

The role of interval appendicectomy following conservative management of appendicular mass and appendicular abscess: A hospital-based prospective observational cohort study from a tertiary care centre in Odisha, India.

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Abstract

Background

Conservative management using the Ochsner–Sherren regimen is widely accepted for appendicular mass and appendicular abscess. However, the routine role of interval appendicectomy after successful non-operative treatment remains controversial because of concerns regarding recurrence, operative morbidity, and occult appendiceal neoplasia.

Objective

To evaluate the clinical outcomes of conservative management and determine the role of interval appendicectomy in adults presenting with appendicular mass or appendicular abscess at a tertiary care teaching hospital.

Methods

A hospital-based prospective observational cohort study was conducted among 50 consecutive adult patients with clinically and radiologically confirmed appendicular mass or appendicular abscess who were managed initially with conservative treatment. Patients with abscesses underwent drainage when clinically indicated. Following successful resolution, participants were reassessed after 6–12 weeks and either underwent interval appendicectomy or continued active observation according to clinical judgement and patient preference.

Results

Conservative management was successful in all 50 participants. Twenty-eight (56.0%) had appendicular mass and 22 (44.0%) had appendicular abscess. Forty-two patients (84.0%) underwent interval appendicectomy, while eight (16.0%) remained under observation. Laparoscopic appendicectomy was successfully completed in 33 patients (78.6%), whereas seven (16.6%) required conversion to open surgery because of dense adhesions. Histopathological examination demonstrated findings consistent with resolved appendicitis.

Conclusion

Initial conservative management was safe and effective in this cohort. Interval appendicectomy was associated with low morbidity and favourable surgical outcomes. However, the short follow-up period and limited sample size support an individualized rather than routine approach to interval appendicectomy, particularly in younger patients.

Keywords: *Acute appendicitis; appendicular abscess; appendicular mass; conservative management; interval appendicectomy; laparoscopic appendicectomy.*

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Introduction

Acute appendicitis remains one of the most common surgical emergencies worldwide and continues to be a leading indication for emergency abdominal surgery in adults [1, 2]. Although the majority of patients present with uncomplicated disease and undergo early appendicectomy, a subset develops a localized inflammatory process in which the greater omentum and

adjacent bowel loops wall off the perforated or inflamed appendix, resulting in an appendicular mass or appendicular abscess. The reported incidence of appendicular phlegmon or abscess ranges from 2% to 10% of all cases of acute appendicitis, with higher rates observed in patients who present late to hospital or receive delayed treatment [3, 4]. This entity is clinically important because it poses unique diagnostic and therapeutic

challenges compared with uncomplicated appendicitis. Traditionally, immediate surgery in the presence of an established appendicular mass has been considered technically demanding and potentially hazardous. Dense inflammatory adhesions, friable tissues, distorted anatomy, and difficulty in identifying the appendiceal base may increase the risk of bowel injury, faecal fistula, postoperative abscess, wound infection, and unplanned ileocaecal resection. For these reasons, conservative management using the Ochsner–Sherren regimen—comprising bowel rest, intravenous fluids, broad-spectrum antibiotics, analgesia, and close clinical observation—has become widely accepted, with drainage reserved for patients with a well-formed abscess or clinical deterioration [5]. Several systematic reviews and meta-analyses have shown that initial non-operative treatment is associated with lower morbidity and fewer reoperations than emergency appendicectomy in selected patients with appendicular abscess or phlegmon [3].

Despite broad agreement regarding the initial conservative approach, the role of interval appendicectomy after successful resolution remains controversial. Historically, interval appendicectomy performed 6–12 weeks after the acute episode was recommended to prevent recurrent appendicitis and to exclude occult appendiceal or caecal malignancy [6]. However, more recent evidence has questioned the need for routine surgery in all patients. Reported recurrence rates after successful conservative management vary considerably, ranging from approximately 7% to 20% in most adult series, while elective appendicectomy itself carries operative risks, postoperative pain, hospital stay, and healthcare costs [7–9]. Conversely, emerging evidence suggests that the risk of underlying appendiceal neoplasm is higher in older adults, particularly those above 40 years of age, and may justify a lower threshold for interval appendicectomy or further colonic evaluation in this subgroup [10,11].

