

## OBSTETRICS

## Techniques for cesarean section

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Cesarean section (CS) is the most commonly performed major abdominal operation in women in both affluent and low-income countries. Rates vary considerably between and within countries.<sup>1-3</sup> Global estimates indicate a CS rate of 15% worldwide, ranging from 3.5% in Africa to 29.2% in Latin America and the Caribbean.<sup>4</sup>

There are many possible ways of performing CS. A study of obstetricians in the United Kingdom and in the North America found a wide variation in techniques.<sup>5,6</sup>

The Joel-Cohen technique includes straight transverse incision through skin only, 3 cm below the level of the anterior superior iliac spines (higher than the Pfannenstiel incision). The subcutaneous tissues are opened only in the middle 3 cm. The fascia is incised transversely in the midline then extended laterally with blunt finger. Finger dissection is used to separate the rectus muscles vertically and laterally and open the peritoneum. All the layers of the abdominal wall are stretched manually to the extent of the skin incision. The bladder is reflected inferiorly. The myometrium is incised

The effects of complete methods of cesarean section (CS) were compared. Metaanalysis of randomized controlled trials of intention to perform CS using different techniques was carried out. Joel-Cohen–based CS compared with Pfannenstiel CS was associated with reduced blood loss, operating time, time to oral intake, fever, duration of postoperative pain, analgesic injections, and time from skin incision to birth of the baby. Misgav-Ladach compared with the traditional method was associated with reduced blood loss, operating time, time to mobilization, and length of postoperative stay for the mother. Joel-Cohen–based methods have advantages compared with Pfannenstiel and traditional (lower midline) CS techniques. However, these trials do not provide information on serious and long-term outcomes.

**Key words:** cesarean section, Joel-Cohen, Misgav-Ladach, Pfannenstiel

transversely in the midline but not to breach the amniotic sac, then opened and extended laterally with finger dissection. Interrupted sutures are used for the closure of the myometrium. The Misgav-Ladach technique<sup>7,8</sup> is a modification of the Joel-Cohen technique developed by Stark et al.<sup>7</sup> The Joel-Cohen abdominal incision is used (see above). The uterus is opened as for the Joel-Cohen method (see above). The placenta is removed manually. The uterus is exteriorized. The myometrial incision is closed with a single-layer locking continuous suture. The peritoneal layers are not sutured. The fascia is sutured with a continuous suture. The skin is closed with 2 or 3 mattress sutures. Between these sutures, the skin edges are approximated with Allis forceps, which are left in place for about 5 minutes while the drapes are being removed.

The Pelosi-type CS includes a Pfannenstiel abdominal incision.<sup>9</sup> Electrocautery is used to divide the subcutaneous tissues and the fascia transversely. The rectus muscles are separated by blunt dissection to provide space for both index fingers, which free the fascia vertically and transversely. The peritoneum is opened by blunt finger dissection and all the layers of the abdominal wall are stretched manually to the extent of the skin incision. The bladder is not reflected inferiorly. A small transverse lower segment incision is made through

the myometrium, and extended laterally, curving upward, with blunt finger dissection or scissors. The baby is delivered with external fundal pressure, oxytocin is administered and the placenta removed after spontaneous separation. The uterus is massaged. The myometrial incision is closed with a single-layer chromic catgut 0 continuous locking suture. Neither peritoneal layer is sutured. The fascia is closed with a continuous synthetic absorbable suture. If the subcutaneous layer is thick, interrupted 3-0 absorbable sutures are used to obliterate the dead space. The skin is closed with staples.

Historically the extraperitoneal approach to CS was used in septic cases in an attempt to limit the spread of sepsis before the advent of effective antibiotics.<sup>10</sup> It is seldom used today.

Scar rupture is a dangerous complication of CS, especially when attempting vaginal birth after CS. Avoiding this complication is crucial, in particular in developing countries, where access to repeated CS may not be available at all times. The rates of scar rupture that have been reported are higher in Africa in comparison with North America.<sup>11,12</sup> It has been suggested that double-layer closure of the uterine wall is associated with a lower rates of uterine rupture in comparison with the single-layer closure, although no advantages of double- over single-layer closure have been reported in

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Received Oct. 29, 2008; revised Feb. 26, 2009; accepted March 6, 2009.

