



Abdominal Hernia Suturing Technique in Primary Abdominal Hernia: Spider Suture - An Experience on 74 Patients

Demirci-Aydin N^{1,2}, Grützmann R² and Demir R^{1,2*}

¹Medical Care Center, MVZ PD Dr. Demir & Colleagues, Nürnberg, Germany

²Department of Surgery, University Hospital Erlangen, Erlangen, Germany

Abstract

Background: The development of suturing techniques for the abdominal fascia appears to have concluded with two techniques - interrupted or continuous - as outlined by the European and American Hernia Society guidelines. The following study describes an additional suturing technique for closing the abdominal fascia using circular stitches, which seems to represent an improvement over existing technique.

Materials and Methods: Between 2014 and 2020, we used the "spider suture technique" to repair umbilical- and epigastric hernias in 74 patients, who did not want a mesh, if it was needed regarding to the guidelines. In addition to a continuous suture, the spider suture involves multiple individual circular threads, which are woven through the ventral sheath of the Linea alba and knotted with themselves to create a new architecture of the Linea alba. This technique prevents the fascia from tearing due to poor quality of the fascia or increased repetitive pressure on it.

Results: The median follow-up time was 30 months. There were no recurrences recorded. All patients reported good to very good satisfaction.

Conclusion: In conclusion, the spider suture represents an effective new technique for closing the abdominal fascia following primary abdominal wall hernias. However, further prospective randomized clinical trials are required to determine the extent of its improvement over existing techniques.

OPEN ACCESS

*Correspondence:

Resit Demir, Department of Surgery,
University Hospital Erlangen,
Maximiliansplatz 2, 91054 Erlangen,
Germany, Tel: +49 911966170; Fax:
+49 9119661735

Received Date: 17 Jul 2023

Accepted Date: 07 Aug 2023

Published Date: 12 Aug 2023

Citation:

Demirci-Aydin N, Grützmann R,
Demir R. Abdominal Hernia Suturing
Technique in Primary Abdominal
Hernia: Spider Suture - An Experience
on 74 Patients. *Clin Surg.* 2023; 8:
3654.

Copyright © 2023 Demir R. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Introduction

Every abdominal surgeon who performs suturing of the abdominal wall after an elective laparotomy or treatment of a primary abdominal wall hernia desires complete healing of the fascia and aims to avoid any further operations for the patient. To this end, the European and American Hernia Society has recommended a specific suturing technique in its latest 2022 guidelines, following a review of the literature. This technique involves avoiding midline incisions, using monophilic slowly absorbable suture with a Suture Length to Wound Length ratio (SL/WL) of 4:1, utilizing small bite technique and continuous suturing [1]. The interrupted suturing technique is another known method, while other innovative suturing techniques [2-4] are not yet considered by the Society. The evolution of suturing techniques for the abdominal fascia appears to have culminated with these two suturing techniques, and the next recommended step for reinforcing the fascia is mesh insertion.

In the following work, a new suture technique is described for closure of the abdominal fascia, which improves upon the previous methods. This provides surgeons with a fresh approach to consider when suturing vulnerable tissue. Primary umbilical hernias or epigastric hernias of the abdomen, even if they are small, can lead to a multitude of follow-up procedures ranging from 1-6 revision surgeries in an unusually short time [5]. As is also reported in the Herniated register, it can start with a primary suture and can take all forms of the currently available surgical techniques: Open IPOM, laparoscopic IPOM and end with open mesh insertion with reconstruction of the abdominal wall with sublay augmentation [5]. We know of similar courses of the disease from our own observations in a 10-year analysis of patients with incisional hernias who were last treated with the Erlangen Inlay-Onlay-Mesh (EIOM) repair technique [6]. Especially with these patients we became aware that the suture material used is not the problem, but the fascia. The sutures hold, but the fascia fails to withstand the repetitive pressure and tears [7]. The thinner and finer the fascia,

the higher the probability that the suture performed will not lead to healing but to an incisional hernia of the fascia. There are also other factors influencing the development of incisional hernias. These are broken down by Schumpelick et al. as follows:

1) surgical-technical factors, including incision, suture material, and suture technique; 2) patient-related biological factors, including wound healing, local wound healing disorders, age, gender, concomitant diseases, obesity, anemia, malignant underlying disease, diabetes mellitus, and abdominal aortic aneurysm; 3) exogenous noxae, including nicotine consumption and medication; and 4) hereditary collagen diseases, patient dependent [8].

