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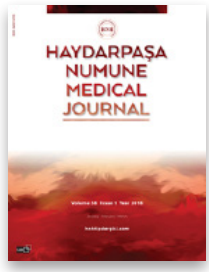

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ORIGINAL ARTICLE

Tissue Response to Suture Materials (4 Different Sutures) Used in Fascia Repair in Single-Port Laparoscopic Cholecystectomy

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Abstract

Introduction: This study aimed to evaluate the tissue inflammatory response to suture materials used for fascia repair in single-port laparoscopic cholecystectomy.

Methods: The medical records of 65 patients who underwent single-port laparoscopic cholecystectomy in general surgery clinics at state hospitals between December 2013 and January 2015 were retrospectively analyzed. Tissue reaction to the suture materials used for repairing a 2-cm fascia incision in single-port laparoscopic cholecystectomy was evaluated. Tissue reaction to the following suture materials used for repairing the fascia defect was analyzed: non-absorbable braided polyester, non-absorbable monofilament polypropylene, absorbable polyfilament polyglactin, and absorbable monofilament poldioxanone.

Results: Non-absorbable braided polyester was used in 14 patients, non-absorbable monofilament polypropylene in 25 patients, absorbable polyfilament polyglactin in 10 patients, and absorbable monofilament poldioxanone in 16 patients. Patients were followed up for at least 6 months. Fourteen patients who had a foreign body reaction could not be treated by antibiotherapy and therefore underwent surgery to excise the sutures responsible for inducing the reaction.

Discussion and Conclusion: Non-absorbable braided polyester caused tissue reaction, which could not be treated by antibiotherapy and medical treatment. All the patients who underwent surgery with this suture material had to be reoperated to excise the suture material. The patients who underwent surgery with other suture materials did not exhibit soft tissue reaction.

Keywords: Foreign body reaction; hernia; laparoscopic cholecystectomy; sutures.

Injury is defined as the compromise of the anatomical integrity of the tissues for whatever reason. Wound care and treatment practices are as old as the history of mankind. The goals of the treatment are alleviating mechanical damage, stopping the bleeding, preventing infection, and returning to daily life. The concept of injury is an issue for all surgery residencies, and the methods of treatment require a multidisciplinary approach [1, 2].

Sutures are implants used in all major and minor operations. Although these implants have improved over time to generate less foreign body reaction, owing to incorrect decisions, the reaction is inevitable [3].

The expectation from a surgical suture is good closure of the wounded tissue in the least amount of time for maximum treatment. Currently, there is a broad selection of surgical sutures produced from natural and synthetic materi-

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Table 1. Classification of surgical sutures

1. Absorbable		2. Non-Absorbable	
Natural Surgical Sutures	**Synthetic Surgical Sutures**	**Natural Surgical Sutures**	**Synthetic Surgical Sutures**
Basic Catgut	Polyglactin 910	Silk	Polyamid
Chrome Catgut	Polydioxanone	Linen	Polyester
Kollagen Strings	Polyglycolic acid Polypropylene Polymethylene carbonate Poliglecaprone 25	Cotton Horsehair suture	

als. For centuries, there have been studies on creating the optimum surgical suture, but such a material that covers all the ideal aspects and can be used for all surgical procedures does not yet exist. It is preferred that the material selected by the surgeon should yield the best results during and after the operation [2, 4].

The basic criteria for selecting the most ideal suture material are as follows:

- Tensile strength
- Easy tissue bite
- Knot safety
- Tissue travel with the suture
- The reaction of the tissue to the suture string
- The convenience of the suture, minimum string memory when unpacked.

The selection of the suture material is an important factor in the occurrence of tissue reaction and prevention [5]. Selecting the most appropriate surgical suture depends on the dynamic process of cellular, physiological, and biochemical events in wound healing and the suture material. As each operation area has a different feature, the surgical sutures are classified as seen in Table 1.

It is a fact that the healing periods of tissues differ from one another. As the healing of fascia requires more time than that of normal tissues, in abdominal operations, transverse abdominal fascia closure should be done with the right suture material [6].