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0002-9378/\$36.00

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doi: 10.1016/j.ajog.2009.03.018

**TABLE**  
**Characteristics of included studies**

Study	Methods	Participants	Interventions	Outcomes	Notes	Allocation concealment
Bjorklund et al <sup>52</sup>	Computer-randomized sequence in sealed opaque envelopes. Assessment could not be blinded.	Women undergoing elective or emergency CS with general anesthesia at >37 gestational wks. Exclusion criteria: repeated CS, previous abdominal surgery, pyrexia >39°C, severe anemia, bleeding disorders, uterine rupture, previous postpartum hemorrhage.	Misgav-Ladach technique (n = 169) vs traditional CS (n = 170): lower midline abdominal incision, double-layer closure of the uterus, closure of both peritoneal layers.	Operating time, blood loss, blood loss >500 mL, suture material used, Appgar scores at 5 and 10 min, intraoperative antibiotics, postoperative complication, length of hospital stay.	Muhimbili Medical Center, Dar es Salaam, Tanzania. December 20, 1996-March 8, 1997. 16 surgeons. There was uncertainty about 4 possible losses to follow-up. 1 woman in each group received the nonallocated technique. Quality assessment: 1. Generation of random allocation sequence: A. 2. Allocation concealment: A. 3. Blinding of participants: C. 4. Blinding of caregivers: C. 5. Blinding of outcome assessment: B. 6. Compliance with allocated intervention: A. 7. Completeness of follow-up data: A. 8. Analysis of participants in randomized groups: A.	A
Dani et al <sup>53</sup>	Randomization not described. Assessment of outcome blind.	Infants delivered at >36 gestational wks admitted to nursery or intensive care. Excluded: major congenital abnormalities, 9 with incomplete data.	76 (53%) Delivered by Stark modified CS and 68 (47%) by traditional CS.	Respiratory depression, perinatal asphyxia, frequency and duration of hospital admission.	Hospital of Rovigo, Italy. January-December 1996. Quality assessment: 1. Generation of random allocation sequence: C. 2. Allocation concealment: B. 3. Blinding of participants: C. 4. Blinding of caregivers: C. 5. Blinding of outcome assessment: A. 6. Compliance with allocated intervention: A. 7. Completeness of follow-up data: B. 8. Analysis of participants in randomized groups: A.	B
Darj and Nordstrom <sup>54</sup>	Randomly allocated, used sealed opaque envelopes opened by women's husband before the surgery. Assessment not blind.	Women undergoing first CS. Exclusion: previous abdominal surgery.	Misgav-Ladach (n = 25) vs Pfannenstiel (n = 25).	Duration of operation, blood loss, analgesic injections, duration and doses, time to drinking water and to standing up, first bowel action, days in hospital.	University Hospital Uppsala, Sweden. 1996-1997. 1 surgeon. No prophylactic antibiotics used. Quality assessment: 1. Generation of random allocation sequence: C. 2. Allocation concealment: A. 3. Blinding of participants: C. 4. Blinding of caregivers: C. 5. Blinding of outcome assessment: C. 6. Compliance with allocated intervention: A. 7. Completeness of follow-up data: A. 8. Analysis of participants in randomized groups: A.	A
Ferrari et al <sup>40</sup>	Randomization by sealed opaque envelopes stored by each of 10 surgeons.	Women requiring first CS, >30 gestational wks, eligible for CS by Pfannenstiel technique.	Joel-Cohen (n = 83) vs Pfannenstiel (n = 75).	Day of urinary catheter removal, stopping intravenous fluids, liquid intake, food intake, flatus, and mobilization; fever, pain on day 1 and 2.	San Raffaele Hospital and San Paolo Hospital of Milan School of Medicine, Italy. January 1997-June 1998. 10 senior surgeons. Quality assessment: 1. Generation of random allocation sequence: C. 2. Allocation concealment: A. 3. Blinding of participants: C. 4. Blinding of caregivers: C. 5. Blinding of outcome assessment: C. 6. Compliance with allocated intervention: A. 7. Completeness of follow-up data: A. 8. Analysis of participants in randomized groups: A.	A

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(continued)

