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Original Article

6:1 Suture/Wound length ratio with the short stitch technique – a reality check on practicability and short term outcome

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Abstract

Aim: To analyze laparotomy closure of conventional midline and transverse abdominal incisions in elective and emergency laparotomies with a longterm, absorbent, elastic suture material.

Method: Prospective, single centre, non randomised, controlled cohort study on short stitches with a longterm resorbable, elastic suture (material: poly-4-hydroxybutyrate) aiming at a 6:1 suture to wound (SL/WL) length ratio in midline and transverse, primary & secondary laparotomies for elective & emergency surgery.

Results: We included 351 patients (♂: 208; ♀: 143), midline (n=194), transverse (n=103) and a combined midline/transverse L-shaped (n=54) incisions. There was no stitch performance quality difference between elective (n=296) and emergency (n=55) operations, while results in the first 150 patients showed a significantly reduced SL/WL-ratio to the following 200 suture closures (SL/WL-ratio: 5.64±2.5 vs 6.1±2.3, p<0.001). Average SL/WL-ratio in general was better for midline than transverse incision sutures (6.62±2.5 vs 4.3±1.51, p<0.001). SL/WL-ratio varied among the 6 surgeons participating, although results steadily improved and eventually approximated each other.

Conclusions: We could show that a 6:1 SL/WL-ratio with a 2-0 single, ultra-long term, absorbent, elastic suture material can be significantly performed better in midline than transverse incisions. Transverse incisions should preferably be closed in 2 layers in order to achieve a sufficient SL/WL-ratio equivalent to the median incision. While on an individual level, results varied between surgeons, quality will improve and eventually approximate.

Introduction

Fascial suture technique is a delicate topic. On the one hand considered irrelevant by most surgeons, as was recently demonstrated by a questionare showing only a 35 % [1] compliance to the gold standard (> 4:1 suture / wound length (SL/WL)-ratio) [2]. The senior surgeon leaving the operating table, the taking over of laparoscopy (smaller incision, lower hernia rate [3] and the anticipated low morbidity & near zero mortality when non-compliant may have added to the reluctance to improve closure technique. Nevertheless general and visceral surgeons actually do at least perform the short stitch > 4:1 (SL/WL)-ratio more commonly (2/3) than gynaecologists/obstetricians (1/3) [4].

On the other hand, the quality of the fascial suture might influence surgical site infection (SSI) [5,6], while definitely has shown to have an impact on burst abdomen and incisional hernia rate [7].

Literature dating back to the 70`s and 80`s [8,9] when suturing evolved from a 2:1 single stay suture to a 4:1 running suture to a > 4:1 SL/WL-ratio, finally asking whether even higher ratios might prove worthwhile. Even a 6:1 SL/WL-ratio was introduced [10] and is most likely commonly been performed by whole stitches with HR 40+ needles through muscle and fascia (loop suture), respecting a stitch width >1 cm and a small stitch interval of 1 cm.

Biomechanical [11], perfusion [12,13] and pathological studies [14] further added evidence that minimising trauma to the fascia and reducing suture tension are essential for reliable closures of laparotomies.

It has been shown by Israelsson et al , that a SL/WL ratio > 4:1 will reduce the likelihood of wound infection and incisional hernia, and thinner material can provide similar, likely even better results than the traditional strong loop [5]. The same group implied in experimental and randomized clinical trials that incorporating the short stitch technique on top it will further reduce the incidence of incisional hernia rate [6,7]. Thus the 4:1 SL/WL ratio with the short stitch became the gold standard in fascial wound closure [2].

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Deerenberg et al from the Rotterdam group have shown in the STITCH -trial that incisional hernia rate following a median laparotomy (PDS II) in elective cases can reduce the 1 year incisional rate from 21 to 13 % [15] and recently the ESTOIH-trial incorporated the short stitch technique reduced incisional hernia rate with a more elastic poly-4-OH-butyrate thread even further [16]. All prospective randomized trials were performed exclusively in elective cases and included only midline incisions.

