Meta-analysis of sublay versus onlay mesh repair in incisional hernia surgery

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KEYWORDS:
Incisional hernia; Onlay; Sublay; Recurrence; Surgical site infection; Complication

Abstract

BACKGROUND: Incisional hernia (IH) remains a very frequent postoperative complication. The 2 techniques most frequently used are the onlay repair and sublay repair. However, it remains unclear which technique is superior.

DATA SOURCES: A meta-analysis was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The quality of the nonrandomized studies was assessed using the Newcastle-Ottawa Scale.

RESULTS: Of 178 articles, 10 articles (2 randomized controlled trials, 1 prospective study, and 7 retrospective studies) comprising a total of 1,948 patients (775 onlay operations and 1173 sublay operations) were selected. Two of the studies scored below 5 points on the Newcastle-Ottawa Scale and were not selected. A trend was observed for IH recurrence in favor of sublay repair (odds ratio = 2.41; 95% confidence interval, .99 to 5.88; I² = 70%; P = .05). Surgical site infection occurred significantly less after sublay repair (odds ratio = 2.42; 95% confidence interval, 1.02 to 5.74; I² = 16%; P = .05). No difference was observed regarding seroma and hematoma.

CONCLUSIONS: Although the majority of the included studies were retrospective studies, sublay repair seems the preferred technique for IH repair. © 2014 Elsevier Inc. All rights reserved.

Incisional hernia (IH) remains one of the most frequent postoperative complications after abdominal surgery, with incidences ranging from 11% to 20%. The incidence of IH is even higher in patients with risk factors such as obesity and abdominal aortic aneurysms. Each year around 200,000 IHs are treated in the United States. The treatment of choice for IHs should be mesh repair. Mesh repair results in lower recurrence rates compared with primary suture as was shown by Luijendijk et al (3-year cumulative recurrence rate of 24% compared with 43%) and Burger et al (10-year cumulative recurrence rate of 32% compared with 63%). In the studies performed by Luijendijk and Burger, the Rives-Stoppa sublay repair (SR) technique was used. With this technique, the mesh is placed on the posterior rectus fascia after dissection of the fascia from the rectus muscle and approximation of the 2 edges of the fascia. Another frequently used technique for IH is the Chevrel or onlay repair (OR) technique. With this technique, the mesh is placed on the anterior rectus fascia after dissection of the fascia from the subcutis and approximation of the 2 edges of the fascia. However, no consensus has been
reached as to which technique is preferable. The anatomic position of the mesh placement has an impact on tissue incorporation, tissue reaction, and tensile strength of the abdominal wall. These factors are important regarding corporation, tissue reaction, and tensile strength of the abdominal wall. These factors are important regarding the repair of incisional hernias. The anatomic position of the mesh placement has an impact on tissue incorporation and tissue reaction. The repair of incisional hernias involves the use of mesh to reinforce the abdominal wall. The mesh is placed over the hernia defect to provide support and prevent recurrence.

**Methods**

A systematic search of MEDLINE, EMBASE, Web of Science, Scopus, PubMed Publisher, and the Cochrane Library was performed. All aspects of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis statement were followed. Manual reference checks (B.G.) of accepted articles in recent reviews and included articles were performed to supplement the electronic searches. Details of the search syntax are listed in Appendix 1. Studies were evaluated for inclusion independently by 2 reviewers (L.T., B.G.) based on title and abstract and finally were evaluated independently based on the full text. Studies were included if they met the following criteria: (1) participants: adult patients who underwent elective IH repair; (2) interventions: OR and SR as described by the European Hernia Society; (3) outcome measures: IH recurrence and postoperative complications; (4) secondary outcome measures: SSI, seroma, hematoma, and fistula. A random check was performed by the senior author (J.F.L.). Articles in which additional dissections had been implemented were excluded to reduce heterogeneity by intervention because the current review was strictly interested in comparing OR and SR and not a mixture of techniques. Any discrepancies in inclusion were resolved by discussion between the reviewers and the senior author (J.F.L.).

All required data from each study included were extracted using a standardized form that covered study characteristics (study design, year of publication, and study period), type of intervention (OR and SR), perioperative information (operation time and period of hospitalization), and postoperative complications (IH recurrence, SSI, seroma, hematoma, and fistula).

**Assessment of study quality**

The methodological quality of the included nonrandomized studies was assessed according to the Newcastle Ottawa Scale (NOS) criteria.