**TABLE**  
**Characteristics of included studies** (continued)

Study	Methods	Participants	Interventions	Outcomes	Notes	Allocation concealment
Franchi et al <sup>59</sup>	Randomization: computer-generated list of numbers. These assignments were placed in sequentially numbered sealed envelopes opened immediately before the start of operation.	Excluded: women with multiple pregnancy, $\geq 2$ previous CS, previous longitudinal laparotomy, previous myomectomy, gestational age $> 30$ wk, antibiotics within 2 wk before CS, requiring additional surgery.	Joel-Cohen (n = 149) vs Pfannenstiel (n = 153).	Operative time, opening time, bladder injury, intraoperative transfusion, postoperative hospital stay, change in hemoglobin concentration, postoperative ileus, wound infection, postoperative morbidity.	Insubria University, Varese, Italy. April 1995-August 1997. Quality assessment: 1. Generation of random allocation sequence: A. 2. Allocation concealment: A. 3. Blinding of participants: A. 4. Blinding of caregivers: B. 5. Blinding of outcome assessment: B. 6. Compliance with allocated intervention: A. 7. Completeness of follow-up data: A. 8. Analysis of participants in randomized groups: A.	A
Franchi et al <sup>60</sup>	Randomization computer-generated, midwife opened sealed envelopes immediately before skin incision.	Excluded: multiple pregnancy, $\geq 2$ previous CS, maternal disease, previous CS $< 32$ gestational wks, myomectomy, previous longitudinal abdominal incision.	Joel-Cohen (n = 154) vs Pfannenstiel (n = 158).	Operating time, extraction time, additional uterine stitches, additional hemostatic uterine stitches, intraoperative transfusion, bladder injury, change in hemoglobin concentration, time to passage of flatus, wound infection, postoperative morbidity, hospital stay.	Insubria University, Varese, Italy. January 1998-May 2000. Junior surgeons. 2 women excluded in Joel-Cohen group: they required cesarean hysterectomy. Quality assessment: 1. Generation of random allocation sequence: A. 2. Allocation concealment: A. 3. Blinding of participants: A. 4. Blinding of caregivers: B. 5. Blinding of outcome assessment: B. 6. Compliance with allocated intervention: A. 7. Completeness of follow-up data: B. 8. Analysis of participants in randomized groups: A.	A
Heimann et al <sup>55</sup>	Randomization not described.	Women with high-risk pregnancies. Groups did not differ in age, gestational age, previous CS. Misgav-Ladach groups had more nulliparous women.	Modified Misgav-Ladach (skin incision as low as Pfannenstiel, n = 117) vs Pfannenstiel (n = 123).	Duration of operation, Apgar score, cord blood pH, intraoperative complications, postoperative complications, decrease in hemoglobin, hematoma formation, pyrexia, wound complications, hospital stay.	Wiesbaden, Germany. November 24, 1998-May 25, 1999. 3 women from Misgav-Ladach group were transferred into Pfannenstiel group: 1 due to obesity, 1 due to scarring from previous CS, 1 due to tumor that required removal. Analysis by intention to treat. Quality assessment: 1. Generation of random allocation sequence: B. 2. Allocation concealment: B. 3. Blinding of participants: C. 4. Blinding of caregivers: C. 5. Blinding of outcome assessment: C. 6. Compliance with allocated intervention: B. 7. Completeness of follow-up data: A. 8. Analysis of participants in randomized groups: A.	B
Koettnitz et al <sup>59</sup>	Randomization alternative.	Women requiring CS.	Modified Cohen with low skin incision (n = 44) vs Pfannenstiel (n = 42).	Wound infection, mobilization, antibiotic use, operating time, cost of materials.	Frauenklinik, Duisburg, Germany. January 1996-July 1996. Quality assessment: 1. Generation of random allocation sequence: C. 2. Allocation concealment: C. 3. Blinding of participants: C. 4. Blinding of caregivers: C. 5. Blinding of outcome assessment: C. 6. Compliance with allocated intervention: A. 7. Completeness of follow-up data: A. 8. Analysis of participants in randomized groups: A.	C

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**TABLE**  
**Characteristics of included studies** (continued)