Aim of our `6:1 Short stitch Monomax trial` was the innovative move of 1) using an elastic, extra-long-term absorbent monofilament suture material (poly 4-hydroxy-butyrate) in 2) median and transverse incisions as well as in elective and emergency surgical procedures reflecting fascial closure under real life conditions.

Material and methods

The design, no of participants and statistical evaluation have been desciped in the trial protocoll (Clinical Trials. gov Identifier: NCT01938222) and have been previously presented as updates in various European Hernia Society (EHS) conferences.

Sample

We included 351 adult patients, planned for elective & emergency surgery aged ≥18 years (American Society of Anaesthesiologists (ASA) group I-IV), frequently high risk patients (stomach, liver, pancreas surgery) requiring midline and transverse incisions. Pregnant women, patients with severe neurological and psychiatric disease and lack of compliance were excluded. All participants gave written informed consent.

Surgical technique (Infobox 1)

The protocol for the suture technique required a meticulous preparation of the fascial lining about 1 cm bilaterally (freed from subcutaneous fat) in order a) to place the stitch properly 0,5-0,8 cm bilateral to the fascial edges and b) observe the adaptation of the fascia by visualising the thread. All sutures (always 2) had to start 1 cm outside the incsion cranially and caudally (midline incision), while for the transverse incision both fascial layers (ventral and dorsal) were sutured separately. For the midline incision the umbilical fascial penetration (sometimes with a minute hernia) was excised as it was considered a potential weak spot for the development of hernia formation. Sutures overlapped in the middle (by 2 stitches) - for the most around the umbilicus - and were knotted separately. Other surgical procedures were carried out according to the standard operating procedures of our hospital.

Recommendation for the short stitch 6:1 in median a& transverse laparotomies

A) *midline laparotomy* (standard)
subcutaneous preparation ventral to the fascia for 1 cm bilaterally (lat. stitch width, landing zone)
lifting and excision of umbilical cord (common minimal hernia and considered weak spot)
starter and closing knots (1 cm cranial and caudal to incision)
(bi)-lateral stitch width ([LSD] distance to fascial margin) of 5–8 mm – (learning curve !)
stitch interval [SI] in longitudinal direction (5mm)
keep suture tension low (tensiometer < 2N)
suture thread should be visible on the fascia
overlap of cranial and caudal thread in the middle (umbilical region) for 2 stitches
measure wound length at the end

B) *transverse laparotomy* (transverse fascia with lower tension strength)
(cave: button hole!)
recognize ventral and dorsal fascia (separate sutures)
suture overlapping at the fusion of ventral and dorsal fascia
- median white line (linea alba)
- lateral semicurcular line
peculiarity: lateral to the linea semilunaris stitch width and depth will have to adapt to the fascia / muscle structure (combined stitches are inevitable)
- dorsal: internal oblique muscle /transversus abdominis muscle + transversalis fascia
- ventral: External oblique muscle + fascia
- most lateral wound angle (we do single 1-0 stay sutures to insure adequate closure)

The participating surgeons (n=6) intended to achieve a short stitch 6:1 SL/WL-ratio. They were trained in situ and taught accordingly by the 1st author (MG), who introduced the SOP `short stitch`, and watched training videos by the principal investigator (R.F.) of the parallel prospective, randomized trial (ESTOIH) on short stitches.

In order to calculate the quality performance indicators (i.e. suture interval (SI), lateral sitch distance/width (LSD) and SL/WL-ratio) it is advisable to modify the commonly used suturing protocol. The short stitch technique started (`hangmans` knot) and ended (`Aberdeen` knot) with a self-fixing knot which allowed accurate measurements of the remnant thread and thus the suture length incorporated in the fascia (Infobox 2). Three parameters describing the suture technique were recorded in the operating protocol (wound length, remnant suture length, no. of sitches). Other paramenters included patient data with respect to the underlying disease and the additional risk factors. Following the operation, all complications were recorded and analyzed.

