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ORIGINAL ARTICLE

A modified Chevrel technique for ventral hernia repair: long-term results of a single centre cohort

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Abstract
Purpose To evaluate the short- and long-term results after a modified Chevrel technique for midline incisional hernia repair, regarding surgical technique, hospital stay, wound complications, recurrence rate, and postoperative quality of life. These results will be compared to the literature derived reference values regarding the original and modified Chevrel techniques.
Methods In this large retrospective, single surgeon, single centre cohort all modified Chevrel hernia repairs between 2000 and 2012 were identified. Results were obtained by reviewing patients' medical charts. Postoperative quality of life was measured using the Carolina Comfort Scale. A multi-database literature search was conducted to compare the results of our series to the literature based reference values.
Results One hundred and fifty-five patients (84 male, 71 female) were included. Eighty patients (52%) had a large incisional hernia (width $\geq$ 10 cm) according the definition of the European Hernia Society. Fourteen patients (9%) underwent a concomitant procedure. Median length-of-stay was 5 days. Within 30 days postoperative 36 patients (23.2%) had 39 postoperative complications of which 30 were mild (CDC I–II), and nine severe (CDC III–IV). Thirty-one surgical site occurrences were observed in thirty patients (19.4%) of which the majority were seroma (16 patients 10.3%). There was no hernia-related mortality during follow-up. Recurrence rate was 1.8% after a median follow-up of 52 months (12–128 months). Postoperative quality of life was rated excellent.
Conclusions The modified Chevrel technique for midline ventral hernias results in a moderate complication rate, low recurrence rate and high rated postoperative quality of life.

Keywords Modified Chevrel technique · Anterior fascia turnover technique · Ventral hernia repair · Complications · Recurrence

Introduction

Since primary closure of ventral abdominal wall hernias is accompanied with high recurrence rates, mesh augmentation is an accepted evidence-based technique to ensure a strong and reliable abdominal wall herniorrhaphy. However, the optimal positioning of the mesh is controversial and heavily debated [1–3].

Intra-abdominal mesh placement can potentially cause bowel adhesion and enterocutaneous fistulas due to the proximity of the mesh to the abdominal viscera. Sublay placement reduces the risk of these fistulas and adhesion formation, though the posterior rectus fascia must be closed in the midline to correctly place the mesh, and prevent contact with the abdominal content. Additionally, it is not always possible to close the anterior rectus fascia in case of large hernias. Therefore, in large hernias sublay placement is frequently used in combination with other repairs such as the (endoscopic) anterior or posterior component separation technique [4, 5]. These techniques require dissection beyond the lateral border of the rectus muscles, increasing

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the risk of damage to the perforating epigastric arteries and nerves, seroma formation, skin necrosis, and bulging of the lateral abdominal wall [4, 6]. Despite the above-mentioned disadvantages, both intra-abdominal and sublay positions are preferred over onlay position of the mesh. The onlay position became disfavoured after large registry based studies reported an alleged increased risk of seroma formation and wound infection when compared to other mesh positions, supposedly caused by extensive subcutaneous dissection [1, 6]. One of the onlay techniques included in these studies is the original Chevrel technique. This technique consists of an anterior fascia 'turnover' closed in the midline with an overlapping midline plasty, combined with a large onlay mesh augmentation sutured with overlap to the lateral part of the anterior rectus fascia, or even to the fascia of the oblique external muscle [4, 7]. To facilitate mesh placement, subcutaneous dissection beyond the lateral border of the anterior rectus fascia is often necessary with the original Chevrel technique.

In this report, we present a modified version of the Chevrel technique, according to an early technique description by Chevrel in 1979 [8]. Because of recurrences Chevrel turned this technique into the well-known 'original' Chevrel technique published in 1986 [7]. Our modified Chevrel technique does not require such large subcutaneous dissection since the mesh is sutured to the remnant of the anterior rectus fascia with only one-and-a-half centimetres overlap [8]. This results in a dual-layer repair where both the sutured anterior fascia turnover and the onlay mesh provide support to the ventral abdominal wall. Therefore, the modified Chevrel technique offers the advantages of onlay mesh placement, potentially without the alleged disadvantage of increased wound complications caused by extensive subcutaneous dissection.

The aim of this study is to describe a modified Chevrel technique and to evaluate its complications, recurrences, and quality of life. These results will be compared to the literature derived reference values.

Materials and methods

A retrospective analysis of all patients receiving a midline incisional hernia repair using the modified Chevrel technique between 2000 and 2012 was performed. Patients were identified by searching ventral hernia repair codes in the electronic operation theatre (OR) database. Patients undergoing concomitant procedures other than a component separation technique were also included. All patients were operated by a single surgeon (JC) in a single institution, the Máxima Medical Centre, a large teaching hospital in Eindhoven, the Netherlands.