**Data analysis**

It was expected that the majority of articles would be nonrandomized studies. Therefore, it was decided to implement a quality assessment before including studies for meta-analysis. Nonrandomized studies were deemed eligible if a NOS score of 5 (out of 9) or higher was established. Articles with a lower score were more at risk of presenting biased results, and thus, were excluded from the meta-analysis. The results of these excluded studies will be presented after each outcome section.

To pool data and calculate a pooled mean for each patient level outcome, a random effects model was used, which takes into account both the variance between studies and the variance within a study. Statistical ratios or mean differences with 95% confidence intervals were calculated to evaluate the statistical difference between outcomes after OR and SR. Statistical heterogeneity was assessed for IH recurrence, SSI, seroma, hematoma, and fistula by calculating the Q statistic and the I^2 statistic.

Selective dissemination of evidence was assessed by plotting each outcome measure of each study against precision (1/standard error) in a plot with P value contours. Funnel plot asymmetry, specifically with an apparent lack of studies in high P value areas of the plot, can be indicative of publication bias. Individual study effects on the results were examined by removing studies 1 at a time to determine whether removing a particular study would change the significance of the pooled effect. Effects were considered statistically significant if the 95% confidence intervals of the overall effect estimate did not overlap 1. Analyses were performed using Review Manager software (RevMan version 5.0.25; The Nordic Cochrane Centre, Copenhagen, Denmark).

**Results**

**Search and study characteristics**

A total of 178 articles were identified after the removal of duplicates. Of these 178, 153 were excluded on the basis of title and abstract. After full-text assessment, 21 articles were excluded because the article was an abstract or letter to the editor, it could not be obtained, it had been published in 2 different journals with similar results, or it did not fulfill the inclusion criterion that information needed to be available for distinguishing results for both techniques.

A total of 10 articles (2 randomized controlled trials [RCTs], 1 prospective study, and 7 retrospective studies) compromising a total of 1,948 patients (775 OR and 1173 sublay operations) did meet the inclusion criteria. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis flow diagram for systematic reviews is presented in Fig. 1. The nonrandomized studies were assessed for quality using the NOS criteria. Two studies did not meet the criteria for inclusion in the meta-analysis because they scored lower than 5 points (out of 9) (Table 1). In these 2 studies, a total of 265 patients were included. The majority of patients (240/265) underwent SR.
Incisional hernia recurrence

Eight studies\textsuperscript{18,20–22,24,26–28} comprising a total of 1,359 patients reported data regarding IH recurrence and were included into the meta-analysis (Figs. 2 and 3).\textsuperscript{20–22,24,26–29} A trend in favor of SR was observed (odds ratio = 2.41; 95% confidence interval [CI], .99 to 5.88; $I^2 = 70\%$; $P = .05$). During sensitivity analysis, results proved to be unstable, and heterogeneity remained high. However, after exclusion of the study by Weber,\textsuperscript{28} heterogeneity was reduced to 0, and results became statistically significant (odds ratio = 3.35; 95% CI, 1.93 to 5.82; $I^2 = 0\%$; $P < .001$). Bridging of the defect was not mentioned in any of the included studies.

The 2 studies not included in the meta-analysis also reported on IH recurrence.\textsuperscript{23,25} In 1 study, the recurrence rate for OR was 33% (3/9) compared with 48% (1/207) in the SR group. In the other study, the recurrence rate in the OR group was 12.5% (2/16) compared with 3% (1/33) in the SR group.

Surgical site infection

Six studies comprising a total of 747 patients reported data regarding SSI and were included in the meta-analysis (Fig. 4).\textsuperscript{18,20,22,24,26,27} SSI occurred significantly less in the SR group (odds ratio = 2.42; 95% CI, 1.02 to 5.74; $I^2 = 16\%$; $P = .05$). During sensitivity analysis, the results proved to be unstable with acceptable heterogeneity scores. Little to no information was present regarding the intraoperative degree of wound contamination and previous SSIs. In most studies, a standard regimen of antibiotic treatment during and after hernia repair was implemented (Table 1). One study not included in the meta-analysis reported data regarding SSI.\textsuperscript{23} The SSI rate in the OR group was 11.1% (1/9) compared with 3.4% (7/207) in the SR group.

