ORIGINAL ARTICLE

Suture Length to Wound Length Ratio in Laparotomy Incisions and Incidence of Incisional Hernia: A Prospective Observational Study

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ABSTRACT

Introduction: Laparotomy is a commonly performed surgical procedure worldwide for a wide range of abdominal conditions. The choice of incision depends on patient factors and surgeon preference, while the principles of wound closure remain consistent across surgical incisions. Evidence suggests that taking smaller fascial bites and maintaining a suture length to wound length (SL:WL) ratio of at least 4:1 can reduce tissue ischemia, wound dehiscence, and the risk of incisional hernia. This study aimed to assess the SL:WL ratio in laparotomy cases at our hospital and to evaluate the short-term incidence of incisional hernia (HI). **Methods:** This prospective longitudinal study was conducted in the Department of General Surgery and included 138 patients who underwent laparotomy. Incision length was measured after rectus sheath closure, and the remaining suture material was collected and measured to calculate the SL:WL ratio. Patients were followed up at 3 and 6 months to assess for the development of incisional hernia. Data were analyzed using descriptive statistics and inferential tests, including the chi-square test and ANOVA. **Results:** Most patients were aged 31–50 years (48%), with a slight male predominance (52%). Emergency laparotomies accounted for 22% of cases, while 78% were elective. Vertical midline incisions were most common (78%), followed by transverse (14%) and vertical paramedian incisions (8%). The mean SL:WL ratios were highest for transverse incisions (6.08), followed by midline (5.85) and paramedian incisions (5.38), with statistically significant differences between incision types. No incisional hernia was observed at either follow-up point. **Conclusion:** The overall mean SL:WL ratio was 5.68:1, exceeding recommended standards. No incisional hernia was detected during the 6-month follow-up, suggesting that adequate SL:WL ratios may contribute to favorable short-term outcomes.
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INTRODUCTION

The word 'Laparotomy' is derived from the Greek word 'lapara' which means flank and 'tomy' which means cut. Laparotomy refers to the incisions on the abdominal wall for exploring the abdominal cavity and to perform the necessary procedure/ operation (1). Anterior abdominal wall is formed by skin, superficial fascia, muscles (Rectus abdominis, External oblique, Internal oblique, Transversus abdominis), Tranversalis fascia, preperitoneal adipose tissue and peritoneum (2). Rectus sheath maintains the integrity and strength of the anterior abdominal wall and is the most important in a laparotomy wound closure.

Laparotomy incisions are classified as midline, transverse and paramedian incisions. Midline incision causes minimal blood loss owing to the relatively avascular nature of the linea alba (3,4). Tissue damage needs to be minimized which may be achieved by reducing the incorporation of muscle of abdominal wall in the closure. There is recent evidence showing that small abdominal fascial bites decrease the chances of wound dehiscence and incisional hernia formation. SL:WL ratio of 4:1 is advocated to reduce tissue ischemia and damage (6).

The incidence of fascial dehiscence after major abdominal surgery has been reported as high as 3.5

%. The primary causes of fascial dehiscence are knot failure, fascial damage, suture material damage. Fascial dehiscence may be associated with either surgical site infection or intra-abdominal abscess, and this will vary by the type of index operation performed (7). Initially, the benefits of large tissue bites and thick sutures were propagated by Dudley (8) for safe closure of abdominal wall after laparotomy, following which there were pragmatic trials that led to disregard this concept. Jenkins (9), being the foremost to propose an accurate SL:WL ratio derived from mathematical calculations, recommended SL:WL of 4:1 for a safe abdominal wall closure. This 4:1 ratio could be achieved by using one-centimetre tissue bites at one-centimetre interval.

There is a 5-20% chance of developing incisional hernia after laparotomy. A defect that is palpable in any previous incision is defined as Incisional hernia (IH). Healing of an abdominal wall incision occurs like any other wound, following all stages of healing (10,11-14). The aim of this study was to study the length of suture material used in all laparotomy incisions and incidence of incisional hernia with respect to the suture length to wound length. The rationale of this study was to determine the amount of suture material required for routine closure of laparotomy wounds in a teaching hospital setting and to ascertain whether there is an association between the amount of suture material used and the incidence of incisional hernia during interim follow-up periods at 3 and 6 months.