Noted endpoints were: patient characteristics, per- and postoperative details, postoperative complications according to the Modified Ventral Hernia Working Group Classification (VHWG), Clavien-Dindo Classification, recurrences, and postoperative quality of life according to the Carolina Comfort Scale [9–12]. Wound complications were reported as surgical site occurrences (SSO), defined as any wound complication (haematoma, superficial and deep wound infection, abscess, seroma, fistula, and wound dehiscence). Infectious wound complications were reported separately as surgical site infections (SSI), defined as abscess, infected seroma, superficial or deep wound infection.

Standard care consisted of at least one pre-operative visit at the outpatient clinic. During this visit, hernia size and treatment options were determined by physical examination. Pre-operative abdominal CT-scans were not performed routinely. Any patient with a midline ventral incisional hernia and sufficient healthy cutis and subcutis to cover the mesh and to close the skin was included. An existing enterostomy or the presence of an enterocutaneous fistula was no contra-indication.

All patients were invited to the outpatient clinic within 4 weeks after discharge. Follow-up was obtained by reviewing patients' medical records. Clinical examination by the surgeon (only if the medical record specifically described the condition of the abdominal wall), abdominal CT-scans and abdominal wall ultrasounds were all accepted as diagnostic instrument for recurrence. Abdominal CT-scans were reviewed by two authors simultaneous (JC, EM) to evaluate recurrence. In case of disagreement, a third author (TdVR) was consulted for arbitration. Any hernia at the site of the modified Chevrel repair was registered as a recurrence.

Quality of life

Quality of life (QoL) measurements were performed with a validated Dutch version of the Carolina Comfort Scale (CCS), a hernia-specific QoL questionnaire consisting of 23 items [9, 11]. The focus of the CCS is mesh-related pain, mesh feeling, and movement limitation. The maximum score is 115 points and reflects the worst possible QoL, the minimum score is 0 and equals perfect QoL. In addition to the 'overall' QoL, the CCS reports three subdomains, 'mesh sensation', 'pain', and 'movement impairment'. The maximum score per subdomain is 40 points for 'mesh sensation' and 'pain', and 35 points for 'movement impairment'. All living patients without a reoperation for a registered recurrence were contacted by letter during July 2015 to participate in the postoperative QoL evaluation. At that time, all patients were at least 3 years postoperative.

Operative technique

The modified Chevrel repair

Antibiotic prophylaxis [Cefuroxime (Kefzol®) 1500 mg] is given intravenously. Following excision of the midline scar tissue, the hernia sac is opened and adhesiolysis is performed to facilitate movement and stretching of the abdominal wall along the abdominal content. The skin and subcutaneous tissue above the anterior rectus abdominis fascia are dissected until 2–3 cm medial of the lateral border of the rectus muscles, exposing the anterior rectus fascia. Depending on the width of the hernia, an elliptical incision is made in the anterior rectus fascia mostly between 2 and 5 cm from the medial edge of the rectus muscle. The medial part of the anterior rectus fascia is separated from the muscle fibres and tendinous intersections, and 'turned over' towards the midline. This procedure is repeated at the contralateral side. Any residue of the hernia sac is left alone or excised. Both the left and right 'turned over' anterior fascia can now be sutured in the midline with a continuous 2/0 polydioxanone (PDS) suture using small bites [13]. This suture 'closes' the abdomen and provides the first 'layer' of the repair (Fig. 1). Any small defect in this new posterior layer is closed with an absorbable suture. The second layer is formed by a polypropylene mesh (Prolene®, Ethicon Inc.; see Table 1 for mesh details) sutured to the edge of the lateral part of the anterior fascia using two long double needled Prolene® 2/0 sutures. One tied suture fixes the mesh at the cranial and one at the caudal meeting point of the left and right lateral part of the anterior rectus fascia. With small bites the mesh is sutured to the edge of the anterior fascia running from cranial and caudal, thereafter, meeting halfway where the cranial and caudal suture are tied together (Fig. 2). During this procedure, some tension is given on the suture line so the lateral abdominal wall muscles are stretched slightly. By manipulation of the tension and size of the mesh it is possible to influence the contour of the abdomen. The mesh must lay flat on the rectus muscle without any folds. Then the excess mesh is trimmed with scissors to leave a rim of approximately 1.5 cm lateral to the continuous suture. This rim is then sutured to the ventral side of the anterior rectus fascia using single Prolene® 2/0 sutures. Some tailoring is necessary to provide a flat 1.5 cm overlap where connective tissue can grow into the mesh (Fig. 2). Two low-vacuum drains are placed in the subcutaneous space. The subcutaneous tissue and skin are closed with resorbable continuous sutures. The drains are removed when the production is less than 50 ml/24 h, mostly within 3 days. Patients with epidural analgesia are mobilised after removal of the catheter, approximately 2–4 days postoperative. All other patients are stimulated to walk the first postoperative day. Patients are advised to wear a comfortable abdominal binder for four weeks to prevent seroma formation. Normal daily activities are permitted, though heavy lifting was discouraged for 6 weeks.