Seroma

Six studies comprising a total of 715 patients reported data regarding seroma and were included in the meta-analysis (Fig. 5).\textsuperscript{18,20,22,24,26,27} No statistical significant results were achieved (odds ratio = 1.06; 95% CI, .38 to 2.95; $I^2 = 48\%$; $P = .89$). During sensitivity analysis, the results proved to be stable with fluctuating heterogeneity scores. One study not included in the meta-analysis reported data regarding seroma.\textsuperscript{23} The seroma rate in the OR group was 11.1% (1/9) compared with 1.9% (4/207) in the SR group.
<table>
<thead>
<tr>
<th>Reference</th>
<th>NOS</th>
<th>Study Type</th>
<th>Year</th>
<th>Hernia size</th>
<th>No. of ORs</th>
<th>No. of SRs</th>
<th>Mesh</th>
<th>Antibiotics</th>
<th>Outcome measures</th>
<th>Follow-up</th>
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<tr>
<td>Kumar et al&lt;sup&gt;20&lt;/sup&gt;</td>
<td>7</td>
<td>Pros</td>
<td>2012</td>
<td>3 cm to 12 cm&lt;sup&gt;*&lt;/sup&gt;</td>
<td>45</td>
<td>18</td>
<td>?</td>
<td>?</td>
<td>IH recurrence, SSI, seroma, postoperative pain</td>
<td>60 months†</td>
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<td>Forte et al&lt;sup&gt;23&lt;/sup&gt;</td>
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<td>9</td>
<td>207</td>
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<td>12 months†</td>
</tr>
<tr>
<td>Abdollahi et al&lt;sup&gt;24&lt;/sup&gt;</td>
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<td>Retro</td>
<td>2010</td>
<td>?</td>
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<td>32</td>
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<td>RCT</td>
<td>2010</td>
<td>11.5 cm (OR)&lt;sup&gt;†&lt;/sup&gt; – 11 cm (SR)&lt;sup&gt;†&lt;/sup&gt;</td>
<td>57</td>
<td>50</td>
<td>PP comp</td>
<td>Yes (oxacilum)</td>
<td>IH recurrence, SSI, seroma, hematoma, ligature fistula, operative time</td>
<td>12 months†</td>
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<tr>
<td>Weber and Horvath&lt;sup&gt;19&lt;/sup&gt;</td>
<td>(2b&lt;sup&gt;‡&lt;/sup&gt;)</td>
<td>RCT</td>
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<td>&gt;25 cm&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>235</td>
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<td>IH recurrence, operative time</td>
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<td>Retro</td>
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<td>—</td>
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<td>23</td>
<td>PP</td>
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<tr>
<td>de Vries Reilingh et al&lt;sup&gt;26&lt;/sup&gt;</td>
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<td>PP</td>
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<td>30 months†</td>
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</tr>
<tr>
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<td>3</td>
<td>Retro</td>
<td>2004</td>
<td>“Loss of domain”</td>
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<td>33</td>
<td>PP</td>
<td>Yes</td>
<td>IH recurrence</td>
<td>—</td>
</tr>
</tbody>
</table>

NOS = Newcastle-Ottawa Score, OR = onlay repair, SR = sublay repair.

*Range.

†Mean.

‡Oxford level of evidence: ? = unknown; IH = incisional hernia; PE = polyester; PP = polypropylene; Pros = prospective; RCT = randomized controlled trial, Retro = retrospective, SSI = surgical site infection.
Hematoma

Four studies comprising a total of 307 patients reported data regarding hematoma and were included in the meta-analysis (Fig. 6).\(^{18,22,26,27}\) No statistically significant results were achieved (odds ratio = .54; 95% CI, 2.1 to 1.38; \(I^2 = 0\%\); \(P = .19\)). During sensitivity analysis, the results and heterogeneity proved to be stable.

Fistula

Four studies\(^ {18,24,26,27}\) reported data regarding fistula.\(^ {17,23,25,26}\) However, the definition of fistula (enterocutaneous, ligature, or intestinal) differed in 3 studies and was not reported in 1. In 2 studies, no cases of postoperative fistula were reported.\(^ {26,27}\) In the RCT by Venclauskas et al,\(^ {18}\) ligature fistula was reported in 14% (8/57) after OR and in 4% (2/50) after SR; this was not statistically significant. In the study by Abdollahi et al,\(^ {24}\) intestinal fistula was reported in 3% (1/33) after OR and in .3% (1/312) after SR; no statistics were performed.

