracy and potential role in reducing unnecessary Appendectomy [5–7]. Other scoring systems, including the AIR and RIPASA scores, have also been assessed in efforts to improve diagnostic stratification [4, 20–22]. The findings of the present study are consistent with the broader need to interpret clinical scores in conjunction with the patient's presentation and appropriate investigations rather than as independent determinants of surgery.

Comparison Between the two Scoring Systems: The Tzanakis system had a higher calculated sensitivity than the Alvarado system (59.09% versus 52.56%), higher specificity (100% versus 72.73%), higher NPV (42.20% versus 30.19%), and higher overall accuracy (68.50% versus 57.00%). The PPV was also higher for Tzanakis (100% versus 87.23%). Descriptively, these results favour the Tzanakis threshold in this dataset. The association between Alvarado Score classification and HPE findings was statistically significant ($p = 0.003$).The association between Tzanakis Score classification and HPE findings was statistically significant (Fisher's exact, $p < 0.001$).

Previous comparative studies have investigated the Tzanakis and Alvarado Scoring Systems, but differences in study design, populations and scoring thresholds limit direct comparisons between their reported estimates [8–18]. In the present study, the observed differences should

therefore be treated as descriptive rather than as proof of statistically significant superiority.

Clinical Implications: The results highlight the importance of considering sensitivity and specificity together when interpreting a diagnostic score. A highly specific result can be useful for supporting a diagnosis when positive, but low sensitivity means that a negative result may fail to identify a considerable number of patients with Appendicitis. In clinical practice, scoring systems should be integrated with history, examination, laboratory results, imaging when appropriate and clinical reassessment. The choice of scoring system may also depend on the availability and quality of Ultrasonography and local clinical practice. Published studies of Appendicitis Scoring Systems support the importance of evaluating their performance within the population in which they are used [1, 4, 19–22].

Strengths and Limitations: An important strength of the study is the evaluation of two diagnostic scoring systems against histopathological examination, which provides a reference standard for patients who undergo Appendectomy. The inclusion of 200 patients also provides a descriptive basis for examining their performance within the study cohort. Several limitations should be acknowledged. The aggregate data do not permit adjustment for potential confounding factors or subgroup analysis by age, sex or Appendix position. The estimates obtained from a single cohort may not generalise to other clinical settings.

Conclusion

The Alvarado and Tzanaki Scores are compared in this study to see which is better for diagnosing Acute Appendicitis. Regarding sensitivity, PPV, NPV and diagnostic accuracy, Tzanaki's Score was better. To improve clinical judgment in the precise diagnosis of Acute Appendicitis and to reduce the morbidity, this research supports the use of Tzanaki's Scoring. Tzanakis Scored higher than Alvarado in the current study.

With a significant P value, the Tzanakis Score fared better than the Alvarado Score, showing superior sensitivity and specificity. According to this study, the Tzanakis Scoring System is a useful tool for the diagnosis of Acute Appendicitis.

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