In light of various factors that can influence the development of incisional hernias, it is important to note that surgeons can only impact surgical-technical factors in hernia repair to prevent recurrence. Studies have shown that the incision itself does not play a significant role in the development of incisional hernias after primary laparotomy [9,10]. When selecting suture material, meta-analyses have demonstrated that the lowest incidence of incisional hernias occurs with monofilament, non-resorbable, or long-term resorbable suture material [11-13]. However, non-resorbable suture material may lead to permanent mechanical irritation of tissue and increase the risk of suture fistulas and postoperative wound pain [8,12]. Jenkins proposed a suture length to wound length ratio of 4:1 in 1976, which has been confirmed in experimental and clinical studies [14-16]. Meta-analyses have demonstrated the advantage of continuous suture [11,12].

A more recent meta-analysis by Patel et al. in 2017 evaluated 55 randomized controlled trials with a total of 19,174 participants and examined the following primary endpoints [17]:

- Seam absorption: Absorbable versus non-absorbable materials; slow versus fast absorbable sutures.
- Closure technique: Continuous versus interrupted closure;
- Closure method: Mass versus layered closure;
- Monofilament versus multifilament sutures.

The study found no evidence that suture absorption, closure method, or closure technique affected the risk of incisional hernia development. However, it did suggest that monofilament sutures reduced the risk of incisional hernia compared to multifilament sutures.

In 2020, the European Hernia Society and American Hernia Society formulated guidelines for the treatment of umbilical and epigastric hernias based on previous knowledge from the literature [18]. The guideline group classified umbilical and epigastric hernias based on defect diameter as small (0 cm to 1 cm), medium (greater than 1 cm to 4 cm), and large (>4 cm). Given the reported recurrence rate of 1% to 57% when using the suture technique and the significantly reduced recurrence rates with mesh insertion, the guideline group recommended mesh insertion for primary umbilical and epigastric hernias larger than 1 cm. A cohort study cited by the guideline group concluded that mesh treatment for small hernias <2 cm would reduce the recurrence rate from 21% to 10% [19].

It is important to note that most studies in the literature comparing hernia suture technique or mesh insertion to closure of the fascia used either a classic continuous or interrupted suture technique. Therefore, the European and American Hernia Society

recommends the above-mentioned fascial closure in hernias.

In this work, we introduce a new approach to suturing technique called the "Spider Suture" [20], which aims to decrease pressure on the fascia. Regardless of the suture material or whether the single or continuous suture technique is used, the fascia will tear if the suture's tensile strength exceeds the fascia's breaking strength. To reduce tension on the fascia and design the suture independently of the fascia quality, circular seams are made like a spider's web. The knotted circular seams maintain tension, reducing pressure on the running suture in the midline. Experimental investigations using simple methods have confirmed that a circular stitch technique can increase the tear strength of paper by up to 287% when compared to a classic continuous suture technique [20]. Since 2014, we have implemented the "Spider Suture" technique for abdominal closure in patients with umbilical and epigastric hernias, who didn't want a mesh if it was needed regarding the Hernia Society guidelines. In this retrospective study, we aimed to evaluate the outcomes of this technique from its implementation in 2014 until November 2020. The results of this study are presented in the following sections.

Materials and Methods

Operation method

Basic Spider-Suture-Technique (BSS): Figure 1 describes the classic running suture technique. Figure 2 describes the basic spider suture technique. After exposure of the hernial sac and repositioning of the contents into the abdominal cavity, the edges of the fascia were accurately exposed. The Spider Suture was started with a circular suture along the edges of the fascia (ventral sheath of the Linea alba) at a distance of 1 cm (Figure 2.1). Depending on the quality of the fascia and the BMI of the patient, monophilic, non-absorbable threads with a strength of 2/0, 0 or 1 were used. In the second step, the classic continuous suture was performed with a monophilic, non-absorbable thread (Figure 2.2).