MATERIALS AND METHODS

The study participants were patients undergoing treatment in the Department of General Surgery, at a tertiary centre at Mangalore, requiring a laparotomy between January 2019 to July 2020. The formula for prevalence study with 95% confidence interval, with a prevalence rate of 9% wound infection with an allowable error of 5%. Sampling was done by simple random sampling and sample size was calculated using the formula,

$$n = Z2\ p\ (1\text{-}p)/\ e2$$

n – sample size
Z – confidence level at 95% (standard value 1.96)
P – estimated prevalence of infection
e – allowable error (5%)

After obtaining informed consent, all patients underwent detailed history taking and clinical examination. In emergency cases, where a complete preoperative assessment was not feasible, information documented in the clinical notes at the time of admission was used. The length of the surgical incision was measured after closure of the abdominal wound at the level of the rectus sheath using a sterile measuring tape. For consistency, all surgeons used a PDS Loop 1 suture (150 cm) to perform continuous suturing for rectus sheath closure. Following wound closure, the remaining lengths of suture material were collected and measured to calculate the suture length used.

Patients were followed up at interim periods of 3 months and subsequently at 6 months to assess the incidence of incisional hernia through clinical examination. In cases where incisional hernia was clinically suspected, ultrasonography was performed to confirm the integrity of the laparotomy scar. Potential confounding factors, including serum albumin levels, body mass index, smoking status, diabetes mellitus, chemotherapy, and wound infection, were not systematically analyzed in this study.

Ethical approval for the study was obtained from the Institutional Ethics Committee of K.S. Hegde Medical Academy, NITTE (IEC No. INST.EC/EC/111/2017–18). Statistical analysis of the collected data was performed using descriptive measures such as frequency, percentage, mean, and standard deviation, along with inferential analysis using the chi-square test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Total number of patients included in the study was 138, of whom 72 (52 %) were males. Majority of the patients belonged to 51- 70 years age group (48 %). Among 138 patients, 78 % (n= 107) were elective cases and 22% (n= 31) were emergency cases.

Among the patients who underwent laparotomy, the largest proportion belonged to the 51–70-year age group, accounting for 48% of the study population (Figure 1). Patients aged 31–50 years constituted 30% of cases, while those below 30 years accounted for 10%. Individuals aged above 70 years represented 12% of the total cohort.

Most of the patients who underwent laparotomy, either elective or emergency were in the 6th to 8th decades. 52% of patients were male (n= 72) and 48% patients were females (n= 66) (Figure 2).