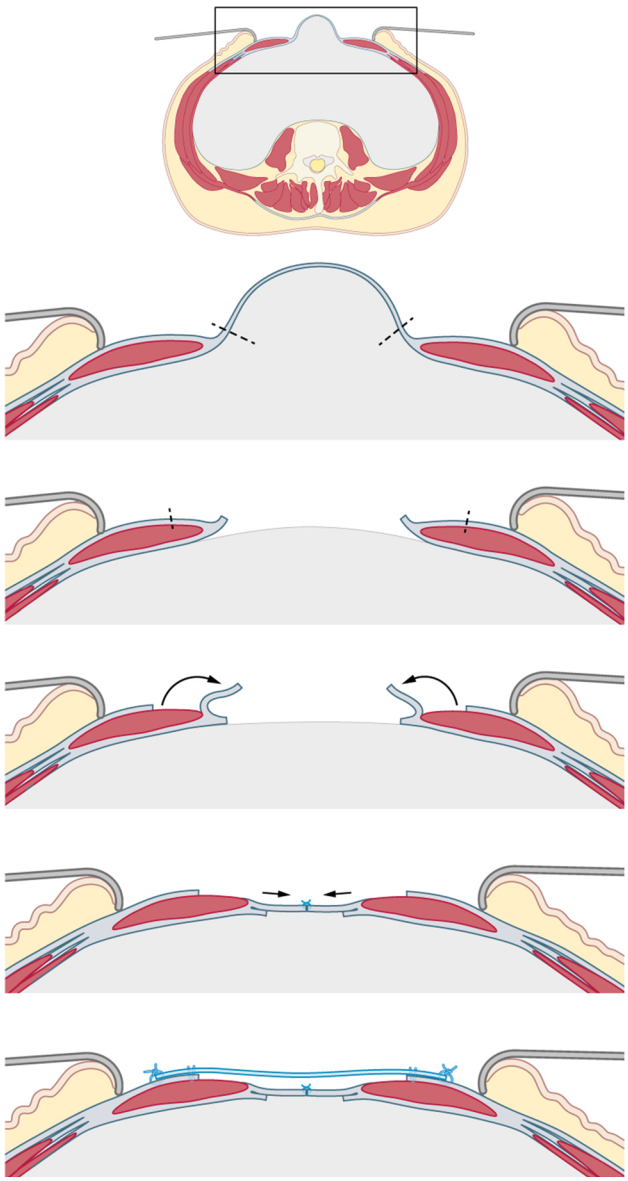

Fig. 1 Schematic approach of the modified Chevrel technique. Schematic approach of a modified Chevrel technique for midline ventral hernia repair. From *top* to *bottom* the following steps are depicted: anatomical situation with the hernia sac in situ; incision of the anterior rectus fascia and 'turnover'; suture of both turned over anterior fascias in the midline to form the new posterior layer; fixation of the mesh with continues and single sutures to the lateral remnant of the anterior rectus fascia with 1.5 cm overlap

Table 1 Demographic characteristics

$n = 155$	
Gender (male/female)	84/71
Smoking (*n*)	26
BMI kg/m^2 (median, range)	28 (18–53 kg/m^2)
COPD (*n*)	17
Diabetes Type 2 (*n*)	20
Previous wound infection (*n*)[a]	26
Wound healing impairing medication (*n*)[b]	3
Abdominal aortic aneurism (*n*)[c]	30
Defect width (median cm, range)	10 cm (2–25 cm)
W1 $<$ 4 cm (*n*)[d]	7
W2 $\leq$ 4–10 cm (*n*)[d]	51
W3 $\geq$ 10 cm (*n*)[d]	80
Defect length (median cm, range)	15 cm (3–35 cm)
Defect surface (median cm^2, range)	118 cm^2 (5–550 cm^2)
Type of mesh placed	
Standard polypropylene (*n*)	102
Small pore polypropylene (Marlex) (*n*)	35
Large pore polypropylene (Vypro I) (*n*)	18