The decision between routine interval appendicectomy and selective observation is therefore increasingly being individualized according to patient age, imaging findings, clinical recovery, comorbidities, and the feasibility of long-term follow-up. This issue is particularly relevant in resource-constrained settings where access to advanced imaging, interventional radiology, and reliable outpatient surveillance may be inconsistent [12]. In many Indian tertiary care hospitals, patients frequently present after several days of symptoms, and continuity of follow-up cannot always be guaranteed, factors that may influence the balance between definitive surgery and observation [13].

Evidence from eastern India regarding the outcomes of conservative management and the subsequent role of

interval appendicectomy remains limited. The present study was therefore undertaken to evaluate the clinical course, operative outcomes, postoperative complications, histopathological findings, and short-term recurrence among adults with appendicular mass or appendicular abscess managed initially by conservative treatment at a tertiary care teaching hospital in Odisha, India. The study also aimed to assess the feasibility and safety of interval laparoscopic appendicectomy and to contribute local evidence to the ongoing debate regarding selective versus routine interval appendicectomy in this patient population.

Materials and methods

Study Design

This study was designed as a hospital-based prospective observational cohort study conducted among consecutive adult patients presenting with appendicular mass or appendicular abscess. Eligible patients were enrolled prospectively at the time of admission and followed from initial conservative management through interval appendicectomy or active observation after clinical resolution. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [14].

Study Setting

The study was conducted in the Department of General Surgery, Hi-Tech Medical College and Hospital, Bhubaneswar, Odisha, India, a tertiary care teaching hospital that provides comprehensive emergency and elective surgical services to patients from urban, semi-urban, and rural areas of Odisha and neighbouring states. The institution functions as a referral centre for primary and secondary healthcare facilities and is equipped with emergency surgical services, advanced diagnostic imaging facilities, intensive care services, laparoscopic surgical facilities, pathology laboratories, and multidisciplinary specialist support. The study was carried out over a period of 1 year (March 2024 to February 2025). During this period, all eligible patients presenting with appendicular mass or appendicular abscess were screened and enrolled consecutively.

Study Population

The study population comprised adult patients admitted with a clinical and radiological diagnosis of appendicular mass or appendicular abscess.

Inclusion Criteria

Patients were included if they:

- Were aged 18 years or older;
- Had a clinical diagnosis of appendicular mass or appendicular abscess;
- Had radiological confirmation by ultrasonography and/or contrast-enhanced computed tomography (CECT);
- Underwent initial conservative management using the Ochsner–Sherren regimen with or without abscess drainage;
- Provided written informed consent to participate in the study.

Exclusion Criteria

Patients were excluded if they:

- Presented with generalized peritonitis requiring emergency surgery;
- Had suspected appendiceal or caecal malignancy at presentation;
- Were pregnant;
- Had significant immunocompromising conditions;
- Had severe cardiopulmonary disease precluding surgery;
- Had undergone previous appendicectomy;
- Declined participation or were unable to comply with follow-up requirements.

Sample Size and Sampling Technique

A formal sample size calculation was not performed because the study was designed as a descriptive observational investigation. Therefore, all eligible consecutive patients presenting during the study period were included. A total of 50 patients satisfied the eligibility criteria and were enrolled using a consecutive sampling technique.

Operational Definitions

Appendicular Mass: A localized inflammatory phlegmon in the right iliac fossa consisting of the inflamed appendix, omentum, and adjacent bowel loops, confirmed clinically and radiologically.

Appendicular Abscess: A localized periappendiceal collection of pus demonstrated by ultrasonography and/or computed tomography.