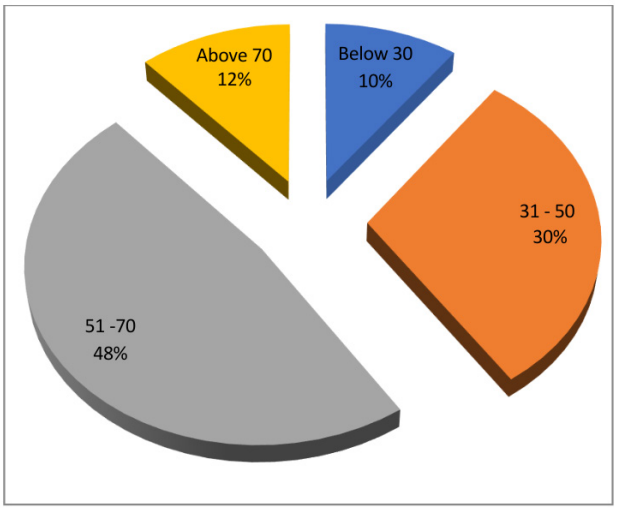

Figure 1: Age group division of the patients

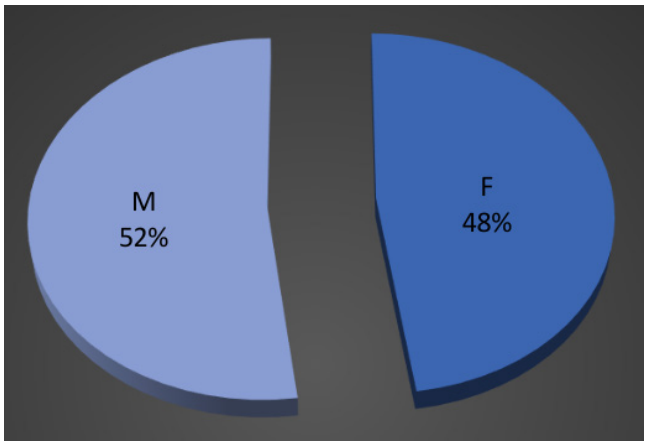

Figure 2: Gender demograhics

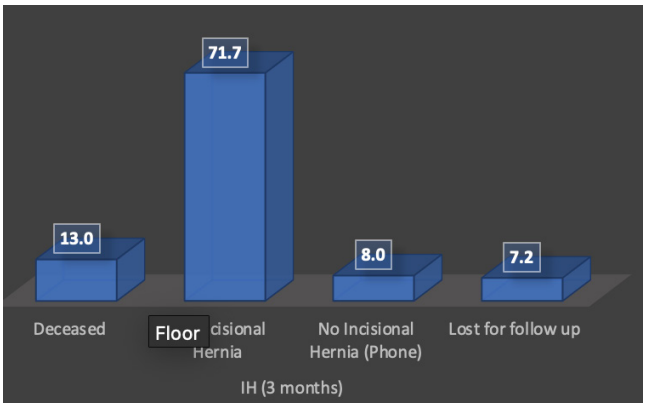

Figure 3: Incisional hernia incidence at the end of 3 months

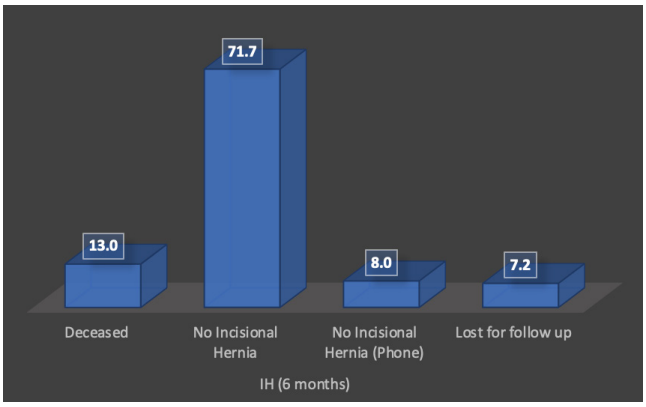

Figure 4: Incisional hernia incidence at the end of 6 months

The SL:WL ratio among emergency and elective surgeries was estimated. It was seen that 5.81 and 5.84 was the ratio in elective surgeries and emergency surgeries respectively. There was no significant difference between ratios indicating that during both electives and emergencies the bite size of the sutures were fairly the same (Table I).

At the end of interim follow up period of 3 months, there was no incisional hernia noted. 8% (n= 18), 71.7% (n=99) patients could be followed up, 8% patients (n=11) were followed up over phone and had no complaints of swelling at the surgical incision. 7.2% (n=10) patients were lost to follow up. (Figure 3)

At the end of follow up period of 6 months also, there was no incisional hernia noted. 71.7% (n=99) patients could be followed up, 8% patients (n=11) were followed up over phone and had no complaints of swelling at the surgical incision. 7.2% (n=10) patients were lost to follow up. (Figure 4)

This study provides supportive evidence that the closure techniques incorporated at our center has achieved the recommended SL:WL ratio.