Advanced Spider-Suture-Technique (ASS): Figure 3 describes the Advanced Spider-Suture Technique. After completing the Basic Spider Suture, the Advanced Spider Suture was applied depending on the patient's size, fascial quality and BMI. The surgeon himself made the final decision on this subjectively by including the parameters mentioned above. The Basic Spider Suture (BSS) was followed by another circular suture with a monophilic, non-absorbable thread along the edges of the fascia (ventral sheath of the Linea alba) at a distance of 1.5 cm (Figure 3.1). The ASS was completed with further circular rows of sutures (Figure 3.2) with small diameters.

Patients

Before the surgery, informed consent was obtained from each patient after explaining the details of the procedure, including the type, scope, implementation, expected consequences and risks of the operation, as well as its necessity, urgency, suitability and chances of success with regard to the diagnosis or therapy as well as treatment alternatives. If several methods that were medically indicated, which can lead to different stresses, risks or chances of recovery, were explained in detail.

We performed the spider suture technique on 74 patients from 2014 to 2020 for primary hernias of the abdominal wall (umbilical and, epigastric hernias). Depending on the quality of the fascia and the prevailing fascia tension, i.e., the BMI of the patient and the size of the hernia, the hernia was repaired using either the Basic Spider Suture technique (Figure 2.1, 2.2) or the Advanced Spider Suture

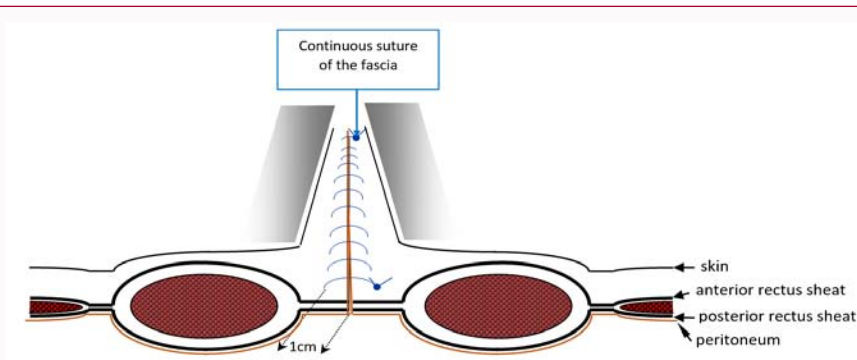


Figure 1: Classic, well-known closure technique of the abdominal wall fascia: continuous suture (blue lines).

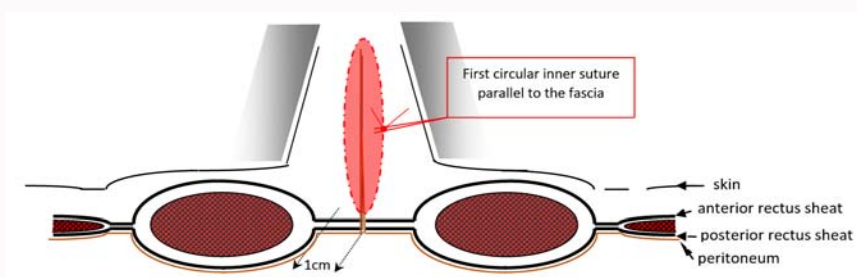


Figure 2.1: Basic Spider-Suture: First Step is to set the first circular suture in 1cm to distance to the edge of the fascia and fixing the end of Suture with a clamp: (red dashed line). With this procedure the red area of the fascia receives a pressure relief.

