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Original Article

Surgery Section

# Efficacy of Modified Alvarado Score versus Tzanakis Score in Diagnosing Acute Appendicitis: A Prospective Observational Study

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## ABSTRACT

**Introduction:** Acute appendicitis is one of the most prevalent surgical emergencies worldwide, with complications arising from delayed diagnosis or misdiagnosis. Accurate and timely diagnosis is critical to prevent complications like perforation, abscess, and peritonitis, while minimising unnecessary surgeries.

**Aim:** To study the diagnostic accuracy of Tzanakis Scoring (TS) versus the Alvarado scoring system, considering histopathology as a gold standard.

**Materials and Methods:** A prospective observational study was conducted at the Outpatient Department (OPD) of Surgery and Emergency Room (ER), S Nijalingappa Medical College (SNMC), HSK (Hanagal Shree Kumareshwar) Hospital and Research Centre, Bagalkot, Karnataka, India from August 2022 to February 2024. A total of 100 patients who presented with right lower quadrant pain were included. Both the Modified Alvarado Score (MAS) and TSs were calculated for each patient. The diagnostic performance of each scoring system was evaluated against histopathological findings. The sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV), and diagnostic accuracy were calculated for both the MAS and TS. Receiver Operating Characteristic (ROC) curves were constructed to determine the optimal cut-off values for each scoring system.

**Results:** The mean age was 29.3±11.8years, and out of 100 patients, 54 were males. A total of 75 had histologically confirmed appendicitis. The TS demonstrated higher sensitivity (92.0% vs 88.0%), specificity (80.0% vs 76.0%), and diagnostic accuracy (89.0% vs 85.0%) compared to MAS. The Area Under the ROC Curve (AUC) was 0.895 for the TS and 0.860 for MAS (p-value<0.001 for both). Cut-off values were ≥8 for the TS and ≥7 for MAS. Both scoring systems reduced negative appendectomy rates compared to clinical judgment alone (4.1% for TS, 5.6% for MAS, vs 8.5% for clinical judgment).

**Conclusion:** Both the MAS and TS are effective tools for diagnosing acute appendicitis, with the TS showing slightly superior performance. These scoring systems can aid in clinical decision-making and potentially reduce negative appendectomy rates. Further large-scale studies are warranted to validate these findings across diverse populations.


**Keywords:** Appendicitis scoring method, Negative appendectomy, Prospective studies, Sensitivity, Specificity, Ultrasonography

## INTRODUCTION

Acute appendicitis remains one of the most common surgical emergencies worldwide, with a lifetime risk of approximately 7-8% [1]. Despite its prevalence, the diagnosis of acute appendicitis can be challenging, especially in its early stages when clinical presentation may be atypical or equivocal [2]. Accurate and timely diagnosis is crucial to prevent complications such as perforation, abscess formation, and peritonitis, while also avoiding unnecessary surgeries [3]. Over the years, various scoring systems have been developed to aid in the diagnosis of acute appendicitis, aiming to improve diagnostic accuracy and reduce the negative appendectomy rate [4]. Among these, the Alvarado score, introduced in 1986, has been widely used and validated [5]. However, recognising the need for further improvement, modifications to the original Alvarado score have been proposed, leading to the development of the MAS [6].

More recently, in 2005, Tzanakis NE et al., introduced a new scoring system that incorporates clinical findings, laboratory results, and ultrasonographic measurements [7]. The TS was designed to enhance diagnostic accuracy by combining multiple parameters and utilising readily available imaging technology.

While both the MAS and the TS have shown promise in various settings, there is a paucity of comparative studies directly evaluating their relative performance in diagnosing acute appendicitis [8]. This gap in the literature highlights the need for a comprehensive, prospective study to assess and compare these two scoring systems.

The findings of the present study have the potential to significantly impact clinical practice by providing evidence-based guidance on the most effective scoring system for diagnosing acute appendicitis. This, in turn, could lead to more accurate diagnoses, reduced rates of negative appendectomies, and improved patient outcomes in the management of this common surgical condition.

## MATERIALS AND METHODS

A prospective observational study was conducted at the surgery OPD and ER room, HSK Hospital, SNMC Bagalkot, Karnataka, India from August 2022 to February 2024. The study protocol was approved by the Institutional Ethics Committee (IEC) (SNMC/IECHSR/2021-22/A-55/1.1). Convenience sampling was followed.

**Inclusion criteria:** Patients aged >18 years and both genders presenting with lower abdomen, clinically diagnosed appendicitis were included in the study.

**Exclusion criteria:**

1. Patient who denied informed consent to participate in the study;
2. Patient previously diagnosed with acute appendicitis;

3. Patients with pelvic inflammatory disease;
4. Patients unwilling to participate or those lost to follow-up were also excluded from the final analysis.