[a] Wound infection after previous surgery

[b] Use of corticosteroids, chemotherapeutics, or immunosuppressive agents

[c] Previous repair of an abdominal aortic aneurism

[d] Exact width measures missing in 17 of 155 patients

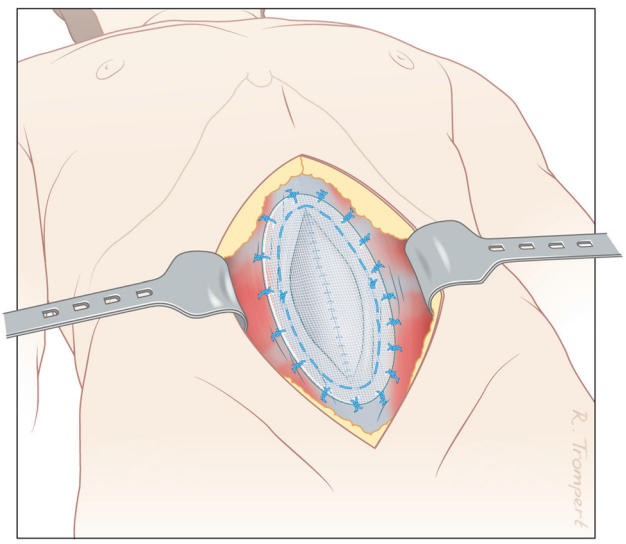

Fig. 2 Schematic view of the anterior abdominal wall after mesh placement. Ventral 'birds-eye-view' after the mesh is fixated to the lateral remnant of the anterior rectus fascia. There is a 1.5 cm overlap between the mesh and the anterior rectus fascia. A continuous suture is used to fixate the mesh to the lateral remnant of the anterior rectus fascia. Single sutures are used to assure that the overlap remains flat on the anterior rectus fascia to facilitate tissue ingrowths in the mesh. The new posterior layer can been seen through the mesh

Literature search

To correctly interpret the results of this study, and make any comparison to the existing body of evidence concerning the original and modified Chevrel techniques, a literature study was performed. The following databases (PubMed, Cochrane database, Google scholar, Medline, EBSCO) were searched using the following terms: 'anterior fascia turnover' OR 'Chevrel method' OR 'Chevrel technique' OR 'anterior' OR 'frontal' OR 'fascia flip' OR 'shoelace technique' AND 'postoperative complications [MESH]' OR 'recurrence' OR 'hernia repair' OR 'hospital stay'.

All studies reporting postoperative complications, recurrence rate, or hospital stay after ventral hernia repair using either the original or modified Chevrel techniques with anterior fascia turnover were included. Only studies in English, French, Dutch, or German that accurately described the operation technique or referenced an article that described the operation technique and the exact limits of the subcutaneous dissection were included. No limitations to the year of publication were applied.

Statistical analysis

All data was analysed using SPSS statistics for Windows, IBM corp. Armonk, NY, released 2013. Baseline characteristics, response rates, and recurrence rates were analysed using descriptive statistics. Statistical significance (α) was set at 0.05. Group comparisons were performed using independent samples Student's *t* test or Mann–Whitney *U* tests depending on the (non)parametric distribution of the data (Levene's test for equality). Correlations between VHWG and SSOs were calculated using bivariate correlations and expressed as Pearsons 'r'.

Results

Overall 297 patients underwent midline incisional hernia repair between 2000 and 2012. One hundred and fifty-five of these patients were operated using the modified Chevrel technique (see Table 1 for demographics and type of mesh implants). The remaining patients, mostly with smaller hernias, were treated laparoscopically or with an open sublay repair. Fifty-two percent ($n = 80$) of all modified Chevrel repairs were done for the reconstruction of large ventral hernias (width $\geq$ 10 cm) according to the definition of European Hernia Society (Table 1) [14]. Fifty-seven patients received epidural analgesia during and after the surgery. Thirty-six patients had one prior hernia repair, and eleven patients had two or more previous repairs at the same site (in total 30% repair for recurrences). All prior

hernia repairs were performed using other techniques than the modified or original Chevrel repair.

Of the 155 patients, 14 (9%) received a concomitant procedure, and 110 patients (71%) had a follow-up of at least 12 months (Table 2). The median hospital stay was 5 days (range 2–95 days).