Recurrence: Development of a subsequent episode of clinically and radiologically confirmed acute appendicitis requiring hospital admission after successful initial conservative treatment.

Study Procedure

Following admission, all patients underwent detailed clinical evaluation, laboratory investigations, and radiological assessment. Conservative management was initiated using the Ochsner–Sherren regimen, which included:

- Nil per oral (NPO) status;
- Intravenous fluid resuscitation;
- Broad-spectrum intravenous antibiotics;
- Analgesics and supportive care;
- Serial clinical monitoring.

Patients diagnosed with appendicular abscess underwent drainage whenever clinically indicated. Clinical improvement was assessed through resolution of fever, reduction in abdominal pain and tenderness, regression of the inflammatory mass, normalization of leukocyte count, and improvement in general condition. Following successful resolution of the acute episode, patients were reviewed after 6–12 weeks. Based on clinical assessment, surgeon preference, and patient choice, participants either underwent interval appendicectomy or continued active observation.

Data Collection

Data were collected prospectively using a structured and pre-tested case record form. Information recorded included:

- Demographic characteristics;
- Clinical presentation;
- Laboratory findings;
- Radiological findings;
- Type of conservative management;
- Operative details;
- Postoperative complications;
- Histopathological findings;
- Duration of hospital stay;
- Follow-up outcomes.

All histopathological examinations were performed in the Department of Pathology by qualified consultant pathologists.

Outcome Measures

Primary Outcome

- Management pathway after successful conservative treatment (interval appendicectomy versus active observation).

Secondary Outcomes

- Operative approach (laparoscopic, open, or converted procedure);
- Postoperative complications;
- Duration of postoperative hospital stay;
- Histopathological findings;
- Recurrence during follow-up;
- Readmission and mortality rates.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized using mean $\pm$ standard deviation (SD) or median with interquartile range (IQR), as appropriate. Categorical variables were expressed as frequencies and percentages. Where exploratory comparisons were performed, the Chi-square test or Fisher's exact test was used for categorical variables, while the independent-samples t-test or Mann-Whitney U test was used for continuous variables. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Institutional Ethics Committee of Hi-Tech Medical College and Hospital, Bhubaneswar, Odisha, India (Reference No. HMCH/IEC/2024/230(34); dated 28 February 2024). Written informed consent was obtained from all participants before enrolment. Participant confidentiality was maintained throughout the study by anonymizing patient information and storing data in password-protected records accessible only to the investigators.

Results

Participant Flow

A total of 50 consecutive patients meeting the eligibility criteria were enrolled during the study period. All participants successfully completed the initial phase of conservative management, and none required emergency surgery because of treatment failure during the index admission. Furthermore, all enrolled participants completed the scheduled follow-up, with no withdrawals or losses to follow-up. Following clinical resolution of the acute inflammatory episode, 42 patients (84.0%) underwent interval appendicectomy, whereas 8 patients (16.0%) opted for continued clinical observation (Figure 1).