Taking into consideration that the surgical sutures used were widely acknowledged, after 6 weeks of implantation, the loss of tensile strength would be minimal. Greenwald et al. conducted an invivo study of tensile strength and loss of tensile strength ratio after 6 weeks with 10 different surgical sutures of the same size. With this study in mind, four suture materials were used for fascia closure in our study (Table 2).

The features of the suture materials used are as follows:

Polyglactin 910, during wound healing, provides the required tensile strength for the ligation of tissues for approximately 3 weeks.

Polydioxanone has non-antigenic and non-pyogenic properties that make it superior to its counterparts. It resorbs very slowly by hydrolysis and creates minimal tissue reaction. It promotes mechanical support for 6 weeks. With this property, it has twice the support compared with that of other sutures.

Polypropylene is immobile and keeps tensile strength for two years. Tissue reaction is minimal and has better knot than other synthetic sutures. Prolene can be used when there is an infection as it is a capillary monofilament material.

Polyester is immobile and maintains tensile strength for 2 years. The tissue reaction rate is low. It is a capillary multifilament material. It traumatizes the tissues when used. To decrease the rate of trauma and manipulation, it is coated with Ethibond®polybutylate [7, 8].

Monofilament suture materials comprise a single thread, whereas multifilament suture materials comprise multiple threads woven together [9].

Table 2. Tensile strength of different surgical sutures before and after 6 weeks of invivo incubation [7]

Suture Material	Tensile Strength before Implantation (N/m^2)	Tensile Strength after 6 weeks of Implantation (N/m^2)	Loss of Tensile Strength aftter 6 weeks of Implantation (%)
Polyglactin 910	0.234	Absorbed after 6 weeks	
Polyester	0.279	0.270	Minimal
Polypropylene	0.577	0.479	17
Polydioxanone	0.784	0.332	58

All suture materials are foreign to tissues and can cause tissue reaction [10]. The severity of the reaction depends on the amount, type, and configuration of the suture used. The degree of reaction reaches its peak 2–7 days after implantation [11]. The reaction to foreign bodies can be described histologically as follows: acute inflammation, chronic inflammation, granulation tissue formation, foreign body reaction and fibrous capsule formation [12].

The inflammatory response differs for every other suture material used. In our study, we compared different suture materials used in single-port laparoscopic cholecystectomy and the tissue response to these suture materials.

Materials and Methods

Between December 2013 and January 2015, patients admitted to the emergency department and general surgery clinic for abdominal pain and dyspeptic complaints were retrospectively observed. The study was conducted at 50 inpatient capacity wards in government hospitals. This study included 65 patients with cholelithiasis, gall bladder polyps, and gall bladder sludge who underwent single-port laparoscopic cholecystectomy. Patient medical records were retrospectively scanned for age, sex, height, weight, body mass index (BMI), American Society of Anaesthesiologists score, operation duration, presence of a drain bag, discharge time, and complications. All data were analyzed using Mac SPSS v21.

Informed consent was obtained prior to conducting the study (25.03.2015 - Ethics No: 213).

Hepatobiliary ultrasound (USG) was performed for every patient, and all patients were diagnosed with a benign gall bladder disease. The same surgical team using the same technique performed all operations. The umbilicus was everted, and a vertical incision was made. The linea alba was seen after the subcutaneous tissue was passed. A flexible SILS port (Covidien) (Fig. 1) was inserted between two rectus abdominis muscles. The abdomen was inflated with CO_2 gas, and pneumoperitoneum was established. The camera and hand tools were inserted through channels of the SILS port. At this stage, an additional trocar was needed for two patients with BMI of 38.06 and 43.2 because the tool was not sufficiently long. Four patients had acute cholecystitis. These patients also needed an additional trocar as the gall bladder could not be handled conveniently. All patients underwent laparoscopic surgery without conversion.

The transverse abdominal muscle fascia was closed after removing the SILS port. Four different suture materials were used for this purpose: braided polyester for 14 patients, polypropylene for 25 patients, polyglactin for 10 patients, and polydioxanone for 16 patients. Patients were divided into four groups according to the suture material used (Fig 2).