Complications

During the first thirty postoperative days, 30 mild (CDC grade I–II) complications and nine severe (CDC grade III–IV) complications occurred in 36 patients (23.2%) that underwent a modified Chevrel repair (Table 3). Thirty-one SSOs were observed in 30 patients (19.4%), of which the majority was seroma's (16 patients 10.3%). Eight seromas required fine needle-aspiration, one was drained under local anaesthetic, five required reinterventions (including two reinterventions 1 year postoperative due to recurrent seroma formation), and two disappeared spontaneously. Three of the nine severe complications within 30 days were seroma's requiring reintervention, two were abscesses, two were severe wound infections, one was a postoperative bleeding, and one was an anastomotic leakage in a patient with concomitant ileostomy takedown. The revision of the anastomotic leakage was complicated by a massive bleeding, though after re-intervention an uneventful recovery followed.

The VHWG classification identified three groups within the population (grade I Low risk, 41% ($n = 63$); grade II Co-Morbid, 54% ($n = 84$); grade III Contaminated, 5% ($n = 8$)). Complications occurred more frequently in the grade II and III patients. SSOs occurred significantly more with an increasing VHWG grade ($r = 0.209$ $p = 0.009$; x^2 $p = 0.017$). Within the VHWG grading scale or the overall population there were no statistically significant differences in the incidence of complications in hernias over or under 10 cm in width ($p = 0.192$).

Table 2 Concomitant procedures

Procedure	(n =)
Cholecystectomy	3
Gastric banding	1
Parastomal hernia repair[a]	2
Hemicolectomy	1
Enterostomy removal	2
Enterocutaneous fistula removal	1
Oophorectomy	1
Removal of ovarian cyst	1
Sterilization	1
Stoppa procedure for bilateral groin hernia	2

Fourteen patients received a total of 15 concomitant procedures with a modified Chevrel repair in the same session

[a] Sugarbaker technique ($n = 1$, colostomy), suturing hernia defect ($n = 1$, urostomy)

Long-term complications

Ten patients (6%) reported persisting localized pain near the rim of the mesh, approximately 1 month postoperative. All these patients received one or more local anaesthetic injections (Lidocaine 1–2%) that relieved their pain sufficiently.

One patient with a severe wound infection was, after drainage, treated with vacuum assisted therapy, though developed a mesh infection more than 30 days postoperative, and later a recurrent hernia. Another patient, with correction of an enterocutaneous fistula as a concomitant procedure, developed a new enterocutaneous fistula after 10 months, perhaps due to erosion or infection of a small part of the mesh. The wound healed after resection of the infected part of the mesh, without finding a bowel defect. Two patients with recurrent seroma formation needed surgical intervention after 1 and 2 years, respectively. Yet another patient developed a suture fistula 16 months postoperative. After excision of a Prolene® suture, the wound healed.

Recurrence

The following methods were used for assessment of recurrence: clinical examination by the surgeon as retrieved from the patient's medical record which specifically described the condition of the abdominal wall (77%), abdominal CT-scans (13%), and abdominal wall ultrasounds (10%). The overall median follow-up for the total cohort was 34 months (range 0–128 months, interquartile range 8–62 months). Forty-five of the 155 patients had a follow-up shorter than 12 months and were not included in the long-term recurrences analysis. In this group of 45 patients no recurrences occurred. The remaining 110 patients had a median follow-up of 52 months (range 12–128 months, interquartile range 31–72 months), two of these patients developed a recurrence (1.8%) after 13 and 15 months postoperative. Both patients had a large hernia (width $\geq$ 10 cm). The first patient received a Vypro I® mesh (large pore polypropylene with polyglactin, Ethicon Inc.) which failed after 13 months. During the re-intervention, it became apparent that the mesh was torn in half. The second patient had a postoperative wound infection that was initially treated with vacuum-assisted therapy, though later progressed into a mesh infection that was treated by removing the infected part of the mesh. Initially, this resolved the problem of the infection, though over time the patient developed a recurrent hernia.