Thread material

In all patients an elastic, extra-long term, absorbent, monofilament suture manufactured from poly-4-hydroxybutyrate (p-4OHB) (MonoMax®, B.Braun Surgical, S.A., Rubi, Spain) was used for closure of the fascia in an intended 6:1 SL/WL ratio. The single 2-0 thread length was 150 cm, armed with a 26-30 HR sized needle.

Documentation and statistical analysis

Case report forms (CRFs) were filled out by 2 junior surgeons (Z.Z., S.B.) not personally involved in the suture technique and later documented in the internet based data file provided by Aesculap. Results were anonymized by a case no. which could only be reallocated to the patient at the center side (in case of queries).

All statistical analyses were done using SAS software version 9.4 (SAS Institute Inc., Cary, NC, USA). Multiple logistic regression models were calculated for midline & transverse incision, elective & emergency surgery. Experience of the surgeons were assessed after 50 & 150 operations indicating performance stitch quality over time while participating surgeons (no. 1-6) were also analyzed individually with respect to suture performance. Endpoints are presented as frequencies and rates; 95% confidence intervals are given when appropriate. The chi-square test was used for rates comparisons. Statistical significance was defined as a p-value < 0.05 for the primary outcome stepped backward elimination method was used for model reduction.

Performance indicators & documentation of the Short Stitch fascial sutures (Quality control)

Performance indicators :
Remnant suture (incorporated suture length [SL] = total suture length – remnant suture)
No. of stitches (*n*=…)
Wound length (… cm)

e.g.: median laparotomy, suture length 150 cm, wound length 29 cm
- 1st suture starting caudally: 35 stitches, remnant: 45 cm, incorporated suture: 105 cm
- 2nd suture starting cranially: 23 stitches, remnant: 70 cm, incorporated suture: 80 cm
SL/WL - ratio = 185 cm : 29 cm = 6,38
WL/stitch = interval = 29cm : 58 stitches = 0,5 cm sitch interval [SI]
SL/58 sitches = 185 cm/58 = 3,2 cm suture length/stitch
Lateral stitch width ≈ 3,2 : 2 ≈ 1,6 cm ≈ 0,8 cm lateral stitch width [LSD]

Results

Patient and suture demographics (Table 1)

We included 351 predominantly male patients (♂: n=208 [59.3%]; ♀: n=143 [40.7%]). Since we perform the majority of our lower risk operations laparoscopically, the patient clientel recruited higher risk elective (n=296, 84.3%) and emergency (n=55, 15.7%) operations. In general, these procedures require open, conventional surgery, resulting in a significant morbidity and mortality. Duration of surgery on average was quite long (163±78 min) and differed between the faster emergency (120±50 min) & slower elective (171±80 min) operations. Incision lengths were longer in elective (34±17 cm) than emergency (25±11 cm) operations. As a consequence, > 26 % of patients spent > 3 days on the ICU and the mortality rate of 5,4 % reflects the comparatively high inclusion rate of ASA 3 (44,4%) and even some ASA 4 (6%) cancer and emergency patients.

Incisions (Tables 2 and 3)

We included standard midline (n=194; 55.3%), transverse (n=103; 29.3%) and combined L-shaped (n=54; 15.4%) incisions which involved a midline and right transverse 2 layer closure. All transverse incisions were closed seperately, anterior & posterior fascial layers. Incisions for emergency cases were exclusively midline laparotomies (n=55), while gastric & pancreatic operations were typically done via a tranverse incisions. Liver operations (n=54) were always performed with an L-shaped incision (Table 2). On a patient basis, performance quality indicators (SI, LSD and SL/WL) of L-shaped incisions are somewhat distorted as they involve midline & transverse incisions. For the comparison of suture quality performance they were integrated into the midline and transverse groups (Table 3).