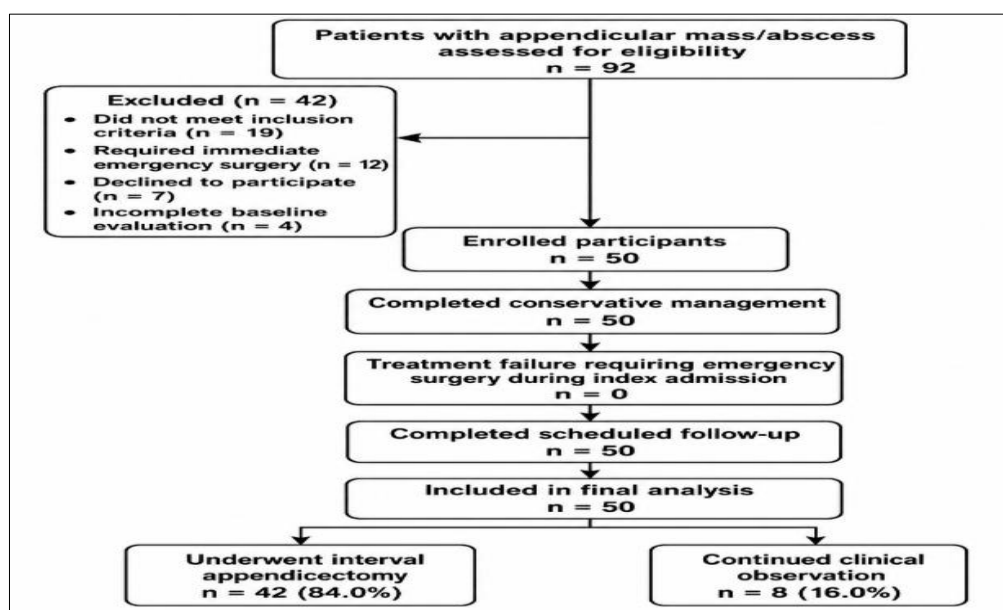


Figure 1: STROBE Participant Flow Diagram

Baseline Characteristics

The demographic characteristics of the study population are summarized in Table 1. Of the 50 participants, 29 (58.0%) were male and 21 (42.0%) were female, yielding a male-to-female ratio of 1.38:1. Most patients belonged to the younger adult age groups, with the highest proportion occurring in the 21–30-year age category, followed by the 31–40-year age group. The detailed age distribution and mean age should be completed from the original dataset before final submission.

Table 1. Baseline demographic characteristics of the study population (N = 50)

Characteristic	n	%
Sex		
Male	29	58.0
Female	21	42.0
Age group (years)		
18–20	6	12.0
21–30	20	40.0
31–40	15	30.0
>40	9	18.0

Mean age (years) 31.8 ± 10.2

Clinical Diagnosis

Among the enrolled participants, 28 patients (56.0%) were diagnosed with an appendicular mass, whereas 22 patients (44.0%) presented with an appendicular abscess. This indicates that appendicular mass was slightly more common than appendicular abscess in the present cohort (Table 2).

Table 2. Clinical diagnosis of participants (N = 50)

Diagnosis	n	%
Appendicular mass	28	56.0
Appendicular abscess	22	44.0
Total	50	100.0

Management Following Conservative Treatment

All patients were initially managed using conservative treatment. Patients diagnosed with appendicular mass received the Ochsner–Sherren regimen, whereas those with appendicular abscess underwent abscess drainage whenever clinically indicated in addition to antibiotic therapy. After complete clinical recovery, 42 patients (84.0%) underwent interval appendicectomy, while 8

patients (16.0%) continued under active clinical observation (Table 3).

Table 3. Management following successful conservative treatment (N = 50)

Management	n	%
Interval appendicectomy	42	84.0
Active observation	8	16.0
Total	50	100.0

Operative Findings

Among the 42 patients who underwent interval appendicectomy, 33 (78.6%) procedures were successfully completed laparoscopically. Two patients (4.8%) underwent planned open appendicectomy, while 7 patients (16.6%) required conversion from laparoscopic to open surgery because of dense inflammatory adhesions and distortion of the appendiceal anatomy. The laparoscopic conversion rate was 17.5% among procedures initially attempted laparoscopically.

Table 4. Operative approach among patients undergoing interval appendicectomy (n = 42)

Operative approach	n	%
Laparoscopic appendicectomy	33	78.6
Planned open appendicectomy	2	4.8
Conversion to open surgery	7	16.6
Total	42	100.0

Postoperative Hospital Stay

The duration of postoperative hospitalization ranged from 3 to 7 days. The median postoperative stay was 5 days, and most patients (77.5%) were discharged by the fifth postoperative day, indicating satisfactory postoperative recovery following interval appendicectomy.

