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Wound Closure Techniques: Subcuticular Vs Interrupted Transdermal Sutures in Paediatric Patients Undergoing Open Appendectomy for Complicated Appendicitis: A Randomized Controlled Trial

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ABSTRACT

Paediatric patients who undergo open appendectomy for complicated appendicitis face risks of surgical site infections (SSIs) and poor wound healing. **Objectives:** To compare continuous subcuticular versus interrupted transdermal sutures to determine their effects on SSI rates, scar cosmesis, and overall wound healing. **Methods:** A randomized controlled trial (TCTR20250527004) was conducted from September 2024 to March 2025, enrolling patients aged ≤12 with complicated appendicitis. Patients of both genders aged up to 12 years presenting to the paediatric surgery emergency with acute appendicitis grade 2 and above. Patients were randomized equally into two groups: Group A (continuous subcuticular closure) and Group B (interrupted transdermal closure). Primary outcomes were SSI, wound dehiscence, and Manchester Scar Scores up to 30 days post-op. Statistical analysis was done using SPSS version 23.0, with t-tests and logistic regression. **Results:** A total of 112 patients were included in the study, with 56 in each group. The mean number of patients with surgical site infection (SSI) in group A was 1.30 ± 0.46, and in group B mean SSI was 1.37 ± 0.49, with a p value of 0.43. However, the grade of appendicitis was a significant predictor of infection, with higher grades correlating with increased odds of infection (OR=1.83, p<0.001). The Manchester scar score showed that Group A had a mean of around 15.5+3.24 versus Group B mean of about 17.8 ± 2.92, p-value <0.005. **Conclusions:** The current study concludes that while both continuous subcuticular and interrupted transdermal suturing led to similar SSI rates.

INTRODUCTION

Appendicitis is defined as an acute inflammation of the vermiform appendix [1]. Evidence shows that acute appendicitis is the most common abdominal surgical emergency [2], with around 50,000 and 300,000 acute appendectomies performed annually in the UK and in the US, respectively [3]. Research reveals that appendectomy, the surgical removal of the vermiform appendix, is the primary treatment for acute appendicitis. However, antibiotic therapy can be effective for certain patients with uncomplicated acute appendicitis [4-6]. Although the use of laparoscopy is increasing but traditional open approach remains common practice worldwide [6]. Although appendectomy is a common surgical procedure, it is often viewed with caution due to

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the considerable risk of surgical site infections (SSIs), especially those with a degree of contamination (Garner class II–IV). These infections can occur at the incision site, in deeper tissues, or in organs at the operative site within 30 days after surgery [7, 8]. Post-appendectomy surgical site infections (SSIs) are a major postoperative concern, increasing financial costs for both the healthcare system and patients. They also negatively impact the patient's health-related quality of life [8, 9]. The optimal wound closure technique for paediatric patients undergoing open appendectomy for complicated appendicitis remains a subject of clinical debate. The risk factors associated with wound-related complications are multifactorial and include the method of wound closure [3].

Although previous studies have reported both advantages and limitations of subcuticular and interrupted transdermal suturing techniques, a definitive consensus regarding their comparative efficacy is still lacking. A meta-analysis by Sharma et al. suggests superior cosmetic outcomes and lower wound dehiscence with subcuticular sutures, whereas interrupted transdermal sutures remain preferred for their simplicity and perceived protection against wound infection. [1] However, evidence from well-designed comparative trials remains limited. Therefore, this randomized controlled trial aims to compare the clinical outcomes of subcuticular versus interrupted transdermal sutures in the target patient population.