Comparing midline and transverse suture quality we could clearly show that performance indicators can be achieved following a midline incision, while likely to fail in transverse sutures (Table 3). Despite fulfilling the >4:1 gold standard, a short stitch 6:1 SL/WL ratio can only be persistently achieved in midline sutures (SL/WL-midline: 6.6±2.5 vs transverse: 4.71±1.63, p<0.001) mainly due to lower SIs (midline: 0.39±0.6 vs transverse: 0.47±0.13; p< 0.001) and higher LSDs (midline: 0.63±0.25 vs transverse: 0.53±0.18; p<0.001). There was no difference in performance indicators when looking for anterior and posterior sheath results following a transverse incision (Table 3).

Experience (Table 4)

To assess the technical experience for the 6:1 SL/WL-ratio plus short stitch technique, we could show that for the first 50 patients only 25% actually achieved a > 6:1 ratio, while 47% even failed to reach > 4:1 SL/WL-ratios (data not shown, presented at the EHS 2018). Furthermore, midline SL/WL-ratio barely reached >4:1 [4.5±2.9] while transverse incision SL/WL ratio fell to an unacceptably low value (3.5±0.8]. We then restarted and arbitrarily chose the first 150 operations to define a first setpoint to evaluate the quality performance indicators (SI, LSD, SL/WL-ratio). We could show a substantial and significant improvement in SI, LSD and SL/WL-ratio and – following an evaluation – aimed at improving the technique with the remaining 201 operations. From then on results substantially improved to 44% (> 6:1) and 87% > 4:1 SL/WL-ratios. Quality performance indicators could clearly demonstrate a highly significant improvement > 150 patients in SI (≤150: 0.38±0.1 to >151-351: 0.44±0.1; p<0.001) and LSD (≤150: 0.51±0.2 to >151-351: 0.65±0.23; p<0.001) eventually resulting in a SL/WL ratio of 6.1±2.3 (>151-351) from 5.6±2.5 (≤150) overall (p<0.001; Table 4).

Table 1. *Demographics of the patient clientel (n=351) in the 6:1 Short Stitch Monomax trial, subdivided into elective & emergency operations and early (< 150) and late (151-351) patient cohorts.*

Patient Clientel	Total	Indication for surgery		patient groups (early/late)	
Subgroups	**Std.dev./ [%]**	**elective**	**emergency**	**no. 1-150**	**no. 151- 351**
Patients (n)	351 [100%]	296 [84.3%]	55 [15.7%]	150 [42.7%]	201 [47.3%]
Age	66.8 ± 13.3	67.2 ± 12.8	64.7 ± 16	66.9 ± 13.2	66.7 ± 13.4
male / female (n)	208 / 143	177 / 119	31 / 24	95 / 55	113 / 88
Duration of surgery (min)	163 ± 78	171 ± 80	120 ± 50	180 ± 80	151 ± 75
Incision length (cm)	32 ± 17	34 ± 17	25 ± 11	31 ± 16	33 ± 17

Table 2. *Presentation of quality performance indicators (SL/WL-ratio, stitch interval and lateral stitch ratio) in the whole patient population with respect to the incision location.*

Performance indicators	patients overall [n=351]	midline [n=194]	transverse [n=103]	L-Shaped [n=54]	p
Incision length (cm)		22.3 ± 6.0	22.7 ± 9.9	43.8 ± 11.7	< 0.001
Stitch interval (SI)	0.42 ± 0.1	0.38 ± 0.1	0.47 ± 0.1	0.44 ± 0.08	< 0.001
Lateral stitch distance (LSD)	0.59 ± 0.23	0.61 ± 0.26	0.54 ± 0.18	0.62 ± 0.16	< 0.001
SL/WL-ratio	5.9 ± 2.4	6.6 ± 2.6	4.7 ± 1.7	5.8 ± 1.3	< 0.001

Table 3. *Presentation of quality performance indicators (SL/WL-ratio, SI, LSD) comparing midline and transverse sutures (n=509) including then anterior and posterior fascial sutures of transverse incidions.*