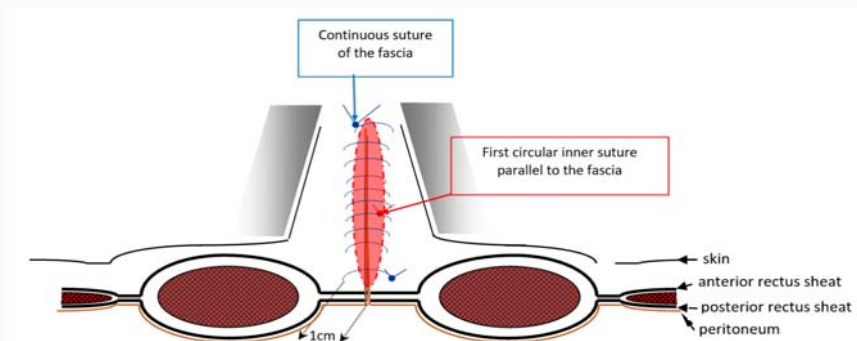


Figure 2.2: Basic Spider-Suture: First Step is to set the circular suture parallel to the fascia: (red dashed line). Then the classic continuous suture (blue) is executed and knotted. The circular suture is then knotted in such a way that the fascia is not contracted but is under tension. In this way, the pressure on the red area is relieved. This knot has to be very tight because all the force is exerted on this knot when the fascia is under tension. This is where the basic spider suture ends. Depending on the quality of the fascia and the size of the hernia, the basic spider suture was used.

(Figure 3.1, 3.2) as described by Demir R. in his 2018 publication [20].

The sutures used in this study were monofilic, non-absorbable threads with a strength of 1, 0, or 2/0 (Prolene® Ethicon Germany, Johnson & Johnson Medical GmbH, Norderstedt, Mopylen®, Resolon®, RESORBA Medical GmbH, Am Flachmoor 16, 90475 Nuremberg, Seralene® SERAG-WIESSNER GmbH & Co. KG, Zum Kugelfang 8-12, 95119 Naila, Germany). The thickness of the sutures was selected according to the quality of the fascia, the size of the hernia, and the BMI of the patient.

For follow-up data out of medical data at 6, 12, and 24 months and then every 2 years after the operation were collected. This data included a questionnaire regarding the course and the subjective state of health was filled out, and examination clinically and sonographically.

Subsequently, the data were incorporated into the IBM SPSS statistics program version 19. The level of significance was determined by the chi-square test and set at $p < 0.05$. The primary outcome was to evaluate the recurrence rate of this technique, while the secondary outcomes were subjective complaints, patient satisfaction, infection, seroma, and hematoma.

Results and Discussion

Seventy-four patients were followed up. Table 1 summarizes their baseline characteristics. Significantly more men ($n=51$) than women ($n=23$) underwent surgery. The median age was 52 years (range 21-84), and the mean follow-up was 30 months (range 12-82 months). The mean hernia size was 2.7 cm^2 (range 1-63 cm^2), and most patients ($n=63$, 85%) had a primary umbilical hernia. Eleven patients had an epigastric hernia. No recurrences were found during the observation period in patients (Table 3).

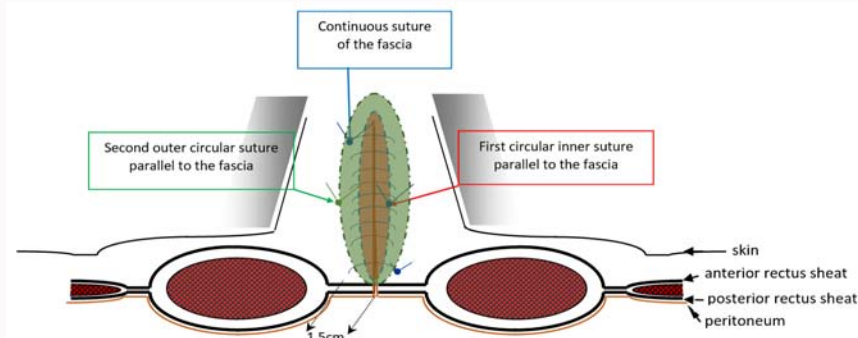


Figure 3.1: Advanced Spider-Suture: It continues with an outer second circular suture (green dashed line), which is placed parallel to the fascia. This leads to a pressure relief of the green area of the Fascia, which includes the inner circular and the continues suture.