### Study Procedure

Upon admission, a detailed history was taken and a physical examination was performed for each patient by a surgical resident. Demographic data, clinical symptoms, and physical examination findings were recorded in a standardised proforma. Laboratory investigations, including complete blood count (>12000 cells/µL) and C-reactive protein levels (>120 mg/L), were conducted for all patients. Additionally, all participants underwent abdominal ultrasonography performed by a radiologist with at least five years of experience, who was blinded to the clinical findings.

Two independent researchers, blinded to each other's findings, calculated the MAS [8] and TS for each patient [7].

- The MAS was calculated based on eight variables: migration of pain, anorexia, nausea/vomiting, tenderness in the right lower quadrant, rebound tenderness, elevated temperature, leukocytosis, and shift of white blood cell count to the left.
- The TS was calculated using four parameters: right lower quadrant tenderness, rebound tenderness, white blood cell count, and ultrasonographic findings, including a diameter greater than 6mm, a target-like appearance of the appendix in the transverse view, and non compressibility.

The decision to operate was made by the attending surgeon based on clinical judgment, independent of the calculated scores. All patients who underwent appendectomy had their appendix specimens sent for Histopathological Examination (HPE). The pathologist was blinded to the clinical details and calculated scores.

Patients who did not undergo surgery were followed-up for a minimum of two weeks to ensure resolution of symptoms and exclude the possibility of missed appendicitis. Follow-up was conducted through telephone interviews or outpatient visits.

## STATISTICAL ANALYSIS

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 29.0. The sensitivity, specificity, PPV, NPV and diagnostic accuracy were calculated for both the MAS and TS. ROC curves were constructed to determine the optimal cut-off values for each scoring system. The AUC was used to compare the overall diagnostic performance of the two scores. A p-value of less than 0.05 was considered statistically significant.

## RESULTS

The study enrolled 100 patients with suspected acute appendicitis, with a slight male predominance (54%) and a mean age of 29.3 years. Of these, 82 patients underwent appendectomy, with 75 cases histologically confirmed as acute appendicitis. The remaining 18 patients were managed conservatively by intravenous (i.v.) antibiotics and called for interval appendicectomy [Table/Fig-1].

The MAS demonstrated a sensitivity of 88.0% and specificity of 76.0%, while the TS showed higher values with 92.0% sensitivity and 80.0% specificity. Overall diagnostic accuracy was 85.0% for MAS and 89.0% for the TS [Table/Fig-2-4].

The ROC curve analysis revealed a slightly higher AUC for the TS (0.895) compared to MAS (0.860), both showing statistically significant discriminatory power (p-value<0.001) [Table/Fig-5]. The optimal cut-off values were determined to be ≥7 for MAS and ≥8 for the TS.

Notably, both scoring systems reduced the negative appendectomy rate compared to clinical judgment alone (8.5%). The TS resulted in the lowest negative appendectomy rate at 4.1%, followed closely by MAS at 5.6% [Table/Fig-6].

| Characteristics | Value |
|---|---|
| Total patients enrolled | 100 |
| Age (in years )(Mean±SD) | 29.3±11.8 |
| Gender (Male:Female) | 54:46 |
| Duration of symptoms (Mean±SD) (in hours) | 23.1±9.2 |
| Patients underwent appendectomy (n,%) | 82 (82%) |
| Histologically confirmed appendicitis (n,%) | 75 (75%) |

**[Table/Fig-1]:** Demographic and clinical characteristics of study participants N=100.

| Modified Alvarado Score | HPE findings | | Total |
|---|---|---|---|
| | Acute Appendicitis | Normal | |
| ≥7 | 66 | 6 | 72 |
| <7 | 9 | 19 | 28 |

**[Table/Fig-2]:** Comparison of Modified Alvardo Score with HPE findings.

| Tzanakis Score (TS) | HPE findings | | Total |
|---|---|---|---|
| | Acute Appendicitis | Normal | |
| ≥8 | 69 | 5 | 74 |
| <8 | 6 | 20 | 26 |

**[Table/Fig-3]:** Comparison of Tzanakis Score (TS) with histopathological findings.

| Parameters | Modified Alvarado Score (MAS) | Tzanakis Score (TS) |
|---|---|---|
| Sensitivity | 88.0% (66/75) | 92.0% (69/75) |
| Specificity | 76.0% (19/25) | 80.0% (20/25) |
| Positive predictive value | 91.7% (66/72) | 93.2% (69/74) |
| Negative predictive value | 67.9% (19/28) | 76.9% (20/26) |
| Diagnostic accuracy | 85.0% (85/100) | 89.0% (89/100) |

**[Table/Fig-4]:** Diagnostic performance of Modified Alvarado Score (MAS) and Tzanakis Score (TS).

| Scoring system | AUC | 95% CI | p-value |
|---|---|---|---|
| Modified Alvarado Score (MAS) | 0.860 | 0.782-0.938 | **<0.001** |
| Tzanakis Score (TS) | 0.895 | 0.825-0.965 | **<0.001** |

**[Table/Fig-5]:** Area Under the ROC Curve (AUC) for MAS and Tzanakis Score (TS) Confidence Interval (CI).

| Scoring system | Negative appendectomy rate |
|---|---|
| Clinical judgment alone | 7/82 (8.5%) |
| Modified Alvarado Score (MAS) (≥7) | 4/72 (5.6%) |
| Tzanakis Score (TS) (≥8) | 3/74 (4.1%) |

**[Table/Fig-6]:** Comparison of negative appendectomy rates.

## DISCUSSION

Acute appendicitis is one of the most common surgical emergencies, and accurate, timely diagnosis is crucial for reducing morbidity and preventing unnecessary procedures like negative appendectomies. In recent years, clinical scoring systems such as the MAS and TS have been widely used to aid in the diagnosis of acute appendicitis.