METHODS

This randomized control trial was carried out from September 2024 to March 2025 after getting approval from the College of Physicians and Surgeons Pakistan (CPSP) ref no: CPSP/REU/PSG-2022-066-561, ethical approval from Institutional Review Board King Edward Medical University, ref no: 580/RC/KEMU, and trial registration with the Thai Clinical Trial Registry, registration number TCTR20250527004. Patients undergoing open appendectomy for complicated appendicitis were assessed for eligibility from the Department of Paediatric Surgery in King Edward Medical University (KEMU)/Mayo Hospital, Lahore. Patients of both genders aged up to 12 years presenting to the paediatric surgery emergency with acute appendicitis grade 2 and above. Individuals with a prior history of abdominal surgery, malnutrition, or comorbidities such as liver disease and tuberculosis, as well as those who were immunocompromised, were excluded from the study. A total sample size of 116 participants (58 per group) was determined, based on a statistical power of 80% and a 5% level of significance. Sample Size was calculated to be 56 in each group at 95% Confidence Interval and 80% power of the study using the formula as directed by Wang *et al.* [9]. $N = (z_1 + z_2)^2 [P_1(1-P_1)P_2(1-P_2)] / (P_1 - P_2)^2$. The anticipated proportion of patient satisfaction regarding wound healing was 91.42 % with subcuticular stitching and 71.42% with interrupted suturing [3]. Participant enrolment was performed through probability-based simple random sampling. 4 patients were lost to follow-up and were excluded. Written informed consent was obtained from all patients' parents/guardians. Baseline data were recorded using a predesigned research proforma. All procedures were conducted under general anaesthesia, following appropriate preoperative fluid and electrolyte correction. Antibiotics administered included intravenous ceftriaxone at a dose of 25 mg/kg and metronidazole at 7.5 mg/kg [5]. Participants were randomized in a 1:1 ratio to either Group A (continuous suture closure) or Group B (simple interrupted suture closure). The randomization sequence was generated using computer-based allocation software. Allocation concealment was ensured with sequentially numbered, opaque, sealed envelopes, each containing the assigned closure method for a single participant. Appendectomy was performed via Lanz incision, and intraoperative findings (Grade of appendicitis) were recorded (Table 1).

Table 1: Grades of Appendicitis

Grades	Characterization
Uncomplicated Acute Appendicitis	
Grade 0	Macroscopically Normal Appendix / Histological Endoappendicitis
Grade I	Inflamed Appendix (hyperemia, edema ± fibrin)
Complicated Acute Appendicitis	
Grade II (Necrosis)	Segmental
	Involving the Base
Grade III (Perforated Inflammatory Tumor)	with Phlegmon
	with < 5 cm Abscess
	with > 5 cm Abscess
Grade IV	Perforated Appendix with Diffuse Peritonitis

Polypropylene sutures of size 4-0 or 3-0 were utilized for wound closure in all enrolled patients. In Group A, wounds were closed using continuous sutures. A single thread of suture is introduced at one end of the incision, approximately 1 cm from the wound margin. Six knots are secured at the starting point, after which the suture is advanced continuously along the incision and exited at the opposite wound edge, where an additional six knots are tied to complete the closure. In Group B, the interrupted suturing method has been employed, in which simple individual sutures were placed, and each was secured with six knots. All wound closures have been done by postgraduate paediatric surgery residents under the supervision of a consultant with more than five years of experience. Postoperative intravenous antibiotics were administered for 24 hours in cases of complicated appendicitis (Grade II and above). In the postoperative

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period, wounds were inspected in the surgical wards at discharge, followed by reassessment on the 7th postoperative day and on day 30 during follow-up. The assessment was done by the principal investigator. There is a risk of bias because, by looking at the wound for assessment, the group allocation would be obvious to the assessor. Wounds were evaluated for surgical site infection (SSI) and wound dehiscence. SSI was defined as postoperative wound erythema, purulent discharge, warmth, swelling, or tenderness requiring dressing changes or antibiotics within 30 days. Verberk et al. reported that surveillance of surgical site infections by clinicians demonstrated high reliability of a mean 95% (range 90–100%), substantial inter-rater Kappa estimates ranging from 0.61 to 0.94, indicating good reliability and moderate validity of clinician-based SSI ascertainment [10]. Scar outcomes were assessed using the Manchester Scar Scor [11]. Manchester scar score has 5 sub-domains, including colour, distortion, texture, finish, and contour, with the highest score 18 and the lowest 5. A lower score means a better scar, and 18 is the worst. Interrater and interrater intraclass correlation coefficients (ICCs) for scar assessments ranged roughly 0.71–0.87 [12]. Visual Analogue Scale (VAS) demonstrated good reliability for pain assessment (ICC = 0.87) and construct validity (correlation with clinical pain intensity, r = 0.65, p<0.001). Cases with wound infections were managed with appropriate wound care and systemic antibiotics. Data analysis has been done with SPSS version 23.0. Quantitative data have been expressed as mean ± standard deviation (SD), whereas qualitative variables were presented as frequencies and percentages. Normality of the data was checked using Shapiro Wilk test. Comparisons between the two groups were conducted using the independent sample t-test for parametric data and by using Mann Whitney U test for non-parametric data, with a p-value of ≤0.05 as statistically significant (Figure 1).