Performance indicators	Sutures [n=509]	Midline [n= 243]	Transverse [n=266]			p
			Total [266]	anterior [133]	posterior [133]	
Stitch interval (SI)	0.43 ± 0.1	0.39 ± 0.6	0.47 ± 0.12	0.49 ± 0.13	0.46 ± 0.1	< 0.001
Lat.stitch dist. (LSD)	0.58 ± 0.22	0.63 ± 0.25	0.53 ± 0.18	0.53 ± 0.16	0.5 ± 0.15	< 0.001
SL/WL-ratio	5.61± 2.3	6.6 ± 2.5	4.71 ± 1.63	4.5 ± 1.5	4.43 ± 1.2	< 0.001

Table 4. *Experience comparing quality performance indicators (SI, LSD, SL/WL-ratio) between the first 150 operations and the following 200 [151-351].*

Performance indicators	≤ 150 patients	151 - 351 patients	p
Stitch interval (SI)	0.38 ± 0.1	0.44 ± 0.1	< 0.001
Lateral stitch distance (LSD)	0.51 ± 0.2	0.65 ± 0.23	< 0.001
SL/WL-ratio	5.6 ± 2.5	6.1 ± 2.3	< 0.001

Individual surgeons (Table 5)

Individual surgeons achieved in 85% of sutures a >4:1 SL/WL ratio closure, while an > 6:1 SL/WL ratio resulted in 43%. Despite some heterogenous performance was seen, the overall results showed no significant difference (Table 5a-5c).

Graphic illustration (Figures 1-3)

Overall results can be better illustrated by scatterplots of the sutures comparing 95% prediction ellipses of midline vs transverse sutures (Figure 1) and emergency vs elective sutures (Figure 2). A flatter `pancake-like' appearance is indicative of a higher lateral stitch width (LSD) while lowering the suture interval (SI). Both parameters are then tilting the SL/WL ratio more in favour of a >4:1, better >6:1 ratio, shown as a more shallow trajectory line approaching the x-axis as seen in Figures 1 and 2.

When comparing suture quality performance, emergency parameters – likely due to the exclusive midline laparotomy closure - outperformed elective surgery. In a multivariate analysis, the only 2 significant variables became `stitch experience` (on a non-individual basis) comparing the

Table 5. *Individual surgeons (n=6, others) and their a) quality performance indicators (SI, LSD, SL/WL-ratio) when doing the `6:1 short stitch Monomax` fascial closure technique b) in absolute values showing no. of patients, min & max values, median, mean, 50% box [Q1-Q3], standard deviation and c) as forest plot.*

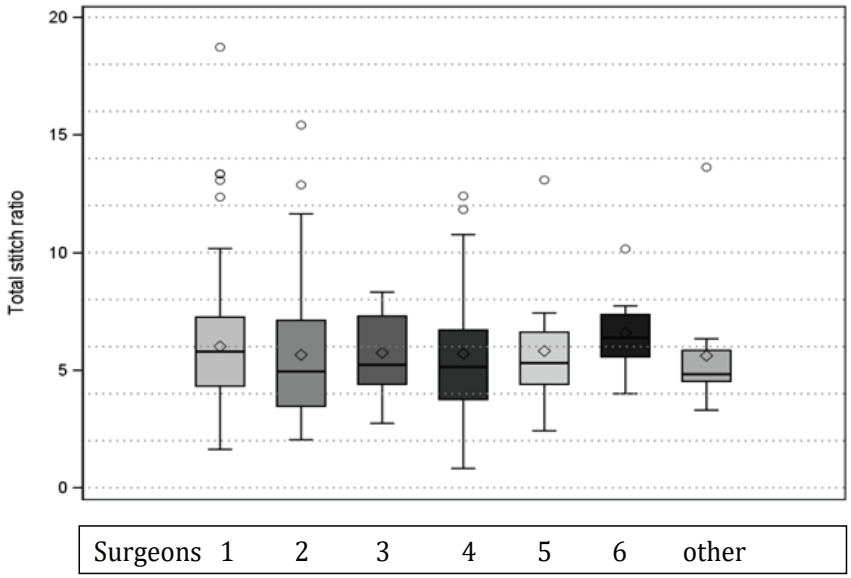
a)