Operation time

Three studies reported data regarding operating time.\(^ {18,21,28}\) However, not all studies reported standard deviations, making pooling of the results impossible. All 3 studies reported lower mean operating times for OR. The study by Israelsson et al\(^ {21}\) reported a mean OR operation time of 92 minutes (95% CI, 88 to 97) compared with 102 minutes (95% CI, 96 to 108) in the SR group; no statistical analysis was performed.\(^ {21}\) The RCT by Venclauskas et al\(^ {18}\) reported a significantly lower \((P = .001)\) operation time for the OR group (135 minutes; 95% CI, 87.5 to 182.5 minutes) compared with the SR group (168.4 minutes; 95% CI, 114.4 to 222.4 minutes). The RCT performed by Weber et al\(^ {28}\) reported a mean operation time of 75 minutes (range 30 to 210 minutes) in the OR group compared with 77 minutes (range 25 to 220 minutes) in the SR group; this was not statistically significant.\(^ {28}\)

Postoperative pain

Two studies\(^ {18,20}\) reported data regarding postoperative pain. However, the 2 studies reported pain in a different manner and thus could not be pooled for meta-analysis. In the RCT by Venclauskas et al,\(^ {18}\) a visual analog scale (VAS) was used to assess pain during the hospital stay of the patient, and an average was presented in their data. The mean VAS score for OR was not statistically different compared with SR during rest (3.96 [95% CI, 2.40 to 4.52] vs 3.78 [95% CI, 1.82 to 5.75]; \(P = .607\)) and during activity (5.48 [95% CI, 3.82 to 7.14] vs 5.2 [95% CI 2.89 to 7.5]; \(P = .607\)). In the prospective study by Kumar, postoperative pain was also measured by means of a VAS.\(^ {20}\) However, they opted to group their results into significant pain (VAS >5) and nonsignificant pain (VAS <5) groups. Patients in the SR group had significantly more pain (33.3% vs 61.1%); however, no \(P\) value was provided.

Comments

SR seems to be the preferred technique compared with OR for IH repair because it results in lower SSI rates. In addition, a trend toward lower recurrence rates was observed when using SR. The 2 techniques did not differ with regard to seroma formation or hematoma. Although results...
regarding operation time could not be pooled, OR seemed to take up less time than SR. No definitive conclusions could be drawn from results regarding postoperative pain and fistula.

**Recurrence**

Worldwide, IH repair is a frequently performed surgical procedure. OR and SR are well-known techniques for IH repair; they both have advantages and disadvantages. OR is assumed to be easier to perform and less time-consuming. The dissection of the posterior rectus fascia from the rectus muscle during SR can be challenging, especially in cases of previous infection and adhesions. However, SR is assumed by many to reduce IH recurrence although this was not directly confirmed in this study. This reduction of IH recurrence might be caused by a higher tensile strength of the abdominal wall after SR. The intra-abdominal pressure would fix the mesh between the posterior fascia and the abdominal muscle. However, experimental studies focusing on abdominal wall strength have reported inconsistent results. Binnebösel et al\(^2\) described less stability of the mesh with regard to OR in their hernia model, but Ko et al\(^1\) discovered no significant differences in tensile strength between OR and SR in their study.

Furthermore, the SR mesh position seems favorable with regard to tissue incorporation. Binnebösel et al\(^1\) described significant in growth and lower collagen type 1:3 ratio after OR in an animal model. These factors are known to promote IH formation. In addition, in an experimental study by Garcia-Urena et al\(^3\), an increase of mesh shrinkage after OR was described. Mesh shrinkage may reduce this overlap and promote IH recurrence.

**Postoperative complications**

Although OR is thought to be easier and quicker to perform, it has been suggested that the dissection of the suprafascial space would promote seroma formation and SSI.\(^4\) With regard to seroma formation, we could not detect any difference in this study. However, of all studies that reported data on seroma, only half of them provided information regarding drain placement.\(^1\)\(^8\)\(^2\)\(^2\)

SR was superior to OR with regard to SSI. This could be explained by the more superficial position of OR making it easier for bacterial colonization. Additionally, mesh positioning on the posterior rectus fascia would benefit from a more vascularized area compared with the OR position.

Dissection of the SR space could be troubled by the higher grade of vascularization and the presence of the inferior and superior epigastric arteries, which could increase the amount of hematoma formation after SR. However, this was not observed during meta-analysis.

Information regarding postoperative pain and fistula could not be pooled in this meta-analysis. Definitions of the postoperative complications varied and/or were reported in such a manner that making assumptions regarding these topics was not possible. However, it seems plausible that the dissection of the space between the posterior rectus fascia and the rectus muscle is a more elaborate procedure and with more possibilities to damage, ligate, or cut nerves and thus induce (chronic) pain. The experience of the...
surgeon in these cases is also of utmost importance and could make a large difference with regard to postoperative pain.