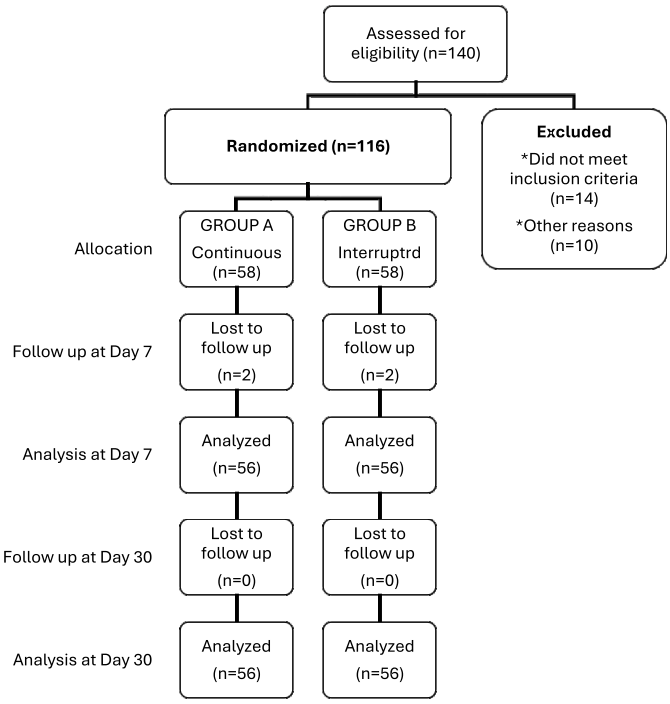

Figure 1: CONSORT Diagram Adjusted for the Study

RESULTS

A total of 112 patients were enrolled in the study, with 56 patients in each group. In group A, continuous closure, the mean age was 9.61 ± 2.47 years. In group B, the interrupted closure mean age was 9.30 ± 2.85 years. In group A, the mean weight was 24.32 ± 6.8 kg. In group B mean weight was 26.84 ± 6.25 kg. In group A, there were 45 male and 11 female, and in group B, there were 43 male and 13 female. Normality of age and weight was assessed using the Shapiro–Wilk test, and both were analyzed with the independent t-test. In group A, the most common grades were Grade 2a and Grade 3a, with 24 and 6 cases, respectively. In contrast, group B exhibited a higher frequency of Grade 2b, Grade 3a, and Grade 3c with 13, 4, and 9 cases, respectively. Grade 4 was rare, observed in only one patient in the interrupted group (Table 2).

Table 2: Baseline Characteristics

Variable	Continuous (Group 1)	Interrupted (Group 2)	Total	p-value	Test
Age (Years)	9.61 ± 2.47	9.30 ± 2.85	9.46 ± 2.66	0.548	t-test
Weight (kg)	24.32 ± 6.80	26.84 ± 6.25	25.58 ± 6.63	0.044*	t-test
Grade	3.0 [2.0-4.0]	3.0 [2.0-4.2]	3.0 [2.0-4.0]	0.397	M-W

Continuous: Mean ± SD; Ordinal: Median [IQR]; Categorical: n (%).
* p-value <0.05. p-values calculated using t-test for continuous variables, Mann-Whitney U for ordinal variables.

The mean number of patients with surgical site infection (SSI) 1-week post-op in group A was 1.30, SD 0.46, and in group B mean SSI was 1.37, SD 0.49, with a p value of 0.43. The logistic regression analysis revealed that the grade of appendicitis is a significant predictor of wound infection

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status, with higher grades corresponding to increased odds of infection (odds ratio = 1.83, 95% CI: 1.33–2.52, p<0.001). In contrast, the method of wound closure (continuous versus interrupted) does not significantly influence infection rates (odds ratio = 1.17, 95% CI: 0.50–2.75, p = 0.711)(Figure 2).

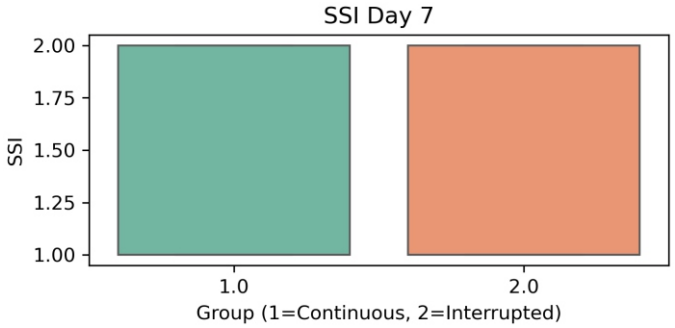

Figure 2: Surgical Site Infection at Day 7 Between Group 1 and Group 2

The ordinal logistic regression analysis demonstrated a significant association between appendicitis grade and the depth of wound infection. For each unit increase in appendicitis grade, the odds of having a deeper category of wound infection (moving from superficial to deep, or from deep to intraperitoneal) increased by 94% (odds ratio = 1.94, 95% CI: 1.43-2.65, p<0.001). The visual analogue scale (VAS) score, at day 7 in group A was 3.32, SD 1.22, and in group B was 4.93, SD 1.17, p value <0.005. Using Cohen's d, the effect size was 1.34, which exceeds the conventional threshold for a "large" effect (|d| ≥ 0.80). The negative sign simply indicates that the continuous-suture group reported lower pain than the interrupted-suture group (Figure 3).