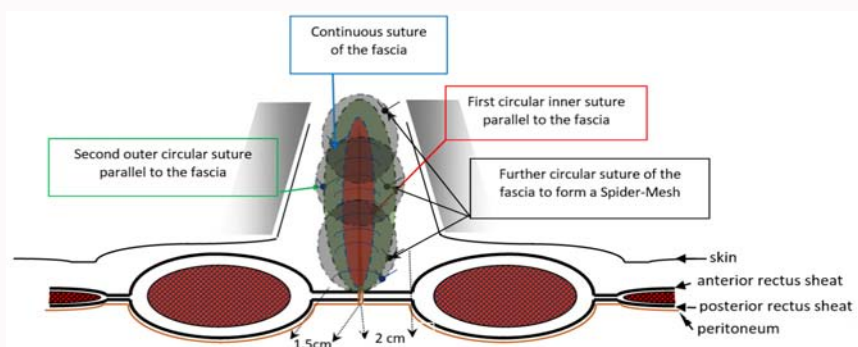


Figure 3.2: Advanced Spider-Suture ends by laying further circular suture (circular line, dashed, black), which hook into each other like a spider's web. Thus, an advanced spider suture consists of the following steps:

1. Inner circular suture parallel to the edge of the fascia (red)
2. Continuous suture (blue)
3. Outer circular suture parallel to the edge of the fascia (green)
4. Circular suture that tie all threads together to form a net (black)

By overlapping the colored surfaces, the pressure relief on the fascia is increased. The pressure relief is the higher, the more surfaces overlap.

One subcutaneous infection was observed during the follow-up period. One patient developed a postoperative hematoma. Both were treated conservatively. Postoperative seroma development was observed in two patients, and the seroma was healed by puncture two or three times (Table 1). Table 2 lists the suture material used for the spider suture.

Subjectively, all patients were well to very well satisfied with the result, and the recommendation rate for other people to undergo the same operation was 100% (Table 4). About a third of the patients still had slight pain after 6 months ($n=20$, Table 5). After 2 years, except for two patients, no longer reported any complaints. Stool behavior was the same before and after the operation (Table 6). More BSS were applied than ASS (45 vs. 29, Table 2).

Primary abdominal wall hernias closed after laparotomy with a classical suture technique remain a persistent problem. The insertion of a mesh leads to a significant reduction in the incidence rate of incisional hernias. Bhangu et al. presented a systematic review and meta-analysis of mesh placement as prophylaxis to prevent incisional hernia after midline laparotomy in 2013 [21]. They concluded that mesh reinforcement after laparotomy in high-risk patients reduced the rate of incisional hernias. This idea also finds its way into the guidelines of the European and American Hernia Society [1]. In its 2022 statement, the guideline group recommends the prophylactic suturing of mesh after elective midline laparotomy in high-risk

patients to avoid incisional hernia. Routine mesh placement should still be evaluated in terms of cost and quality of life. Studies with innovative suturing techniques are not considered in guidelines by the European and American Hernia Society. Recently, an open randomized clinical trial reported the results at 3 years of follow-up of the use of the Reinforced Tension Line (RTL) technique compared with Primary Suture Only (PSO) closure in the prevention of IH in high-risk patients undergoing laparotomy [22]. With the RTL technique, the incisional hernia was significantly decreased to 9.8% (RTL group) vs. 28.3% (PSO group).

The RTL technique developed by Hollinsky et al. [3,4] is an excellent alternative to mesh repair. It is worth considering in the next guidelines. The suturing technique and the surgical approach presented in this work show a new idea and awareness of the surgical abdominal wall closure or building of pressure relief areas with circular threads.