Table 3 Complications ≤ 30 days postoperative

VHWG grade	Patients	CDC I–II (%)	CDC III–IV (%)	Surgical site occurrence (%)[c]	Surgical site infection (%)	Seroma (%)	Ileus/ pneumonia/ UTI (%)
All patients	Total cohort ($n = 155$)	30 (17.4)	9 (5.8)	31 (19.4)	9 (5.8)	16 (10.3)	8 (5.2)
Grade I	All patients ($n = 63$)	8 (9.5)	2 (3.2)	6 (9.5)	1 (1.6)	3 (4.8)	4 (6.3)
	Width < 10 cm ($n = 26$)	1 (3.8)	0	1 (3.8)	0	1 (3.8)	0
	Width ≥ 10 cm ($n = 28$)	6 (14.3)	1 (3.6)	4 (14.3)	0	2 (7.1)[a]	3 (10.7)
	Width unknown ($n = 9$)[b]	1 (11.1)	1 (11.1)	1 (11.1)[a]	1 (11.1)[a]	0	1 (11.1)
Grade II	All patients ($n = 84$)	20 (22.6)	6 (7.1)	22 (26.2)	7 (8.3)	12 (14.3)	4 (4.8)
	Width < 10 cm ($n = 28$)	5 (17.9)	1 (3.6)	6 (21.4)	1 (3.6)	5 (17.9)[a]	0
	Width ≥ 10 cm ($n = 49$)	15 (28.6)	3 (6.1)	14 (28.6)[a]	4 (8.2)[a]	7 (14.3)[a]	4 (8.2)
	Width unknown ($n = 7$)[b]	0	2 (28.6)	2 (28.6)[a]	2 (28.6)[a]	0	0
Grade III	All patients ($n = 8$)	2 (25)	1 (12.5)	3 (37.5)	1 (12.5)	1 (12.5)	0
	Width < 10 cm ($n = 5$)	2 (40)	0	2 (40)	1 (20)	1 (20.0)	0
	Width ≥ 10 cm ($n = 3$)	0	1 (33.3)	1 (33.3)*	0	0	0

% = percentage of population affected with complication (NB: CDC I–II and CDC III–IV complications may be observed more than once in one patient, hence the percentage of population affected is lower than the times the complication is observed divided by the group size)

UTI Urinary Tract Infection, *CDC* Clavien-Dindo Classification, *VHWG* Modified Ventral Hernia Working Group septic risk scale for surgical site occurrences

[a] One or more patients within this category required surgical intervention

[b] Exact defect measurements were not available in 16 patients

[c] Statistically significant difference between VHWG grades

Surgical site occurrence = infection, wound dehiscence, seroma, or development of an enterocutaneous fistula; surgical site infection = deep or superficial wound infection, abscess, infected seroma

Quality of life

At the time of measurement 23 of the 155 patients were deceased, and two patients were operated for a recurrence using a different surgical technique. The remaining 130 patients were sent the CCS questionnaire. Ninety-six patients responded (response rate 74%). The median follow-up of these patients was 35 months. The average CCS score was seven on a scale of 115 (SD ± 15), 58 patients (60%) reported an excellent QoL-score of zero. A subanalysis of patients that reported any impairment in QoL (total score ≥1; $n = 38$) showed the following results: median overall QoL 12 (range 1–76), median sensation score 5 (range 0–27), median pain score 2 (range 0–26), and median movement score 4 (range 0–24).

Literature review

Twenty-two studies were identified through the database search, and four articles were identified through cross-reference (last search performed November 2016). A total of 26 articles were screened for eligibility. Fifteen studies were excluded, one due to language restrictions, and 14 because they did not meet the inclusion criteria. Finally, ten studies (eleven including the current series) were included (Fig. 3; Table 4) [7, 8, 15]. Studies were divided in two groups, the original Chevrel technique and the modified Chevrel techniques, depending on the overlap of the mesh and the amount of subcutaneous dissection. The modified Chevrel repairs used a trimmed mesh and no subcutaneous dissection lateral of the anterior rectus sheath.

The current evidence as displayed in Table 4 consists of multiple small case series with heterogeneous populations in term of hernia size, location, origin, complexity, and follow-up method. The median and average follow-up varies between the studies, though is mostly longer than 1 year.

Wound complication rates varied from 0 to 25% in the modified Chevrel group, and from 9 to 44% in de original Chevrel group. Hospital stay was slightly shorter in the modified Chevrel group (5–6 vs. 5–11 days). The recurrence rates in the modified Chevrel group were 0–2% compared to 0–33% in the original group, though the defect size in two of the five studies describing the modified Chevrel technique were not measured objectively.

Based on the limited evidence available, the results of the current series are comparable with previously published studies of the modified Chevrel techniques. Previous studies have never reported any recurrences using the modified Chevrel technique. This could be due to the relative short follow-up, retrospective methodology, small