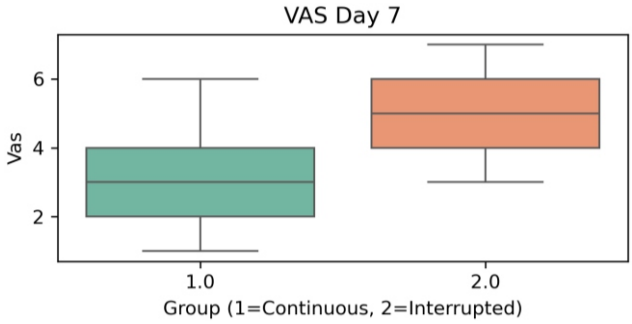

Figure 3: Visual Analog Score (VAS) at day 7 Between Group 1 and Group 2

The Manchester scar score at Day 7 showed that Group A had a mean of around 15.5, SD 3.24, versus Group B's mean of about 17.8, SD 2.92, p-value <0.005 using the independent sample t-test. Manchester scar score on Day 30 also showed a significant difference, group A with a mean score of 7.21 ± 1.87 vs. group B with a mean score of 9.34 ± 2.08. Cohen's d is equal to -1.07 shows a large effect size (Figure 4).

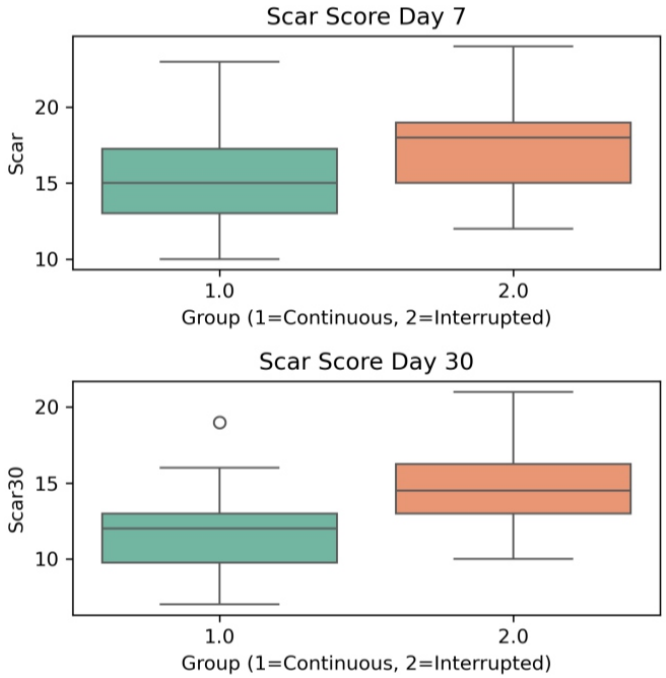

Figure 4: Box plot showing Manchester Scar Score at day 7 (a) and day 30 (b) between Group 1 and Group 2

Across all five Manchester Scar Scale sub-scores, continuous closure produced consistently more favourable scar characteristics than interrupted closure. Colour showed the greatest separation. Group A scars blended almost a half-point closer to the surrounding skin (1.91 ± 0.61 vs 2.45 ± 0.60), a highly significant difference (p<0.001). Texture and contour were likewise better with continuous subcuticular stitches (texture 1.71 ± 0.59 vs 2.18 ± 0.69, p ≈ 0.0002; contour 1.57 ± 0.57 vs 1.84 ± 0.50, p ≈ 0.009), indicating flatter, less palpable scars. Distortion, which captures wound contracture or puckering, remained lower as well (1.86 ± 0.59 vs 2.14 ± 0.35, p ≈ 0.002), suggesting less tissue deformation. Shine, the only domain not reaching significance, was marginally lower in Group A (1.16 ± 0.37 vs 1.21 ± 0.41, p=0.47), implying comparable reflective quality between techniques (Table 3).