Without detailed explanation, the Spider-Suture and RTL technique seem equal, but it is not. The idea of both techniques is developed independently. The idea of reinforced tension line is a line of thread sutured at a distance of 1.5 cm from the fascial margin between the anterior and posterior rectus sheath, as shown in Figure 1 in Hollinsky et al. 2008 [3]. Quote [3]: "The new technique is based on the load-resistant architecture of the Linea alba as described by Axer et al. [23]. In this study, Axer et al. also found fibers arranged

Table 1: Baseline characteristics of the patients with prim. abdominal hernia.

| Variable | N =74 | Variable | N=74 |
|--|---------|------------------------------------|---------|
| Gender, men/women | 60/37 | | |
| Age in years | | Abdominal Hernia | |
| Median | 52 | Primary Umbilical (%) | 63 (85) |
| Range | 21-84 | Primary Epigastric Hernia (%) | 11 (15) |
| Body mass index | | Postoperative Complications | |
| Median | 28 | Infection (%) | 1 (1) |
| Range | 17-47 | Hematoma (%) | 1 (1) |
| Follow-up in months | | Seroma (%) | 2 (1) |
| Median | 31 | Diabetes (%) | 7 (9) |
| Range | 12-82 | Steroid treatment (%) | 6 (8) |
| Intraoperative size of hernia in cm ² | | Hard-Work | |
| Median | 6.4 | No (%) | 25 (26) |
| Range | 01-63 | 5-10 kg (%) | 35 (36) |
| Intraoperative diameter of hernia in cm | 01-63 | 10-30 kg (%) | 27 (28) |
| ≤ 1 cm (%) | 1 (3) | >30 kg (%) | 10 (10) |
| <1 cm – 4 cm (%) | 62 (83) | | |
| >4 cm (%) | 10 (14) | | |
| Operation time in minutes | | | |
| Median | 32 | | |
| Range | 20-63 | | |

Table 2: Characteristics of spider suture repair of abdominal hernia.

| Spider suture (n=74) | |
|--|---------|
| Basic (%) | 45 (61) |
| Advanced (%) | 29 (39) |
| Strength of the sewing material | |
| inner circumferential suture (n=74) | |
| 2-0 | 29 (39) |
| 0 | 37 (50) |
| 1 | 8 (10) |
| Outer circumferential suture (n=47) | |
| 2-0 | 23 (31) |
| 0 | 24 (32) |
| Continued suture (n=74) | |
| 2-0 | 16 (22) |
| 0 | 58 (78) |

Table 3: Overall rate of recurrence after spider suture repair.

| Variable | N=74 |
|------------|----------|
| Recurrence | |
| No (%) | 74 (100) |
| Yes (%) | 0 (0) |

in a crosswise fashion, but no fibers in craniocaudal direction. Thus, by its very nature, the Linea alba is not suited to stabilize sutures for fascial closure." They further wrote, Quote [3]: "In order to avoid this

(rupture), we devised a suture technique for reinforcement of the suture base. A thread is inserted parallel to the fascial margin. The thread protects the tissue by distributing the tensile load uniformly into the surrounding tissue, away from the (midline) suture base."

Spider Suturing techniques is based on circular sutures. It is important to note that the circular Spider Suture is a single thread knotted to itself. It works like a mesh, which is weaved in the ventral sheath of Linea alba. As a result, the type of tissue, i.e., how thin and weak the tissue may be, or the fiber architecture of the Linea alba, mentioned above does not matter. The circular threads built a new architecture of the Linea alba. The threads are placed only on the ventral sheath of Linea alba. In this way in the surrounded area of Linea alba with circular threads, a relief of tearing pressure arise. As a result, the pressure in the inner surface of the circles is reduced the more circular sutures are applied. The circular weaved threads are communicating with each other like a spider web.

In the 74 patients with primary hernias (umbilical, epigastric) a very good result (Table 3) was achieved with satisfied patients (Table 4) who did not develop a recurrence in the median observation time of 30 months.

The results and experiences gained from this study provide motivation for evaluating this technique and approach on a larger, multi-center scale.

Aside from reducing hernia recurrence rates, investigating patients' subjective experiences has become crucial to determining whether genuine improvement can be achieved [24].