Surgeons	No.	Stitch interval (SI)	Lat. stitch distance (LSD)	SL - /WL- ratio
Surgeon 1	351	0.44 ± 0.11	0.60 ± 0.2	5.66 ± 2.16
Surgeon 2	76	0.42 ± 0.12	0.52 ± 0.26	5.22 ± 2.74
Surgeon 3	14	0.45 ± 0.16	0.61 ± 0.23	5.66 ± 1.78
Surgeon 4	31	0.40 ± 0.13	0.52 ± 0.3	5.55 ± 2.71
Surgeon 5	16	0.39 ± 0.09	0.53 ± 0.13	5.88 ± 2.52
Surgeon 6	8	0.38 ± 0.07	0.62 ± 0.16	6.59 ± 1.83
Others	14	0.35 ± 0.12	0.49 ± 0.33	5.53 ± 2.30

b)

Surgeons	N	Min	Q1	Median	Q3	Max	Mean	Std Dev
total	344	0,82	4,20	5,45	7,08	18,73	5,90	2,38
1	211	1,63	4,32	5,79	7,26	18,73	6,01	2,21
2	57	2,04	3,46	4,94	7,12	15,42	5,65	2,90
3	13	2,74	4,40	5,23	7,30	8,32	5,74	1,81
4	29	0,82	3,75	5,14	6,71	12,40	5,69	2,75
5	13	2,42	4,40	5,30	6,62	13,08	5,81	2,57
6	8	4,00	5,56	6,37	7,37	10,15	6,59	1,83
other	13	3,30	4,52	4,83	5,84	13,63	5,61	2,57

C)



patients 1-150 with the 2nd cohort ([151-351], F-test: 16.189, p< 0.0001) and midline vs transverse fascial closures (F-test: 20.3521, p<0.0001; Figure 3).

Discussion

So far randomized studies involved in the short stitch technique focus on the short term (SSI, SSO) and longterm (hernia incidence after 1–3 years) complications and success rates respectively. In almost all trials, a median/midline incision was chosen [8,9], likely because of a more standardized closure (straight line, more common) and fascial properties of the linea alba (thicker, more rigid, universally more common). Interestingly, technique has never been stressed as intricate or tricky, despite some substantial differences in individual center results [17,18].

In this unique trial, we wanted to focus on the technical issue of actually performing the short stitch in real life conditions in a tertiary center with all kinds of incisions (midline, transverse, combined L-shaped) & conditions (elective and emergency surgery) [8]. Since most elective even larger oncological/abdominal procedures are nowadays at least contemplated to be performed laparoscopically, our patient clientel here is regarded as an intermediate, probably even high risk group from a diagnostic standpoint (presenting disease), but also in general (underlying diseases).

We know of three randomised-controlled trials investigating the effect of the `short stitch` suture technique using polydioxanone (PDS) as the suture material [6,15,19]. Recently the ESTIOH-trial using poly-4-OH butyrate (same thread as in this study) as alternative suture material involved 425 patients showed a clear benefit by almost cutting in half the incisional hernia incidence (3.3% vs 6.4%) compared to conventional 4:1 SL/WL ratio [16].