Study	Methods	Participants	Interventions	Outcomes	Notes	Allocation concealment
Li et al <sup>56</sup>	Randomization not described.	Women requiring CS.	Modified Misgav-Ladach (transversely incising fascia 2-3 cm, then dividing bluntly without opening and dissociating the visceral peritoneum, 2-layer suturing of low transverse uterine incision, closing the skin by continuous suturing, n = 59) vs Misgav-Ladach (n = 57) vs Pfannenstiel (n = 56).	Operating time, delivery time, blood loss, postoperative pain, diet, bowel movement, and hospital stay.	Xiehe Hospital, Tongji. May-December 1999. Quality assessment: 1. Generation of random allocation sequence: C. 2. Allocation concealment: C. 3. Blinding of participants: D. 4. Blinding of caregivers: D. 5. Blinding of outcome assessment: D. 6. Compliance with allocated intervention: A. 7. Completeness of follow-up data: A. 8. Analysis of participants in randomized groups: A.	C
Mathai et al <sup>57</sup>	Randomization in blocks, slips of paper with the allocated incision were placed in identical, consecutively numbered sealed opaque envelopes. Blood loss and time for surgery assessed by anesthetist; postoperative analgesia on demand; allocation not known to anesthetist or staff in postoperative ward.	Women with singleton pregnancy, longitudinal lie, at term requiring CS under spinal anesthesia. Excluded: multiple pregnancy, previous abdominal surgery, need for midline or paramedian incision, spinal anesthesia contraindicated.	Joel-Cohen (n = 51) vs Pfannenstiel (n = 50).	Time to analgesia, delivery time, operative time, blood loss, time to oral fluids, total dose of analgesics, febrile morbidity, postoperative hematocrit, time to breast-feeding, time in special care nursery, hospital stay.	Christian Medical College and Hospital, Vellore, India. 1 of 31 registrars performed the surgery. 4 women excluded from analysis: in Joel-Cohen group, 1 had cesarean hysterectomy, 1 had vaginal delivery before CS, 1 had ineffective spinal block; in Pfannenstiel group, 1 woman had ineffective spinal block. Quality assessment: 1. Generation of random allocation sequence: A. 2. Allocation concealment: A. 3. Blinding of participants: D. 4. Blinding of caregivers: D. 5. Blinding of outcome assessment: D. 6. Compliance with allocated intervention: A. 7. Completeness of follow-up data: B. 8. Analysis of participants in randomized groups: A.	A
Mokgokong and Crichton <sup>62</sup>	Randomization using odd and even numbers of admission number.	Women requiring CS who had intrauterine infection; 412 black and Indian women.	Extraperitoneal (n = 239) vs intraperitoneal (n = 173) CS.	Time to delivery, peritonitis, pelvic abscess, abdominal wound sepsis, secondary postpartum hemorrhage, further surgery, septicemic shock, hospital stay, mortality.	Kind Edward VIII Hospital, Durban, South Africa. Quality assessment: 1. Generation of random allocation sequence: B. 2. Allocation concealment: C. 3. Blinding of participants: D. 4. Blinding of caregivers: D. 5. Blinding of outcome assessment: D. 6. Compliance with allocated intervention: A. 7. Completeness of follow-up data: B. 8. Analysis of participants in randomized groups: A.	C
Moreira et al <sup>58</sup>	Randomization was not described.	Women requiring CS.	Misgav-Ladach (n = 200) vs traditional (n = 200).	Time to delivery, operative time, use of suture material, dose of analgesia, postoperative complications, hospital stay, cost.	Dakar Teaching Hospital, Senegal. April-July 2000. Quality assessment: 1. Generation of random allocation sequence: C. 2. Allocation concealment: B. 3. Blinding of participants: D. 4. Blinding of caregivers: D. 5. Blinding of outcome assessment: D. 6. Compliance with allocated intervention: A. 7. Completeness of follow-up data: A. 8. Analysis of participants in randomized groups: A.	B

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(continued)