DISCUSSION

Laparotomy is one of the most common surgical procedures performed globally. The mechanical support to the closed laparotomy wound is provided by the sutures and help in the initial process of healing. This study was essentially carried out to assess the suture length to wound length ratio in laparotomy incisions at a teaching institution along with finding out the incidence of incisional hernia for a follow up period of 6 months. The study included all patients above the age of 18 years undergoing laparotomy in the department of General Surgery either as an elective or an emergency procedure. In this study, we measured the wound length after closure of rectus sheath, the suture length used and a ratio of the suture length used to the wound length. Patients were then followed up and were assessed for the incidence of incisional hernia at the end of 3 months (interim period) and 6 months.

138 patients were included in this study undergoing laparotomy in the Department of General Surgery. There were 107 elective cases constituting 78% of the study population and 31 were emergency cases, constituting

Table I: Comparing SL: WL ratio among emergency and elective surgeries

Type of surgery	N	Mean	Std. Deviation	95% Confidence Interval for Mean		t test p value	
				Lower Bound	Upper Bound		
Elective	31	5.8184	0.60394	5.5969	6.0399	0.785	Not significant
Emergency	107	5.8486	0.52296	5.7484	5.9488		
Total	138	5.8418	0.54003	5.7509	5.9327		

22% of the study population. There was a wide spectrum of cases under both emergency and elective category. Elective cases included cases ranging from feeding jejunostomy to Whipple's procedure. Emergency cases included acute bowel obstruction, bowel perforation, etc. The SL: WL ratio among the emergency cases were between the range 5.6 to 6.03 and that among elective cases were between 5.52 to 5.94.

Jenkins TPN (9), in his study found that the diameter of the suture material and the bite size had an inverse relationship with the force distribution between interface of suture and tissue. Based on this principle, ideally larger bites with thicker sutures are supposed to have reduced tendency to cut out than small bites with thin sutures. The minimum suture to wound length ratio to reduce formation of incisional hernia was found to be 4:19,15.

A study by Deerenberg and colleagues in 2015, showed that small tissue bites resulted in lesser rates of incisional hernia than with large fascial bites. At a follow up period of one-year, incisional hernia rate was found to be significantly lower in the small bites group (13%) than those in the large bites group (21%) (6). The multicenter, prospective, double-blinded, randomized controlled STITCH (Small bites versus large bites for closure of abdominal midline incisions) trial by using interrupted sutures, abdominal wound dehiscence risk can be reduced to less than one-third. The malfunction or delay in collagen synthesis is supposed to be the most important risk factor in the development of incisional hernia after laparotomy. The important predictors of burst abdomen according to Agarwal et al (16)., were intraperitoneal sepsis, uremia, cough, wound infection and necrosis of linea alba. Patel SV et al (17) reviewed 55 RCTs in which 19,174 participants were included in the meta-analysis. They found that the majority of incisional hernias to occur within the first two years after surgery thereby suggesting that initial wound closure is an important factor in hernia prevention. According to this study, around 5.2% of incisional hernias were diagnosed within the first 12 months, while 10.2% of hernias were diagnosed within the first 24 months.

Friedman et al (18), in his study proved a direct association between a reduced collagen I/III and an unstable scar following laparotomy. He also asserted that connective tissue disorders, steroid therapy, malnutrition, use of nicotine are also contributing factors for the development of incisional hernia.

In surgical practice, patient criteria along with clinical preference form the basis of choice of operation. For a surgeon, ease of access to the abdomen, time to open and close the abdomen, the incidence of postoperative complications like surgical site infection, burst abdomen, incisional hernia is important. However, for a patient, pain and quick return to near normal function is important especially after a laparotomy. The main supportive structures of the body are muscles and fascia. By the end of 2 weeks approximately 20% of the fascia of abdominal wall would be healed; by the end of the month at least 50% would be healed. 60-80% healing happens by 2 months and by the end of a year it is around 90%. After successful wound closure, fascia begins to have strength by 2-4 weeks but there is risk for wound dehiscence. By 40 days the abdominal wall regains 50% strength, 70% by 120 days and 73-93% by 140 days (16). Apart from the suture length to wound length ratio, other factors were to be considered in abdominal wound closure.