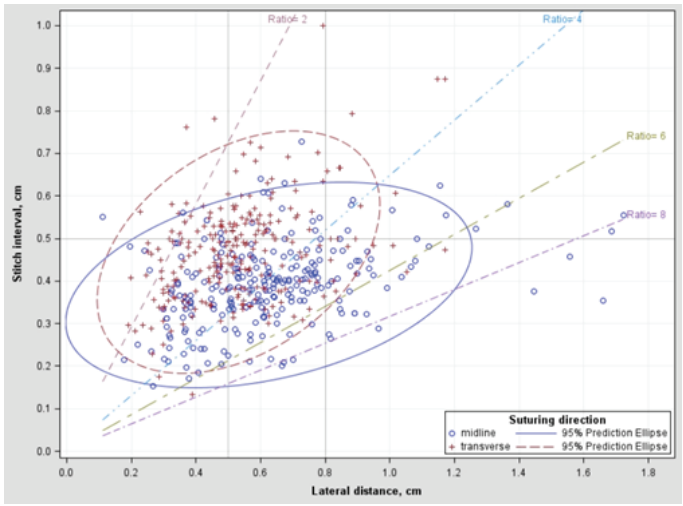


Figure 1. *Scatterplots of midline and transverse incisional closures (n=508) showing quality indicators, (LSD, SI and SL/WL-ratio). Ellipse representing 95% of the individual results). Straight lines refering to the Suture-Wound length (SL/WL) ratio between 2 and 8.*

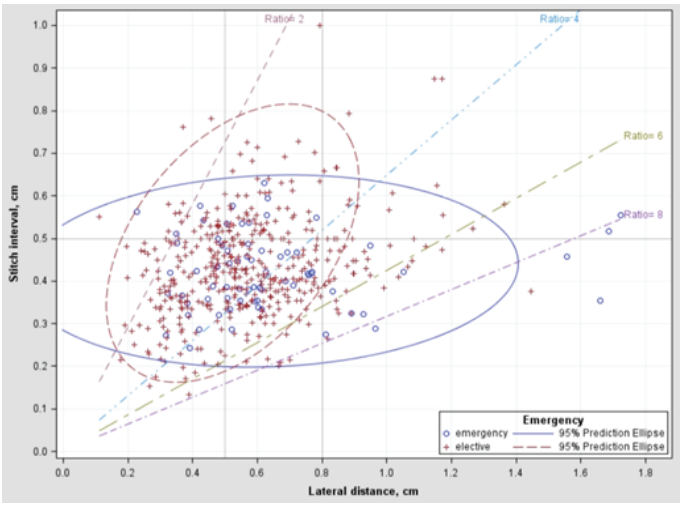


Figure 2. *Scatterplots of elective and emergency incisional closures (n=508) showing quality indicators (LSD, SI). Ellipse representing 95% of the individual results. Straight lines refering to the Suture-Wound length (SL/WL) ratio between 2 and 8.*

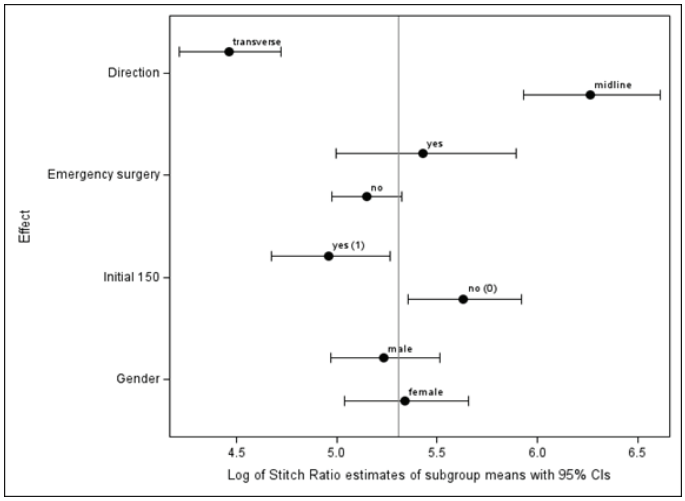


Figure 3. *SL/WL - ratios (related to sutures 509) comparing 1) transverse vs midline, 2) elective vs emergency surgery, 3) initial 150 patients vs following 201 patients and 4) gender comparison. Estimates with 95% confidence interval.*

Diagram of endpoint (Log of Stitch ratio), effect, level and means with upper/lower 95% confidence intervals showing signifcance in the multivariate test of no effect hypothesis for direction (F test value 16.189, p< 0.0001) and experience [initial 150 patients vs > 150 patients] with F test value 20.3521, p<0.0001.