Figure 1. Covidien flexible SILS port.

Patients were followed up for 1 year postoperatively. Patients with wounds emitting a foul odor or showing discharge and redness underwent control USG and were administered antibiotics. Patients with persistent complaints underwent a second surgery after at least 6 months. Non-absorbable suture materials were excised. After the second operation, progressive healing was observed on the wound area of these patients.

Results

This study enrolled a total of 65 patients. The study group consisted of 43 women and 22 men with an average age of 47.90 (range: 21–75) years and average BMI of 26.94 (range: 19.6–43.25).

After fascia closure following single-port laparoscopic cholecystectomy, 65 patients were divided into four groups

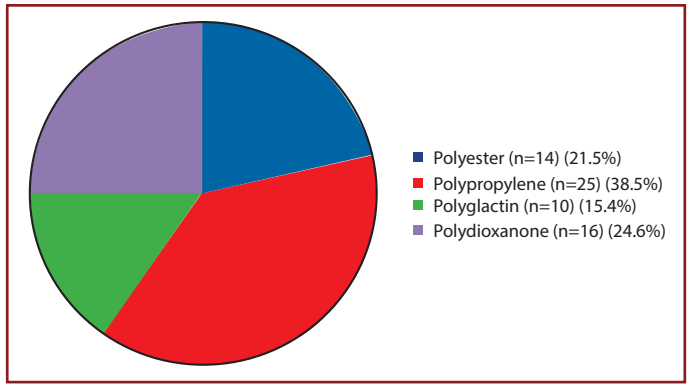

Figure 2. Patients were divided into four groups according to the suture material used for fascia closure.

according to the suture material used: group 1:14 patients who received braided polyester sutures, group 2:25 patients who received polypropylene sutures, group 3:10 patients who received polyglactin sutures, and group 4:16 patients who received polydioxanone sutures. In group 1, 13 patients developed tissue reaction, whereas in other groups, this reaction was not seen (Fig. 3). Data was observed with SPSS v21. Statistical analysis was conducted using the chi-square test. The result was, $p<0.01$. The foreign body reaction developed in patients of the group in which braided polyester was used (group 1) had shown a statistically significant difference in comparison to other groups ($p<0.01$).

The average operation duration was 90.90 (range: 50–185) minutes. Three patients had bile drainage postoperatively. One patient underwent surgery on the first day postoperatively for 300cc daily drainage. Aberrant bile drainage was diagnosed laparoscopically and clipped. After 7 days, no bile drainage was observed, the drain was removed, and the patient was discharged. Bile drainage in two patients stopped spontaneously. Patients were discharged within an average of 1.21 (range: 1–7) days. While 53 patients were discharged on the first postoperative day, 11 were discharged on the second postoperative day following drainage. All patients were administered prophylactics: 1 g of cephalosporin (cephazoline) preoperatively. On the 15th day of the operation, 14 patients who underwent surgery with the braided polyester suture for fascia closure had redness and discharge on their umbilical area. Antibiotic treatment was resumed for these patients. None of the patients had a remission. USG was performed to check for collection and incisional hernia. Tissue edema due to the inflammatory response was observed, whereas no additional pathology was observed. These patients were reoperated after waiting for fascia recovery (a minimum of 90 days). Under sedoanalgesia, suture materials that induced inflammation were excised (Fig. 4). A sample of the excised material was taken for pathological examination. The results were non-specific pus and fibrosis (Fig. 5). Fascia recovery was complete, no resuturing was needed, and thus, only the skin was closed. Patients who underwent a second operation had no inflammatory findings. At the 1-year follow up, no incisional hernia was observed after the first or the second operation.

At the end of the 1-year follow up, one patient from the polypropylene group and two patients from the polyglactin group (a total of 3) had incisional hernia. Patients from the polyester and polydioxanone groups did not develop incisional hernia.