Table 5. Duration of postoperative hospital stay (n = 40*)

Hospital stay (days)	n	%
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3	8	20.0
4	7	17.5
5	16	40.0
6	6	15.0
7	3	7.5
Total	40	100.0

Follow-up Outcomes

All participants completed approximately three months of follow-up. Among the eight patients managed by observation alone, no recurrence of appendicitis, readmission, or treatment-related complications were observed during the follow-up period. Likewise, patients who underwent interval appendicectomy experienced no major postoperative complications, no mortality, and no hospital readmissions. Although no adverse outcomes were recorded, the relatively small sample size and short follow-up period limit the precision of these estimates and preclude meaningful comparative statistical analysis between treatment groups.

Table 6. Clinical outcomes at three-month follow-up

Outcome	n	%
Recurrence (observation group)	0/8	0.0
Readmission (observation group)	0/8	0.0
Late postoperative complications	0/42	0.0
Readmission after appendicectomy	0/42	0.0
Loss to follow-up	0/50	0.0
Mortality	0/50	0.0

Discussion

Principal Findings

This hospital-based prospective observational cohort study evaluated the outcomes of conservative management followed by interval appendicectomy in adult patients presenting with appendicular mass or appendicular abscess. Conservative treatment using the Ochsner–Sherren regimen, supplemented with abscess drainage where clinically indicated, was successful in all enrolled patients, thereby avoiding emergency surgery during the acute inflammatory phase. Following clinical recovery, the majority of participants (84.0%) underwent interval appendicectomy, most of which were completed laparoscopically with low postoperative morbidity.

During the three-month follow-up period, no recurrence of appendicitis was observed among patients managed by active observation, and no mortality or major postoperative complications occurred. These findings suggest that conservative management is an effective initial treatment strategy and that interval appendicectomy can be safely performed in appropriately selected patients.

Interpretation of Findings

The 100% success rate of conservative management observed in the present study compares favourably with published literature, although it should be interpreted cautiously because of the relatively small sample size. Previous systematic reviews have reported success rates ranging from approximately 80% to 95% following non-operative management of appendicular mass or appendicular abscess [4, 15]. Andersson and Petzold [3] demonstrated that conservative treatment was associated with lower morbidity than emergency appendicectomy, while Simillis et al. reported significantly fewer postoperative complications and reoperations among patients managed initially without surgery. The complete absence of treatment failure in the present cohort may reflect careful patient selection, prompt initiation of broad-spectrum antibiotics, standardized institutional management protocols, and exclusion of patients presenting with generalized peritonitis.

The demographic characteristics of the study population were comparable with previous reports from Asia and other developing countries, demonstrating a slight male predominance and a greater frequency among young adults [2]. Acute appendicitis is most prevalent during the second to fourth decades of life, and complicated appendicitis similarly affects economically productive age groups [16]. The predominance of younger patients in the present study may partly explain the absence of appendiceal neoplasms on histopathological examination, as the risk of occult malignancy increases substantially after the age of 40 years [11,12].

The role of interval appendicectomy following successful conservative treatment remains controversial. Traditionally, elective appendicectomy has been recommended to prevent recurrent appendicitis and exclude occult malignancy. However, increasing evidence supports a more selective approach, particularly in younger adults with complete clinical resolution. Several systematic reviews have demonstrated that recurrence following successful conservative management is relatively infrequent and that repeat conservative treatment can often be safely performed in patients who experience recurrence. Consequently, routine interval appendicectomy may expose many patients to

unnecessary surgery while providing limited clinical benefit.

In the present study, interval appendicectomy was performed in 84% of participants, reflecting prevailing surgical practice within the institution [9]. The high proportion of elective operations likely reflects concerns regarding recurrence, patient preference, surgeon experience, and the challenges associated with ensuring long-term follow-up in resource-limited healthcare settings. In many tertiary hospitals in India, reliable outpatient surveillance cannot always be guaranteed; therefore, definitive surgical management after successful conservative treatment may represent a practical and acceptable strategy for selected patients.