**TABLE**  
**Characteristics of included studies** (continued)

Study	Methods	Participants	Interventions	Outcomes	Notes	Allocation concealment
Wallin and Fall <sup>38</sup>	Randomization: computer generated in large blocks, using sealed envelopes opened by physicians just before surgery. Results of randomization were known only to a single obstetrician who performed surgery. Outcome assessment was blind.	Women requiring elective CS with no history of abdominal surgery.	Modified Joel-Cohen (>3 cm of original Pfannenstiel, n = 36) vs Pfannenstiel (skin incision >3 cm of originally described, n = 36).	Operating time, blood loss, intravenous fluids, blood effusion, hemoglobin, C-reactive protein, hospital stay.	Sahlgrenska University Hospital, Gothenburg, Sweden. Quality assessment: 1. Generation of random allocation sequence: A. 2. Allocation concealment: A. 3. Blinding of participants: B. 4. Blinding of caregivers: B. 5. Blinding of outcome assessment: B. 6. Compliance with allocated intervention: A. 7. Completeness of follow-up data: A. 8. Analysis of participants in randomized groups: A.	A
Xavier et al <sup>61</sup>	Randomization: outcome assessment blinded.	Women for CS by 1/3 surgeons.	Modified Misgav-Ladach (n = 88) vs Pfannenstiel-Kerr (n = 74).	Operating time, requested paracetamol, bowel recovery, febrile morbidity, postoperative antibiotics, endometritis, wound complications.	Porto University Hospital de Sao Joao, Portugal. 3 surgeons. Quality assessment: 1. Generation of random allocation sequence: A. 2. Allocation concealment: A. 3. Blinding of participants: D. 4. Blinding of caregivers: D. 5. Blinding of outcome assessment: D. 6. Compliance with allocated intervention: A. 7. Completeness of follow-up data: B. 8. Analysis of participants in randomized groups: A.	A

A, adequate; B, inadequate; C, unclear; CS, cesarean section; D, no information.

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trials.<sup>13-15</sup> No randomized control trials (RCTs) have reported on risks of scar dehiscence during subsequent pregnancies.

The techniques used to perform CS may depend on many factors including the clinical situation and the preferences of the operator. CS is often performed as an emergency procedure after hours when senior staff may not be immediately available. It is important that all those who perform this operation use the most effective and safe techniques, as determined by a systematic review of RCTs.

The emphasis of this review is on surgical techniques for CS.

Over the years, many variations in the technique of CS have developed:

1. The woman's position may be supine or with a lateral tilt.<sup>16</sup>
2. The skin incision may be vertical (midline or paramedian) or transverse lower abdominal (Pfannenstiel, Joel-Cohen, Pelosi, Maylard, Mouchel, or Cherney). For very obese women, a transverse incision above the umbilicus has been sug-

gested, but not shown to decrease morbidity.<sup>17</sup>

Electrocautery has been compared with cold-knife incision for the abdominal wall opening.<sup>18</sup> The lower leaf of the rectus sheath may be freed or not.<sup>19</sup> Randomized trials of various abdominal surgical incisions for CS have been reviewed elsewhere.<sup>20</sup>

3. The bladder peritoneum may be reflected downward or not.<sup>21</sup>
4. The uterine incision may be transverse lower segment (Munro-Kerr), midline lower segment, or midline upper segment (classic).
5. The uterus may be opened with a scalpel, with scissors, by blunt dissection, or using absorbable staples.<sup>22</sup>
6. The placenta may be removed manually or with cord traction, and allowing the cord to bleed has been used to assist placental delivery.<sup>23</sup>
7. The uterus may be delivered from the abdominal cavity or left in position during repair.<sup>24</sup>

8. The uterus may be closed with interrupted or continuous sutures in 1, 2, or 3 layers.<sup>25</sup> Observational studies have suggested that a single-layer closure is associated with more ultrasound scar defects<sup>26</sup> and is more likely to dehiscence in subsequent pregnancies.<sup>27-29</sup> In another study, increased uterine "windows" were found after single-layer closure, but no scar ruptures occurred.<sup>15</sup>
9. Blood may be recovered during the procedure for retransfusion.<sup>30</sup>
10. The visceral or the parietal peritoneum, or both, may be sutured or left unsutured.<sup>31</sup>
11. Various materials may be used for closure of the fascia. In women at increased risk for wound dehiscence, a running Smead-Jones suture has been suggested.<sup>32</sup>
12. Careful handling of tissues and good surgical technique are suggested to reduce the risk of infection.<sup>33,34</sup>
13. The subcutaneous tissues may be sutured or not.<sup>35</sup>

FIGURE 1

**Operating time (minutes) using Joel-Cohen and Pfannenstiel techniques for cesarean section**

CI, confidence interval; WMD, weighted mean difference.