Discussion

In abdominal operations, a broad range of absorbable and non-absorbable sutures can be used for fascia closure. Each

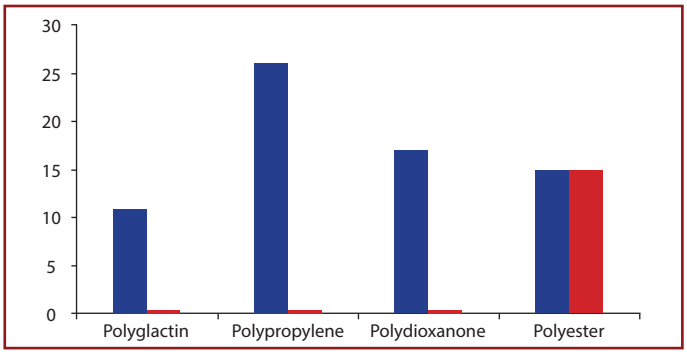

Figure 3. In Group 1, all the patients developed tissue reaction, whereas in other groups, this reaction was not observed.

Figure 4. Suture materials that induced inflammation were excised.

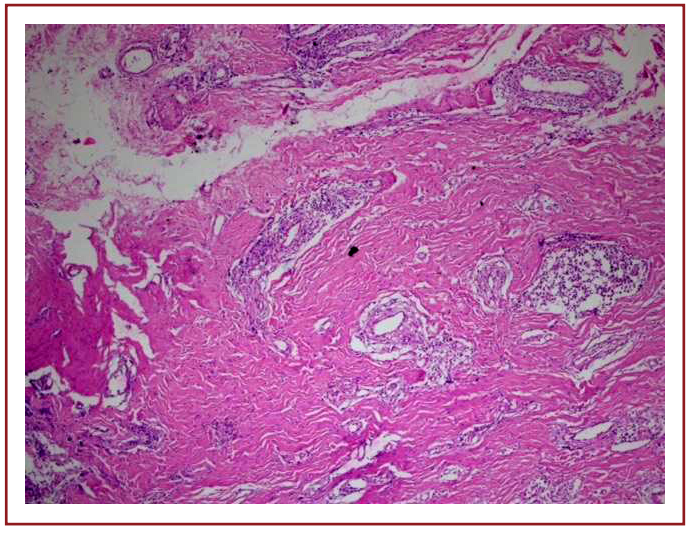

Figure 5. A sample of the excised material was sent for pathological examination. The results were non-specific pus and fibrosis.

suture material has its pros and cons. Every material is perceived as a foreign body by the organism and thus creates tissue reaction at different rates [13].

There are few studies on suture materials, their interactions, and tissue reaction. In some experimental rat studies, the endurance caused by suture materials and tissue reaction were evaluated, and poliglecaprone and polydioxanone were found to be appropriate suture materials for wide-defect area repairs. In these studies, polyglactin 910 was found to create severe tissue reaction, and thus, it should be used on non-infected areas [14, 15].

In the experimental study of Lambertz et al. [16], the suture materials polyvinylidene fluoride (PVDF), polyester (Miralene®), polytetrafluoroethylene (Gore®), poliglecaprone (Monocryl®), polydioxanone (Monoplus®), and polyglactin 910 (Vicryl®) were researched for tissue reaction. Histopathological and immunohistochemical analyses were performed, and it was found that each suture material can induce a foreign body reaction in relation to inflammation, proliferation, and fibrotic tissue. The suture material can develop a granuloma.

Anderson et al.[17], in their clinical study conducted on sea rabbits, analyzed the gross and histological reactions of Aplysia californica to five commonly used suture materials, including polydioxanone, black braided silk, polyglactin 910, monofilament nylon, and monofilament poliglecaprone. Compared with untreated control tissue, all suture materials caused significantly increased tissue reaction, but the overall histology score did not differ among the suture materials. In this study, silk was shown to create less tissue reaction and induce less granuloma formation. Other materials did not differ in this aspect.

In an experimental study with 21 male albino rabbits, silk, PVDF, polyglycolic acid, and catgut suture materials were applied on the oral mucosa and were evaluated for inflammation, granulation formation, and fibrosis. The result of this study showed that PVDF was the ideal suture material in comparison to other suture materials [18].