Itatsu K et al (20)., conducted a study wherein 3927 patients who underwent abdominal surgery were analysed and followed up. The primary endpoint of the study was incisional hernia. The risk factors of incisional hernia were analysed and the effect of preoperative chemotherapy in cancer patients was one of the study variables. It has been advocated that preoperative chemotherapy induces immunosuppression which in turn impairs the tissue-healing process and render patients susceptible to infection. Preoperative chemotherapy in their study had a hazard ratio of 1·61 and a significant 'p' value of 0.017. In our study, there were 75 cancer patients and 62 patients among them received neoadjuvant chemo-radiotherapy.

The surgical technique and the suture material used are important determining factors for closure of abdominal wall incisions. To provide guidelines on the materials and methods of abdominal wall closure for all surgical specialists, the European Hernia Society formed the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach. In this study which was conducted in 2015, after literature search, publications up to April 2014 were included. This study, recommends utilisation of a non-midline approach to a laparotomy whenever possible. Continuous suturing technique with slowly absorbable monofilament suture is advocated for elective midline incisions with a suture length to wound length ratio of at least 4:1, but this study did not provide any guidelines for optimal closure of emergency laparotomy incisions (21).

Fink et al (22) in 2014, analysed the 3-year follow up of two prospective trials namely ISSAAC study, to evaluate the safety and the efficacy of suture material for abdominal wall closure after primary median laparotomy and INSECT study which stood for Interrupted or continuous slowly absorbable Sutures – Evaluation of abdominal Closure Techniques – a multicentre randomized trial. Fink and his colleagues reported that there was an increase in incisional hernia rates from 12.6 % at the end of 12 months to 22.4 % at 26 months which was statistically significant with a p value of 0.001.

Garcia- Valdecasas et al (23) in their randomised

controlled trial, compared midline with oblique incisions, however, did not show significant difference in the incidence incisional hernia. Incisional hernia rate of 14 % was reported after a midline incision and 4 % after oblique incision in a study by Blomsedt et al (24), which was statistically significant ($p<0.01$).

A study by Yamada. T et al (25) in 2016, that considered colorectal cancer resections, indicated that the development of IH was influenced by higher age. The study suggested that patient characters play an eminent role in the abdominal wound healing and incisional hernia development. It was also propagated that age-related changes in the composition of interstitial collagen may affect abdominal wound healing. These age-related physiological changes are one of the etiological mechanism for incisional hernia development. Hence from this study the risk factors for incisional hernia were delineated, like, choice of surgical procedure, male sex, post-operative wound infection, acute surgery (emergency laparotomies), obese patients with excessive adipose tissue. These factors are associated with higher incidence of incisional hernia formation, thereby giving a clue to the surgeons in identifying high risk patients and being more meticulous (26,27,28,29).

This study has several limitations that should be acknowledged. A proportion of patients (n = 11) were followed up via telephone due to long commuting distances, and reliance on clinical assessment alone may have resulted in missed small or subclinical incisional hernias. The sample size within certain incision subgroups, particularly paramedian and transverse incisions, was relatively small, limiting subgroup comparisons. Additionally, ten patients were lost to follow-up for various reasons, which may have affected outcome assessment. Important confounding factors, including serum albumin levels, body mass index, smoking status, diabetes mellitus, and chemotherapy, were not evaluated in the analysis. Finally, the relatively short follow-up duration of six months is insufficient to capture the true incidence of incisional hernia, which is known to peak up to two years postoperatively.

CONCLUSION

The mean suture length to wound length ratio observed in this study was 5.68:1 across all cases. No incisional hernia was detected during the 6-month follow-up period, although longer-term follow-up is required to confirm sustained outcomes. While potential confounding factors such as serum albumin levels and wound healing parameters were not systematically analyzed, they were unlikely to have significantly influenced the suture length to wound length ratio in this cohort, particularly in the absence of incisional hernia.

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