Table 3: Inferential Statistics – Continuous vs Interrupted Wound Closure

Variables	Continuous (Group 1) Mean ± SD	Interrupted (Group 2) Mean ± SD	p-value
SSI Day 7	1.30 ± 0.46	1.38 ± 0.49	0.429
VAS Day 7	3.32 ± 1.22	4.93 ± 1.17	<0.001*
Scar Score Day 7	15.50 ± 3.24	17.84 ± 2.92	<0.001*
Scar Score Day 30	11.62 ± 2.79	14.64 ± 2.88	<0.001*

* Significant p-value <0.05

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DISCUSSION

A meta-analysis of skin closure techniques post-appendectomy reported that infection risk does not substantially vary between continuous and interrupted sutures, provided that aseptic technique and appropriate perioperative antibiotic coverage are ensured [11]. Similarly, a Cochrane review concluded that the overall incidence of SSI in non-obstetric surgeries did not significantly differ between subcuticular and transdermal approaches, even in potentially contaminated fields [11]. However, this study contributes meaningfully by demonstrating that subcuticular suturing provides significantly better outcomes. This was reflected in both the lower VAS scores and better Manchester Scar Scores in the subcuticular group on postoperative days 7 and 30. These findings are particularly important in paediatric populations, where visible scarring can have long-term psychological implications for both children and their caregivers. Subcuticular sutures are associated with more uniform tension distribution, better wound edge apposition, and reduced skin puncture marks, all contributing to improved scar appearance. This is consistent with scar physiology literature, which suggests that lower mechanical stress and uniform tension across wound edges promote optimal collagen alignment and healing [12, 13]. From a surgical standpoint, although interrupted transdermal sutures are widely regarded as being more secure in contaminated fields due to their ability to localize infection to individual stitch sites [2], this theoretical advantage did not translate into clinical significance in our trial. This supports an evolving view that when infection control measures such as appropriate wound irrigation, debridement, and systemic antibiotics are followed, the closure technique itself may play a secondary role in determining infection outcomes. Another key finding from this study is the strong correlation between the grade of appendicitis and both the incidence and depth of wound infection. Logistic regression analysis showed that higher grades of appendicitis were associated with a nearly twofold increase in the odds of developing deeper infections. This highlights the biological plausibility that more severe intra-abdominal inflammation and contamination contribute to impaired wound healing, independent of skin closure strategy [14]. Similar studies have been done in adult laparotomies as well, with comparable outcomes [15]. Importantly, the improved aesthetic outcome observed with subcuticular closure offers valuable implications for practice, especially in paediatric settings where psychological and emotional factors related to body image are increasingly recognized. Better cosmetic outcomes can positively affect patient satisfaction and reduce parental anxiety [12]. Moreover, the potential for reduced dressing needs and easier wound management may translate into cost savings and fewer outpatient visits, an area worthy of future health-economic analysis [16-19]. The lack of a statistically significant difference in infection rates, combined with the clearly superior scar outcomes in the subcuticular group, has important clinical implications. In paediatric settings, where cosmetic outcomes and minimal skin trauma are priorities, subcuticular suturing may be the preferred technique, especially when coupled with standardized intraoperative protocols and postoperative care [11]. Moreover, the use of subcuticular closure may reduce dressing requirements, promote ease of wound care, and improve parental satisfaction [16, 20].

Despite the strengths of this trial, including randomization, clearly defined outcome measures, and standardized operative protocols, some limitations should be acknowledged. The follow-up duration of 30 days may not be sufficient to see hypertrophic scar formation, which may take months to develop. Since this study was done at a single tertiary hospital with dedicated paediatric surgical teams, its generalizability to other settings, especially those with fewer resources, could be limited. Future studies should include longer follow-up periods to adequately assess late scar outcomes such as hypertrophic scarring.

CONCLUSIONS

In this randomized controlled trial comparing subcuticular continuous sutures with interrupted transdermal sutures for skin closure in paediatric patients undergoing open appendectomy for complicated appendicitis, both techniques were found to have comparable rates of surgical site infections (SSI). However, continuous intradermal suturing yielded scars that were better blended in colour, flatter in contour, smoother in texture, and less distorted, while maintaining similar surface shine. Given their favourable scar profiles and clinical safety, subcuticular sutures should be considered the preferred method of skin closure in paediatric open appendectomies.

Authors' Contribution

Conceptualization: BF, MKB, MA
Methodology: MRW, BF, SSHZ, BS
Formal analysis: ZA Writing and
Drafting: MRW, ZZ, ZA
Review and Editing: MRW, BF, SSHZ, ZZ, BS, ZA, MKB, MA

All authors approved the final manuscript and take responsibility for the integrity of the work.

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Conflicts of Interest

All the authors declare no conflict of interest.

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