There are few human studies on tissue reaction against suture materials. A case was reported on an allergic reaction to prolene suture material. A 27-year-old female with a history of Ehlers–Danlos syndrome underwent surgery for chiari type 1 malformation, and the dura defect was closed with a prolene suture. After 2 months, the patient presented with urticaria and itching on the incision area. Diagnosis was made with a skin allergy test [19].

The formation of a suture granuloma is one of the reactions caused by suture materials. Granulomas created in experimental studies are clinically observed in many cases where suture materials are used. Suture granulomas usually occur when a non-absorbable suture material is used. This formation presents itself as a foreign body reaction and is characterized by giant cells with multiple nuclei, which is a specific inflammatory response to the suture material. The granuloma can develop after every operation in which a non-absorbable suture material is used. The granuloma formation can be diagnosed on clinical suspicion and radiology [20-22].

In an animal study by Esenyel et al.[3] with three different thread materials (monofilament polypropylene, braided polyester, and braided polyethylene–polyester mix), it was found that non-absorbable braided polyester created higher tissue reaction than the other threads at the end of the 6th week.

A current systematic review analyzing surgical techniques for abdominal wall closure (INLINE) revealed a significantly lower incisional hernia rate using a continuous (instead of an interrupted) suture technique with a slowly absorbable (instead of a rapidly absorbable) suture material for elective, primary abdominal wall closure [23]. Furthermore, a comparison of absorbable vs. non-absorbable sutures, independent of the suture technique, showed a significantly lower incisional hernia rate for absorbable sutures in comparison to non-absorbable ones. These findings were contrary to those of some existing meta analyses favoring non-absorbable sutures as the ideal suture material for the closure of midline incisions [24, 25].

In a prospective multicenter clinical study by Albertsmeier et al.[26], suture materials MonoMax®, PDS®, and MonoPlus® used for the closure of abdominal wall midline incisions were compared. It was found that MonoMax® was the ideal suture material for the closure of midline incisions. In a related study, MonoMax®, an absorbable, long-lasting, ultra-flexible, and elastic monofilament, had an excellent starting durability and anticipated constant degeneration rate. When compared with other absorbable suture materials, it was shown that the MonoMax® knot was ideal for abdominal wall closure and had long-lasting durability against the linear pulling force for extra safety.[27]

To date, there is no clinical study evaluating tissue reaction induced by suture materials, except case reports. Our study aimed to evaluate the foreign body reaction to polyester suture materials used in single-port laparoscopic cholecystectomy for the closure of a 2-cm midline umbilical incision made for port entry. In 14 patients who underwent surgery with polyester sutures, the use of this material was

discontinued due to discharge and inflammation developed against the suture material. The discharge and inflammation did not respond to antibiotherapy but ceased after the material was excised. The excised suture threads and tissue samples were analyzed, and it was concluded as a foreign body reaction against the suture material. In our study, other suture materials polydioaxanone, polyglactin 910, and polypropylene did not cause any foreign body reaction. Polyester is a non-absorbable braided material. Polypropylene is a non-absorbable suture material and is a monofilament. Polyester is the only suture material out of the four threads that did not lose its tensile strength after 6 months. However, the inflammation that presented with tissue reaction was unacceptable. We thought that the cause of the foreign body reaction was the polyfilament structure of polyester.

In the light of these findings, the improper selection of the suture material may be an important factor in foreign body reaction; however, there are also many other factors (biological, surgical method, experience of the surgeon, sterility) [28].

Conclusion

In conclusion, the selection of the suture material for fascia repair and the material's reliability, potency, and tensile strength loss constant should be considered. The selected suture material must not cause tissue reaction and inflammation. According to our findings, braided polyester used for fascia closure causes severe foreign body reaction. Our literature review indicated that there is limited research on the use of braided polyester, which was used in our study.

Ethics Committee Approval: The approval of the local Ethics Committee was obtained. (25.03.2015 - Ethics No: 213)

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Authorship Contributions: Concept: S.F., T.D.; Design: S.F., T.D.; Analysis or Interpretation: S.F., T.D., O.S., S.S.; Literature Search: S.F., S.S., D.F.; Writing: S.F., T.D., O.S.

Conflict of Interest: None declared.

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