A very recent study addressed the question of whether and

Table 4: Subjective results after spider suture repair.

| Variable | |
|---------------------------------|----------|
| Satisfaction (n=74) | n (%) |
| Very good (%) | 64 (86) |
| Good (%) | 10 (14) |
| Satisfied (%) | 0 (0) |
| Rather not satisfied (%) | 0 (0) |
| Not satisfied (%) | 0 (0) |
| Recommendation of the operation | 74 (100) |

Table 5: Pain after spider suture repair.

| Variable | After 6 months | After 1 year | After 2 years |
|------------------------------|----------------|--------------|---------------|
| Pain (n=74) | n =74 | n =74 | n =62 |
| No (%) | 53 (71) | 72 (97) | 60 (81) |
| Barely (%) | 20 (27) | 2 (3) | 2 (3) |
| From time to time (%) | 1 (1) | 0 | 0 |
| Often (%) | 0 (0) | 0 | 0 |
| Always (%) | 0 (0) | 0 | 0 |
| Movement-Pain | n=74 | n=74 | n=61 |
| No (%) | 60 (86) | 72 (97) | 61 (82) |
| Yes, with every movement (%) | 13 (17) | 2 (3) | 1 (1) |
| Yes, while sitting (%) | 1 (1) | 0 | 0 |
| Yes, while going (%) | 0 | 0 | 0 |
| Yes, when binding shoes (%) | 0 | 0 | 0 |

Table 6: Constipation (Bowel movement).

| Constipation (n=74) | Pre OP | Post OP |
|-----------------------|---------|---------|
| No (%) | 60 (86) | 82 (85) |
| Barely (%) | 13 (17) | 7 (7) |
| From time to time (%) | 4 (4) | 7 (7) |
| Often (%) | 1 (1) | 1 (1) |
| Always (%) | 0 (0) | 0 (0) |

which symptoms patients still have after 3 years of incisional hernia surgery [25]. They contacted 210 patients, a little less than half of whom had been operated on laparoscopically, the remainder openly for an incisional hernia, 91.4% of those through the insertion of a mesh. They found out that 63% of patients reported symptoms 3 years after incisional hernia surgery, mostly discomfort, pain, and bulging. Thirty-seven percent of patients experienced a similar or worse condition of their abdominal wall compared to the preoperative situation. This study shows that mesh insertion, open or laparoscopic, reduces recurrence rate but does not result in patient satisfaction.

Conclusion

It is now all the more important to work on the idea of evolving suturing techniques that reduce abdominal hernias, the recurrence rate and the increase patient satisfaction.

The results and experiences gained from this study provide motivation for evaluating this technique and approach on a larger, multi-center scale.

Acknowledgement

The present work was performed in the fulfillment of the

requirements for obtaining the degree "Dr. Med." We thank all patients.