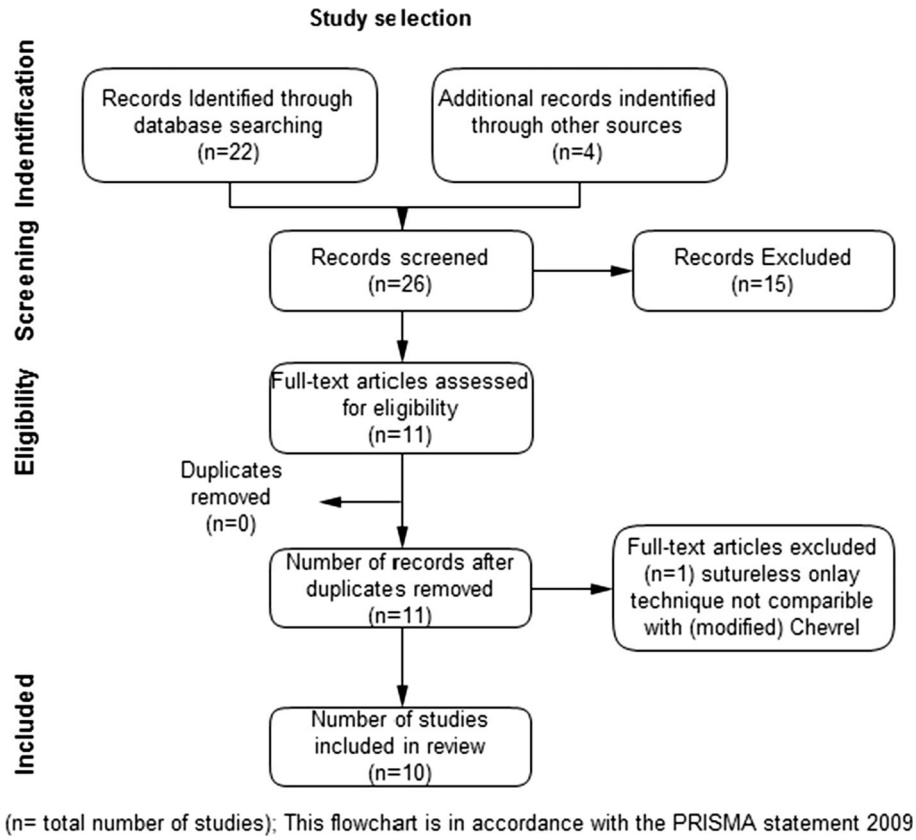

Fig. 3 Flowchart of study identification and inclusion

Table 4 Current literature describing the original and modified Chevrel technique

	Population	Defect size	Hospital stay	Wound complications (%)	Follow-up	Recurrences (%)
Original Chevrel technique						
Chevrel [7]	50	1–20 cm	NR	18 (36)	10 months–114 months	4 (8)
San Pio [21]	67	NR[a]	NR	6 (9)	5.7 years (range 0–17)	10 (15)
Licheri [18]	64	5–15 cm	10 days (2–21)	17 (26.5)	54 months	2 (3.5)
Forte [16]	9	5–10 cm	9 days (5–18)	4 (44)	NR	3 (33)
Marchesi [15]	21	±8 cm	11 days (4–58)	7 (33)	17 months	0 (0)
Hodgman [22]	123	65 cm^2	5 days (0–31)	40 (34)	18 months	6 (5)
Modified Chevrel technique's						
Chevrel [8]	12	>10 cm	NR	3 (25)	30 months–8 years	0 (0)
Whiteley [19]	10	NR[a]	NR	0 (0)	17 months	0 (0)
Khaira [20]	35	NR[a]	6 days (1–27)	8 (22)	20 months, (range 6–54)	0 (0)
Joshi [17]	30	>4 cm	5 days SD ± 4	3 (10)	12 months	0 (0)
Mommers [5]	155	10 cm	5 days (2–95)	27 (19)	52 months (median)	2 (2)*

Characteristics of all included studies; Wound complications = wound/mesh infection, seroma, haematoma, or wound dehiscence

NR not reported in the publication

[a] Only patients with a follow-up ≥12 months were included ($n = 110$), values can be average, median or range, depending on the original publication

populations, or due to publication bias, though, considering the low recurrence rate in the current series, recurrences are rare after a modified Chevrel technique.

Discussion

Previous studies have reported a relatively high wound complication rate after the original Chevrel technique, which was contributed to the extensive subcutaneous dissection to facilitate overlap of the mesh beyond the lateral border of the rectus abdominis muscles. This was also demonstrated in the meta-analysis of Timmermans et al. from 2014, though this meta-analysis does not distinguish between different types of onlay repair [1]. The modified Chevrel technique requires less subcutaneous dissection and a smaller mesh. This could account for the reduced wound complication rate in comparison with the original technique as observed in this study. The modified Chevrel technique can be used for any patient with a sufficient amount of healthy skin and subcutaneous tissue to cover the mesh, and can even be used in patients with an enterostomy, urostomy, or enterocutaneous fistula.