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14. Various techniques and materials may be used for skin closure.<sup>36</sup>

Apart from variations in individual aspects of the operation as outlined above, several complete techniques of CS have been described. Comparisons of such complete techniques will be evaluated in this review. Described CS techniques include the following: (1) Pfannenstiel; (2) Pelosi type<sup>9</sup>; (3) Joel-Cohen<sup>37,38</sup> and its modifications<sup>7,38-40</sup>; (4) Misgav-Ladach<sup>8</sup>; and (5) extraperitoneal.<sup>10</sup>

### Objective

We sought to compare the effects of complete methods of CS not covered in previous reviews of individual aspects of CS technique.

### Materials and Methods

#### Studies

We considered all published, unpublished, and ongoing RCTs comparing intention to perform CS by different tech-

niques, excluding individual aspects covered in previous systematic reviews. We excluded quasirandomized trials and studies reported only in abstract form with inadequate methodological information. Studies were included if there was adequate allocation concealment and violations of allocated management and exclusions after allocation were not sufficient to materially affect outcomes.

#### Interventions

CS performed according to a prespecified technique was studied.

#### Outcome measures

##### Primary

1. Serious intraoperative and postoperative complications, including organ damage, blood transfusion, significant sepsis, thromboembolism, organ failure, high care unit admission, or death.