Laparoscopic appendicectomy was successfully completed in the majority of patients, confirming the feasibility of minimally invasive surgery after resolution of acute inflammation [7]. Nevertheless, approximately one-sixth of laparoscopic procedures required conversion to open surgery because of dense adhesions and distorted anatomy. Similar conversion rates have been reported in previous studies of complicated appendicitis, highlighting that inflammatory fibrosis may persist even several weeks after the acute episode. These findings emphasize the importance of preoperative counselling regarding the potential need for conversion and reinforce the need for adequate laparoscopic expertise when performing interval appendicectomy [10].

Histopathological Findings

Histopathological examination of all resected specimens demonstrated findings consistent with resolved appendicitis, without evidence of appendiceal neoplasia. Although this observation is reassuring, it should not be interpreted as evidence that routine histopathological assessment is unnecessary [17]. Recent randomized studies have demonstrated a clinically significant incidence of appendiceal neoplasms among older adults undergoing interval appendicectomy after appendicular abscess. Consequently, patient age, radiological findings, and clinical suspicion should continue to guide decisions regarding interval surgery and further colonic evaluation [18].

The absence of recurrent appendicitis among patients managed without surgery should likewise be interpreted cautiously. The observation group consisted of only eight participants, and follow-up was limited to approximately three months [19]. Most published studies indicate that recurrence commonly occurs during the first one to two years following conservative treatment. Therefore, the present findings cannot establish the long-term safety of observation alone but rather demonstrate that early

recurrence was uncommon within the available follow-up period [20].

Clinical Implications

The findings of the present study support the continued use of conservative management as the initial treatment strategy for selected patients presenting with appendicular mass or appendicular abscess. Initial non-operative treatment can successfully control the acute inflammatory process while avoiding technically difficult emergency surgery and reducing immediate postoperative morbidity. The decision regarding interval appendicectomy should be individualized rather than applied routinely to all patients. Factors such as patient age, radiological findings, operative fitness, availability of long-term follow-up, and patient preference should be considered during shared clinical decision-making. Patients older than 40 years or those with suspicious imaging findings may derive greater benefit from interval appendicectomy because of the increased risk of occult appendiceal neoplasia, whereas younger patients with complete clinical recovery may be appropriate candidates for careful observation [21].

Comparison with Previous Studies

Overall, the findings of the present study are consistent with contemporary evidence supporting selective rather than mandatory interval appendicectomy after successful conservative management. The observed clinical outcomes align with previous systematic reviews and randomized studies demonstrating high success rates for conservative treatment, low postoperative morbidity following delayed appendicectomy, and relatively low short-term recurrence rates [20]. However, unlike several larger multicentre studies with longer follow-up, the present investigation was not designed to determine predictors of recurrence or directly compare operative and non-operative strategies. Consequently, its findings should be regarded as supportive observational evidence rather than definitive comparative proof [21].

Conclusion

This hospital-based prospective observational cohort study demonstrated that initial conservative management using the Ochsner-Sherren regimen, with drainage of appendicular abscesses when clinically indicated, was an effective treatment strategy for adults presenting with appendicular mass or appendicular abscess. Conservative treatment was successful in all enrolled patients, avoiding emergency surgery during the acute inflammatory phase and allowing definitive management to be undertaken under more favourable clinical conditions. Among patients who subsequently underwent interval appendicectomy, laparoscopic surgery was feasible in the

majority of cases and was associated with low postoperative morbidity, short hospital stay, and excellent short-term clinical outcomes. Although no recurrence was observed among patients managed by active observation during the three-month follow-up period, the limited duration of surveillance and the relatively small observation group preclude definitive conclusions regarding the long-term safety of non-operative follow-up alone. Overall, the findings support an individualized approach to interval appendicectomy rather than routine surgery for every patient following successful conservative treatment. Clinical decision-making should consider patient age, radiological findings, risk of occult appendiceal neoplasia, availability of long-term follow-up, and patient preference. Larger prospective multicentre studies with extended follow-up are required to further define the optimal management strategy for patients with appendicular mass and appendicular abscess.