Limitations

Performing a good meta-analysis can be challenging, and a number of aspects should be kept in mind during the process. Ideally, a meta-analysis should consist of a number of high-quality studies, preferably RCTs, with comparable study populations and interventions. The results of the individual studies should be homogeneous and have a common dependent variable or end point. Also, the quality of the data being combined should be similar among studies. This limits the possibility of bias and heterogeneity between studies.32

In this meta-analysis, only 2 RCTs were included, and the vast majority of the studies were of retrospective nature. However, all of the included studies had comparable study populations, similar interventions, and a common end point (incisional hernia recurrence). Additionally, a quality assessment was performed to make sure that nonrandomized trials were of decent quality before including them in the meta-analysis. However, excluding trials might also facilitate publication bias. All data from the excluded studies regarding IH recurrence, SSI, and seroma displayed comparable results as calculated in this meta-analysis. Including these studies would not have changed any outcomes except for IH recurrence. Instead of a trend, SR would have been significantly better with regard to IH recurrence compared with OR.

The results regarding IH recurrence, the main outcome of this study, were subject to a high level of heterogeneity. When looking at the funnel plot for this analysis, the study by Weber et al12 in particular is the source of asymmetry. Removal of this study reduced the heterogeneity to 0, and results became statistically significant. Furthermore, the RCT by Weber et al was of mediocre quality and might be subject to location bias. Additionally, this study did differ somewhat compared with other studies because Weber et al only included larger hernias, which could contribute to heterogeneity.

Although the included studies were all assessed regarding quality, the retrospective nature of most studies still is a limitation to this meta-analysis. The number of IH recurrence and postoperative complications are likely to be underreported especially because no ultrasonography was performed in any of the included trials. In addition, a lot of variables such as the amount of mesh overlap, experience of the surgeon, wound classification, number of stitches, and time to recurrence remain unclear or differed between studies. These inconsistencies and the instability of this meta-analysis make it difficult to allow for solid conclusions.

Conclusion

Although the majority of included studies were of a retrospective nature, SR seems to be the preferred technique for IH repair compared with OR.

Acknowledgments

We would like to thank Wichor Bramer for his assistance on the search strategy.

References

hernias by "overcoat" plasty and prothesis (author’s transl)]. Nouv Presse Med 1979;8:695–6.


28. Weber G, Baracs J, Horvath OP. [:”Onlay” mesh provides significantly better results than “sublay” reconstruction. Prospective randomized multicenter study of abdominal wall reconstruction with sutures only, or with surgical mesh–results of a five-years follow-up]. Magy Seb 2010;63:302–11.


Appendix 1

Search Strategy

**Embase 144**
(hernia/exp OR scar/exp OR ‘postoperative complication’/exp OR (herni* OR scar* OR cicatr* OR postoperat* OR (post NEXT/1 operat*)):ab,ti) AND (onlay OR chevrel OR prefascial OR ‘pre fascial’):ab,ti AND (sublay OR (rives NEAR/1 stoppa) OR underlay OR ‘under lay’ OR subfascial OR ‘sub fascial’ OR preperitoneal OR ‘pre peritoneal’ OR retrorect* OR (retro NEXT/1 rect*)):ab,ti

**Medline OvidSP 106**
(exp hernia/ OR exp Cicatrix/ OR exp “Postoperative Complications”/ OR (herni* OR scar* OR postoperat* OR post-operat*).ab,ti.) AND (onlay OR chevrel OR prefascial* OR pre fascial*).ab,ti. AND (sublay OR (rives ADJ1 stoppa) OR underlay* OR under lay* OR subfascial* OR sub-fascial* OR preperitoneal* OR ‘pre peritoneal’ OR retrorect* OR (retro ADJ rect*)):ab,ti.

**Cochrane Central 3**
((herni* OR scar* OR cicatr* OR postoperat* OR (post NEXT/1 operat*)):ab,ti) AND (onlay OR chevrel OR prefascial OR ‘pre fascial’):ab,ti AND (sublay OR (rives NEAR/1 stoppa) OR underlay OR ‘under lay’)

**Web of Science 104**
TS=(((herni* OR scar* OR cicatr* OR postoperat* OR (post NEXT/1 operat*))) AND (onlay OR chevrel OR prefascial OR ‘pre fascial’)) AND (sublay OR (rives NEAR/1 stoppa) OR underlay OR ‘under lay’ OR subfascial OR ‘sub fascial’ OR preperitoneal OR ‘pre peritoneal’ OR retrorect* OR (retro NEXT/1 rect*))

**Scopus 143**
TITLE-ABS-KEY((herni* OR scar* OR cicatr* OR postoperat*) AND (onlay OR chevrel OR prefascial OR “pre fascial”) AND (sublay OR (rives W/1 stoppa) OR underlay OR “under lay” OR subfascial OR “sub fascial” OR preperitoneal OR “pre peritoneal” OR retrorect* OR (retro-rect*))

**PubMed Publisher 6**