References

- Deerenberg EB, Henriksen NA, Antoniou GA, Antoniou SA, Bramer WM, Fischer JP, et al. Updated guideline for closure of abdominal wall incisions from the European and American Hernia Societies. *Br J Surg.* 2022;109:1239-50.
- Agarwal A, Hossain Z, Das A, Chakraborty S, Mitra N, Gupta M, et al. Reinforced tension line suture closure after midline laparotomy in emergency surgery. *Trop Doct.* 2011;41(4):193-6.
- Hollinsky C, Sandberg S, Koch T, Seidler S. Biomechanical properties of lightweight versus heavyweight meshes for laparoscopic inguinal hernia repair and their impact on recurrence rates. *Surg Endosc.* 2008;22(12):2679-85.
- Hollinsky C, Sandberg S, Kocijan R. Preliminary results with the reinforced tension line: A new technique for patients with ventral abdominal wall hernias. *Am J Surg.* 2007;194(2):234-9.
- Lorenz R, Koch A, Köckerling F, Herniated-Studiengruppe D. Doch unterschätzt- Nabel- und epigastrische Hernien: Herniated-Datenanalyse 2009-2014. *CHAZ-Kongresszeitung.* 2014:408-11.
- Ayik N, Klein P, Grutzmann R, Demir R. Long-term outcome of incisional hernia repairs using the Erlangen Inlay Onlay Mesh (EIOM) technique. *J Surg Res.* 2019;243:14-22.
- Mioton LM, Dumanian GA. Theoretic and evidence-based laparotomy closure with sutures and meshes. *Plast Reconstr Surg.* 2018;142(3 Suppl):117S-24S.
- Schumpelick V, Junge K, Klinge U, Conze J. Narbenhernie - Pathogenese Klinik und Therapie. *Deutsches Ärzteblatt.* 2006;103(39):A2553-8.
- Ellis H, Coleridge-Smith PD, Joyce AD. Abdominal incisions--vertical or transverse? *Postgrad Med J.* 1984;60(704):407-10.
- Greenall MJ, Evans M, Pollock AV. Midline or transverse laparotomy? A random controlled clinical trial. Part II: Influence on postoperative pulmonary complications. *Br J Surg.* 1980;67(3):191-4.
- Hodgson NC, Malthaner RA, Ostbye T. The search for an ideal method of abdominal fascial closure: A meta-analysis. *Ann Surg.* 2000;231(3):436-42.
- Rucinski J, Margolis M, Panagopoulos G, Wise L. Closure of the abdominal midline fascia: meta-analysis delineates the optimal technique. *Am Surg.* 2001;67(5):421-6.
- Weiland DE, Bay RC, Del Sordi S. Choosing the best abdominal closure by meta-analysis. *Am J Surg.* 1998;176(6):666-70.
- Hoer J, Anurov M, Titkova S, Klinge U, Tons C, Ottinger A, et al. Influence of suture material and suture technique on collagen fibril diameters in midline laparotomies. *Eur Surg Res.* 2000;32(6):359-67.
- Israelsson LA, Jonsson T. Suture length to wound length ratio and healing of midline laparotomy incisions. *Br J Surg.* 1993;80(10):1284-6.
- Jenkins TP. The burst abdominal wound: A mechanical approach. *Br J Surg.* 1976;63(11):873-6.
- Patel SV, Paskar DD, Nelson RL, Vedula SS, Steele SR. Closure methods for laparotomy incisions for preventing incisional hernias and other wound complications. *Cochrane Database Syst Rev.* 2017;11:CD005661.
- Henriksen NA, Montgomery A, Kaufmann R, Berrevoet F, East B, Fischer J, et al. Guidelines for treatment of umbilical and epigastric hernias from the European Hernia Society and Americas Hernia Society. *Br J Surg.* 2020;107(3):171-90.
- Christoffersen MW, Helgstrand F, Rosenberg J, Kehlet H, Strandfelt P, Bisgaard T. Long-term recurrence and chronic pain after repair for small umbilical or epigastric hernias: A regional cohort study. *Am J Surg.*

- 2015;209(4):725-32.
20. Demir R. Novel suturing technique for fascia closure after laparotomy: Spider suture to increase the tearing force of the fascia. *Int J Surg Res.* 2018;5(4):107-10.
21. Bhangu A, Singh P, Lundy J, Bowley DM. Systemic review and meta-analysis of randomized clinical trials comparing primary vs delayed primary skin closure in contaminated and dirty abdominal incisions. *JAMA Surg.* 2013;148(8):779-86.
22. Lozada-Hernandez EE, Mayagoitia-Gonzalez JC, Smolinski-Kurek RL, Montiel-Hinojosa L, Hernandez-Villegas L, Morales-Vargas JM, et al. Prevention of incisional hernia with a Reinforced Tension Line (RTL) versus primary suture only in midline laparotomies: 3-year follow-up in a randomized clinical trial. *Hernia.* 2022;26(2):447-56.
23. Axer H, Keyserlingk DG, Prescher A. Collagen fibers in Linea alba and rectus sheaths. I. General scheme and morphological aspects. *J Surg Res.* 2001;96(1):127-34.
24. Jensen KK, Henriksen NA, Harling H. Standardized measurement of quality of life after incisional hernia repair: A systematic review. *Am J Surg.* 2014;208(3):485-93.
25. van Veenendaal N, Poelman MM, van den Heuvel B, Dwars BJ, Schreurs WH, Stoot J, et al. Patient-reported outcomes after incisional hernia repair. *Hernia.* 2021;25(6):1677-84.