Limitations

The present study has several limitations that should be considered while interpreting the findings.

First, this was a single-centre study conducted at a tertiary care teaching hospital, which may limit the generalizability of the findings to other healthcare settings, particularly primary and secondary care hospitals.

Second, the sample size was relatively small ($n = 50$), thereby reducing the statistical precision of the estimated outcomes and limiting the ability to identify predictors of recurrence, postoperative complications, or conversion to open surgery.

Third, the follow-up period of approximately three months was relatively short. Most reported recurrences after successful conservative management occur within the first one to two years; therefore, the present study could not adequately evaluate long-term recurrence or delayed complications.

Fourth, allocation to interval appendicectomy or active observation was based on clinical judgement and patient preference rather than randomization, introducing the possibility of selection bias and limiting direct comparison between management strategies.

Fifth, no concurrent comparison group undergoing immediate appendicectomy was included; therefore, the study was not designed to compare early surgical intervention with delayed or selective operative management.

Finally, several clinically relevant variables, including detailed age distribution and long-term recurrence data, were unavailable in the present dataset and should be incorporated in future studies to strengthen the evidence generated.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. Conservative management should remain the preferred initial treatment for carefully selected patients with appendicular mass or appendicular abscess who are clinically stable.
2. Routine interval appendicectomy should not be considered mandatory for all patients. Instead, management should be individualized after considering patient age, imaging findings, clinical recovery, comorbidities, and patient preference.
3. Patients aged 40 years or older, or those with suspicious radiological features suggestive of appendiceal neoplasia, should be considered for interval appendicectomy and appropriate colorectal evaluation.
4. Healthcare institutions should establish standardized follow-up protocols to facilitate early detection of recurrent appendicitis among patients managed without surgery.
5. Future research should include large multicentre prospective cohort studies and randomized controlled trials with longer follow-up durations, standardized treatment protocols, and comprehensive evaluation of recurrence, quality of life, healthcare costs, and occult appendiceal neoplasia to develop robust evidence-based clinical guidelines.

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List of Abbreviations

CT	Computed Tomography
IEC	Institutional Ethics Committee
SPSS	Statistical Package for the Social Sciences
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
SD	Standard Deviation
IQR	Interquartile Range
SSI	Surgical Site Infection
WBC	White Blood Cell
RIF	Right Iliac Fossa
HMCH	Hi-Tech Medical College and Hospital

Ethics Approval and Consent to Participate

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and its subsequent amendments. Ethical approval was obtained from the Institutional Ethics Committee (IEC), Hi-Tech Medical College and Hospital, Bhubaneswar, Odisha, India (Approval No. HMCH/IEC/2024/230(34); dated 28 February 2024) before commencement of the study. Written informed consent was obtained from all participants prior to enrolment.

Consent for Publication

Written informed consent for publication of anonymized clinical information was obtained from all participants included in the study.

Availability of Data and Materials

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request. Data will be shared after removal of all personally identifiable information and in accordance with institutional ethical guidelines.

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Conflict of Interest

The authors declare that they have no competing interests related to this study.

Author Contributions

Sourav Paikray contributed to the conceptualization and methodology of the study, conducted the investigation, collected and curated the data, and prepared the original draft of the manuscript. Ashoak Acharya contributed to the conceptualization and methodology, supervised the study, performed validation, critically reviewed and edited the manuscript, and managed the overall project administration. Asutosh Dhal participated in the investigation, performed the formal analysis, interpreted the data, and contributed to the review and editing of the manuscript. Durga Prasad Sahu was involved in the investigation, conducted the literature review, collected data, prepared the visualizations, and assisted with manuscript editing. All authors read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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