2. Blood loss (as defined by trial authors).
3. Blood transfusion.

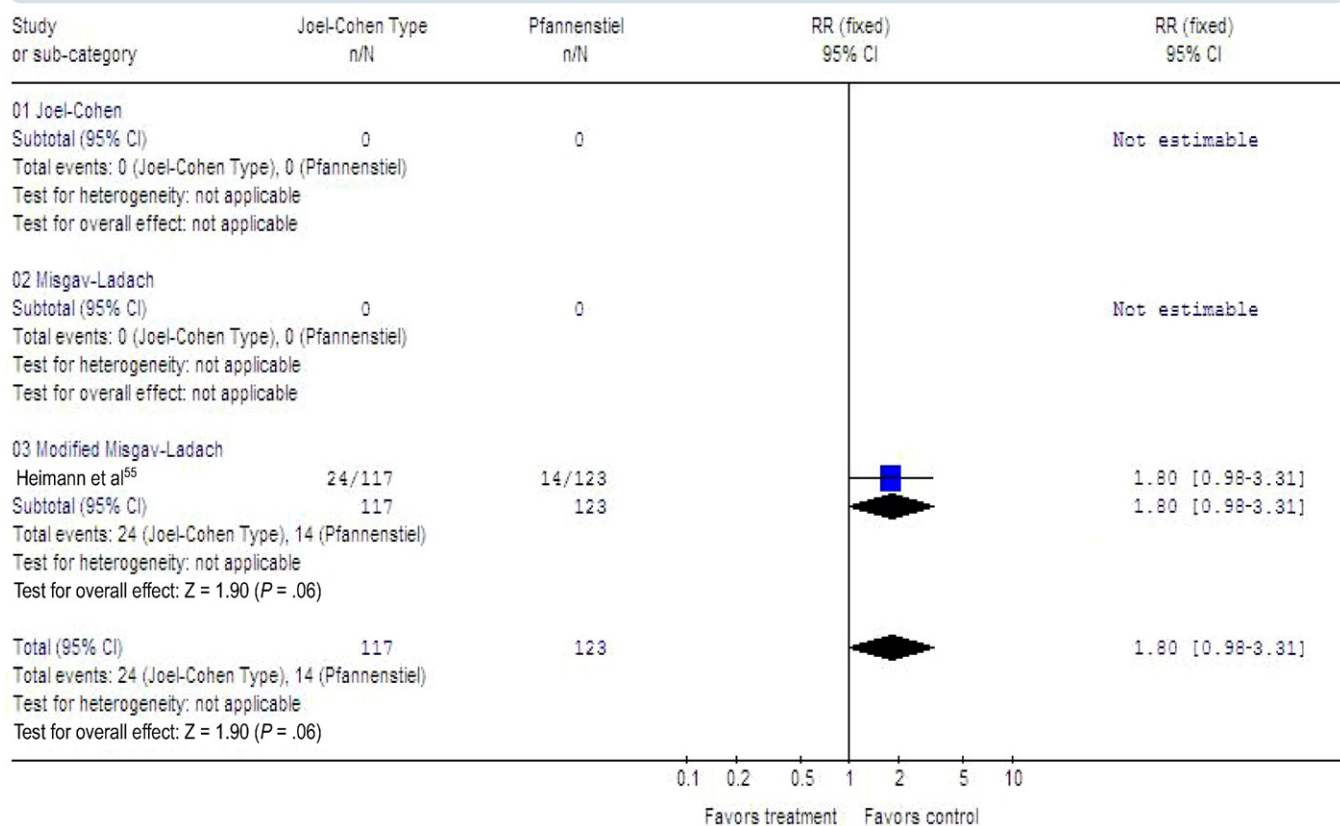
##### Secondary

Short-term outcome measures for the mother

4. Operating time.
5. Maternal death.
6. Admission to intensive care unit.
7. Postoperative hemoglobin or hematocrit level, or change in these.
8. Postoperative anemia, as defined by trial authors.
9. Wound infection, as defined by trial authors.
10. Wound hematoma.
11. Wound breakdown.
12. Endometritis, as defined by trial authors.
13. Time to mobilization.
14. Time to oral intake.
15. Time to return of bowel function.

FIGURE 2

## Wound hematoma after modified Misgav-Ladach and Pfannenstiel cesarean section techniques



CI, confidence interval.

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16. Time to breast-feeding initiation.
17. Fever treated with antibiotics or as defined by trialists.
18. Repeated operative procedures carried out on the wound.
19. Postoperative pain as measured by trial authors.
20. Use of analgesia, as defined by trial authors.
21. Unsuccessful breast-feeding (at discharge or as defined by the trial authors).
22. Mother not satisfied with care.
  - Short-term outcome measures for the baby
23. Time from anesthesia to delivery.
24. Time from skin incision to delivery.
25. Birth trauma.
26. Cord blood pH <7.2.
27. Cord blood base deficit >15.
28. Apgar score <7 at 5 minutes.
29. Neonatal intensive care admission.
30. Encephalopathy.
31. Neonatal or perinatal death.
  - Longer-term outcomes for the mother
32. Long-term wound complications (eg, numbness, keloid formation, incisional hernia).
33. Long-term abdominal pain.
34. Future fertility problems.
35. Complications in future pregnancy (eg, uterine rupture, placenta praevia, placenta accreta).
36. Complications at future surgery (eg, adhesion formation).
  - Health service use
37. Length of postoperative hospital stay for mother or baby.
38. Readmission to hospital of mother or baby, or both.
39. Costs.
  - Outcomes were included if clinically meaningful; reasonable measures taken to minimize observer bias; missing data insufficient to influence conclusions; data available for analysis according to

original allocation, irrespective of protocol violations; or data available in a format suitable for analysis.