The current study population consisted of 100 patients, the mean duration of symptoms was 23.1±9.2 hours, and 82% of the patients underwent appendectomy. HPE confirmed acute appendicitis in 75% of the cases.

In the present study, the sensitivity of the MAS (88.0%) was lower compared to the TS (92.0%), and this is consistent with findings from previous studies where TS demonstrated superior sensitivity [Table/Fig-7] [9-13]. The Tzanaki score's higher sensitivity suggests its better ability to correctly identify patients with acute appendicitis, which is particularly important in clinical settings where timely diagnosis is critical.

| Authors name | Modified Alvarado Score (MAS) | | Tzanakis Score (TS) | |
|---|---|---|---|---|
| | Sensitivity | Specificity | Sensitivity | Specificity |
| Rajpura AK et al., [9] | 84.26% | 72.7% | 88.2% | 72.7% |
| BL YB et al., [10] | 54% | 75% | 87% | 50% |
| Malik AA et al., [11] | 94.95% | 92.6% | 98.32% | 96.29% |
| Malla BR and Batajoo H [12] | 76% | 75% | 86.9% | 75% |
| Iftikar A et al., [13] | Alvarado score- 74% | 55% | 94.11% | 88.88% |

**[Table/Fig-7]:** Sensitivity, specificity of both scoring systems published in various studies [9-13].

In the current study, the negative appendectomy rate was lower for the TS (4.1%) compared to the MAS (5.6%), with clinical judgment alone leading to the highest negative appendectomy rate (8.5%). The lower negative appendectomy rate observed with TS supports findings from previous studies such as Malla BR and Batajoo H (2016) and Iftikhar A et al., (2021), who reported lower negative appendectomy rates when TS was used as a diagnostic tool [11]. In a study by Iftikar A et al., the negative appendectomy rate for the TS was 2.04%, while for the Alvarado score it was 9.5%. [13] In a study by Malla BR and Batajoo H the negative appendectomy rate was 1.74% for MAS (cut-off ≥7) and 0.84% for TS (cut-off ≥8) [11].

The AUC for Tzanakis Score (0.895) was slightly higher than that for the MAS (0.860). In a study by BL YB et al., the ROC curve for the Alvarado and TSs showed that the AUC was greater for the Tzanakis scoring system (0.670) than for the Alvarado scoring system (0.598) [10].

In a recent meta-analysis, the overall sensitivity of the TS was calculated as 0.86 (95% CI; 0.84-00.87) while the specificity was 0.73 (95% CI; 0.69-0.78). The pooled sensitivity of the Alvarado score was 0.67 (95% CI; 0.65-0.69) and the specificity was 0.74 (95% CI; 0.69-0.79) [14].

Ohle R et al., in their systematic review, found a pooled sensitivity of 82% and specificity of 81% at a cut-off score of 7 [4]. However, the present study showed a higher sensitivity (88.0%) and slightly lower specificity (76.0%), which may be attributed to variations in study population and setting.

The performance of the TS in the current study (sensitivity 92.0%, specificity 80.0%) aligns closely with the original study by Tzanakis NE et al., which reported a sensitivity of 95.4% and specificity of 97.4% [7]. The slight differences may be due to our smaller sample size and potential variations in ultrasound expertise.

However, it's important to note that while the TS showed better performance, the difference was not substantial, and both scores demonstrated good diagnostic accuracy. The choice between these scores in clinical practice may depend on factors such as the availability of ultrasonography and the specific patient population.

## Limitation(s)

The study's findings may have been influenced by subjective errors in ultrasonographic interpretation, as ultrasound results can vary depending on the examiner's experience and technique. Additionally, the exclusion of the paediatric age group limits the generalisability of the results to children. Furthermore, the relatively small sample size may not provide enough statistical power to make universal statements about the performance of the scoring systems across all populations.

## CONCLUSION(S)

Both the MAS and TS are effective diagnostic tools for acute appendicitis. The TS, however, showed slightly superior performance in terms of sensitivity, specificity, and diagnostic accuracy. These scoring systems can assist clinicians in decision-making and potentially reduce the rate of negative appendectomies. Nevertheless, further large-scale studies involving diverse populations are necessary to validate these findings and establish the broader applicability of the results.

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