All these randomized studies are accompanied by the bias of exclusively including midline incisions in elective patients. We aimed at exceeding the current gold standard (> 4:1 SL/WL-ratio) by further increasing the SL/WL-ratio to >6:1 plus integrating the short stitch technique simultaneously.

Interestingly, the ESTOIH-trial with the identical suture material (poly 4-OH butyrate) showed a lower hernia rate at 1 year (short vs long stitch: 3.3% vs 6.4%) and almost reached (in the short stitch group) our targeted values of the SL/WL-ratio (5.3±2.2) thereby exceeding the conventional gold standard[16].

Experience and looking at performance quality indicators is essential in the initial phase, as was shown in our case. In a preliminary study period of 50 sutures, which had to be mostly discarded, the results were insufficient. This aspect is mostly ignored in the studies [8,9]. After the shortcomings were adressed, we restarted the trial and decided to a) only include a limited amount of surgeons (n=6, senior registrar level) and b) make sure that the surgeon itself will be held responsible for a sufficient documentation at the end of the operation.

It was not surprising that quality performance indicators for midline incisions outplayed transverse incisions, since collagen structure, width and durability of the linea alba will assure a better overall SL/WL ratio[14]. The short stitch with a small bore needle and 2-0 thread has resulted in a better perfusion [13] within the landing zone of the stitch and has established itself as superior to a more traumatising wide, fascia/muscle combined stitch with a 35-40 HR needle with a loop[10]. Nevertheless, the lower strength of the ventral and especially dorsal fascia of the rectus and the transverse abdominis muscle may have contributed to button holes in the fascia and muscle resulting in a shorter SL/WL-ratio [20,21].

It should be mentioned that, the short stitch might not always be better. A recent study found a higher rate of burst abdomen (4% vs 0%) in relaparotomy cases (RELAP study) [22].

To our knowledge, no previous paper in recent years has addressed a standard 6:1 small stitch technique in all incisions and all conditions. We can perform a 6:1 SL/WL ratio following midline laparotomies, for transverse incisions > 6:1 is possible but a 2 seperate layer closure is strongly advised.

Conclusion

We introduced - to our knowledge for the 1st time - the 6:1 SL/WL short stitch technique involving a new, more elastic, low weight, ultra long absorbent, monophilic suture material (poly 4-OH-butyrate). This technique can be performed in median and transverse incisions, yet more accurately & sustainably performed with a midline incision due to the different fascial stability. There is a significant learning curve and heterogeneity amongst surgeons to avoid shortcomings in quality performance. Meticulous documentation (wound length, counting stitches, suture length incorporated) is the precondition of eventually and continuously good results. The poly 4-OH butyrate thread is easy to handle and requires the user to reduce pull and tension on the thread avoiding extensive overstretching and potential `button holes` on a fascial level.

Clinical Trial information

Acronym: Short Stitch MonoMax

(https://www.clinicaltrials.gov/ct2/show/NCT01938222)

Clinical trial Responsible Party: (Diakonie Klinikum Schwäbisch Hall),

Clinical Trials.gov Identifier: NCT01938222

Acknowledgement

Aesculap provided the internet-based data platform and statistical analysis. We used the regular fascial suture material provided by the hospital (MonoMax 2-0) produced by B.Braun Surgical, Spain. All the authors employed by the DIAK/DIAKONEO (MG, ZZ, SF) received no financial funding and have no financial disclosures to make.

Conflict of interest

Technical results described in the publication did not refer to a specific suture material. VB & PB are employed by Aesculap AG. All the other authors (MG, ZZ, SF) are employed by the DIAK/DIAKONEO and have no conflict of interest.

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