In our series, the most frequent postoperative complication was seroma formation. Seromas occur in nearly 100% of the mesh based repairs, and are easily detected after onlay mesh placement due to the proximity of the dissection plane and mesh to the skin [23, 24]. Therefore, the authors would argue that seroma 'detection', rather than seroma formation, is increased in onlay mesh placement. With sublay or intra-abdominal mesh placement the mesh and dissection plane are situated on a deeper level, meaning seromas are often not clinically detected, although radiologically, they are present. Therefore, the high amount of seromas usually reported after onlay placement should not be an argument to discard the technique, especially not since the wound complication rate as observed in our series is comparable with sublay mesh placement, and the recurrence rate is low [6].

Previous studies have demonstrated that onlay mesh placement could lead to fewer recurrences when compared to sublay placement, though the evidence is not conclusive. A prospective 5-year trial of Wéber et al. showed recurrence rates after onlay mesh placement to be half of the recurrence rates after sublay mesh placement (12% onlay vs. 22% sublay, $p < 0.05$) [25]. A 2008 Cochrane meta-analysis pre-dates the above-mentioned trial, though did show a clear trend towards lower recurrence rates in onlay mesh placement compared to sublay placement (RR0.66, 95% CI [0.35–1.25]) [26]. On the other hand, Timmermans et al. showed a trend towards lower recurrence rates in sublay repair (OR 2.41 95% CI [0.99–5.88]) in their 2014 meta-analysis [1]. In the present series, we observed only two recurrences (1.8%). The authors emphasize the importance of a meticulous continuous suturing technique of the mesh to the lateral remnant of the anterior rectus fascia to replicate these results. The meticulous suturing technique is the most time-consuming part of the procedure that will take approximately 2 h in total.

Our study shows excellent postoperative quality of life after the modified Chevrel repair. An overall average score of 7/115 indicates only minimal impairment of QoL. Those patients that did experience an impairment of their daily function mainly reported that they 'felt the presence of the mesh' during daily activity.

In our series, we observed ten patients who had localized abdominal wall pain somewhere in the course of the suture line, at the rim of the mesh over the anterior rectus fascia. The clinical presentation was comparable to the anterior cutaneous nerve entrapment syndrome (ACNES) [27]. Similar to the proposed treatment of ACNES patients, these hernia repair patients could be treated with local anaesthetic injections at the location of the maximum pain point. The phenomenon of localized abdominal wall pain might be contributed to traction on, or damage to the intercostal cutaneous nerve end branches in the suture line, or irritation by the mesh [27].

The modified Chevrel technique offers a comprehensive approach to all types of midline ventral hernias, if there is sufficient healthy skin to cover the mesh. If this technique alone is not sufficient to close the defect, it can easily be combined with a minimally invasive or endoscopically assisted component separation technique [5]. However, since the fascia turnover creates a new posterior layer that is wider than the 'anatomical' posterior rectus fascia, this technique on its own can bridge wider defects than the Rives–Stoppa approach. Therefore, a sublay position of the mesh will require additional techniques, such as component separation, sooner than the modified Chevrel repair. Additionally, due to the onlay placement of the mesh continuity of both the anterior rectus fascia and the new posterior layer are ensured, resulting in a double layer repair. In our series, we could conveniently close defects of 15 cm wide using only the modified Chevrel technique. Between 2000 and 2012 there were three modified Chevrel repairs combined with additional component separation procedures, these patients were not included in this study.

Due to the retrospective nature of this study some limitations must be accentuated.

First, retrospective studies are more susceptible to report bias due to their dependence on historical descriptions. Second, no baseline measurement for QoL could be performed and the postoperative measurement was cross-sectional meaning that patients were at different postoperative intervals. The CCS questionnaire specifically focuses on mesh related complaints, and

leaves no room for 'other pain' or discomfort not caused by the mesh. Therefore, the incidence of 'mesh pain' or 'mesh sensation' might be overrepresented since not all abdominal wall pain experienced by the patient is caused by the mesh, nor does the CCS questionnaire distinguish different types of pain. Third, a meta-analysis of the literature review was deemed unfit by the authors due to the small patient samples, lack of proper RCT's, and heterogeneity in outcome variables. Since all patients were operated by the same surgeon, in the same institution, performance bias was practically excluded. Considering the aforementioned limitations, the authors feel that the following conclusion can be drawn from this study.

Conclusion

The modified Chevrel technique for midline ventral hernia repair provides a durable repair with a 19.4% wound complication rate, of which the majority are seromas, and a low recurrence rate of 1.8% after a median follow-up of 52 months, and a high rated post-operative quality of life. Overall, these results exceed the results published on the original Chevrel technique, indicating that this modified Chevrel technique leads to favourable results, and should have a place in modern ventral hernia repair.

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Compliance with ethical standard

Disclosure statement All other authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee, and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Statement of human and animal rights This article does not contain any studies with animals performed by any of the authors.

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