#### Search strategy for identification of studies

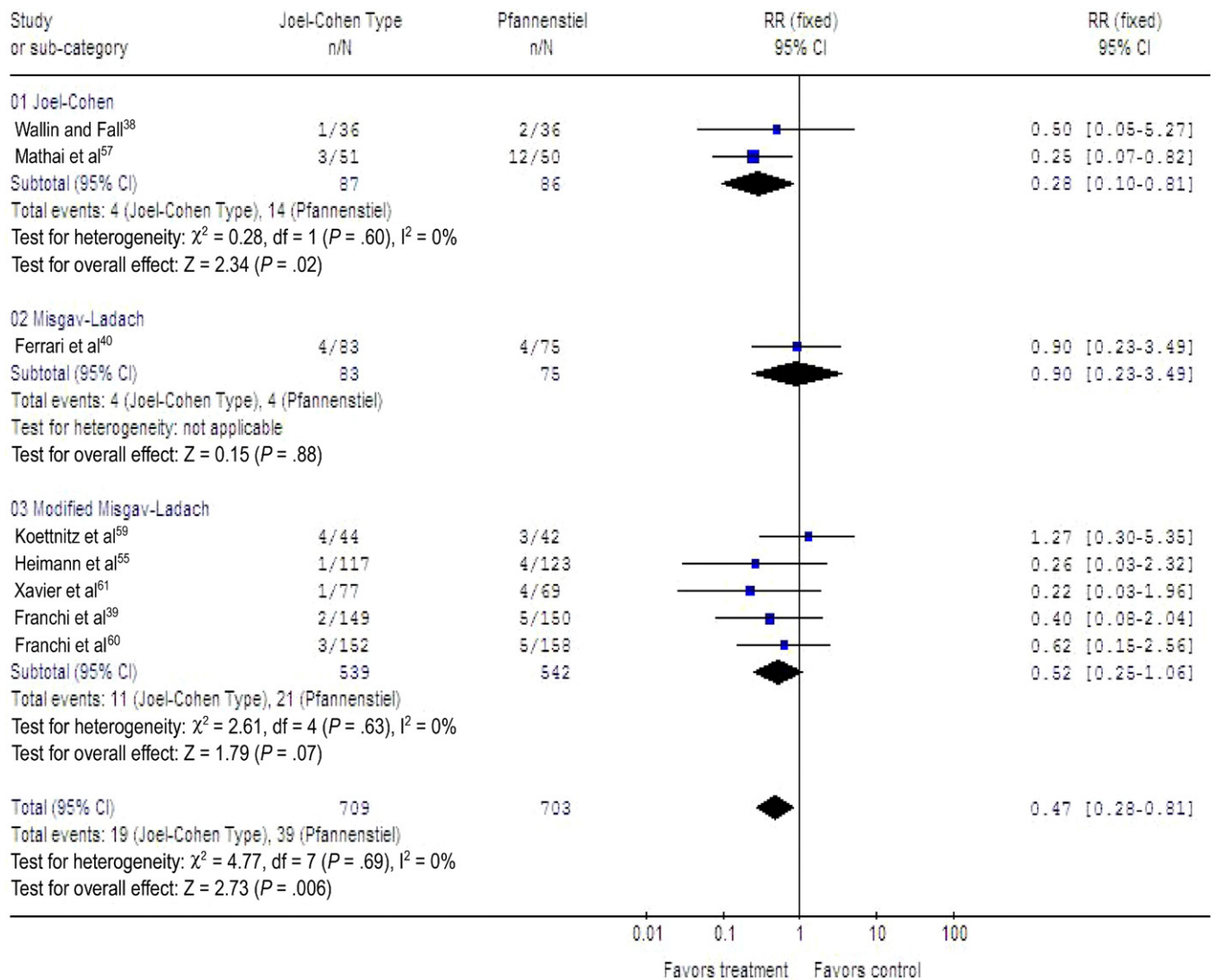
We searched the Cochrane Pregnancy and Childbirth Group's Trials Register by contacting the trials search coordinator (August 2007). In addition, we searched the Cochrane Central Register of Controlled Trials (The Cochrane Library 2007, Issue 3) using the search terms "(caesarean OR cesarean) AND technique" and conducted a manual search of the reference lists of all identified articles.

We did not apply any language restrictions.

#### Methods of the review

Trials under consideration were evaluated for appropriateness for inclusion

**FIGURE 3**  
**Fever treated with antibiotics after Joel-Cohen–based and Pfannenstiel cesarean sections**



CI, confidence interval.

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and methodological quality without consideration of their results by 2 review authors according to the prestated eligibility criteria. Trials that met the eligibility criteria were assessed for quality using the standard criteria.<sup>41</sup>

If a publication did not report analysis of participants in their randomized groups, we attempted to restore them to the correct group (analysis by intention to treat). If there was insufficient information in the report to allow this, we contacted the authors and requested further data.

Two authors extracted data. Data from different trials were combined if we considered them sufficiently similar for this to be reasonable. We performed metaanalyses using relative risks as the measure of effect size for binary outcomes, and weighted mean differences (WMD) for continuous outcome measures. If trials used different ways of measuring the same continuous outcome (eg, pain), we used standardized mean differences. Further details on analysis can be found in a previous publication.<sup>41</sup>

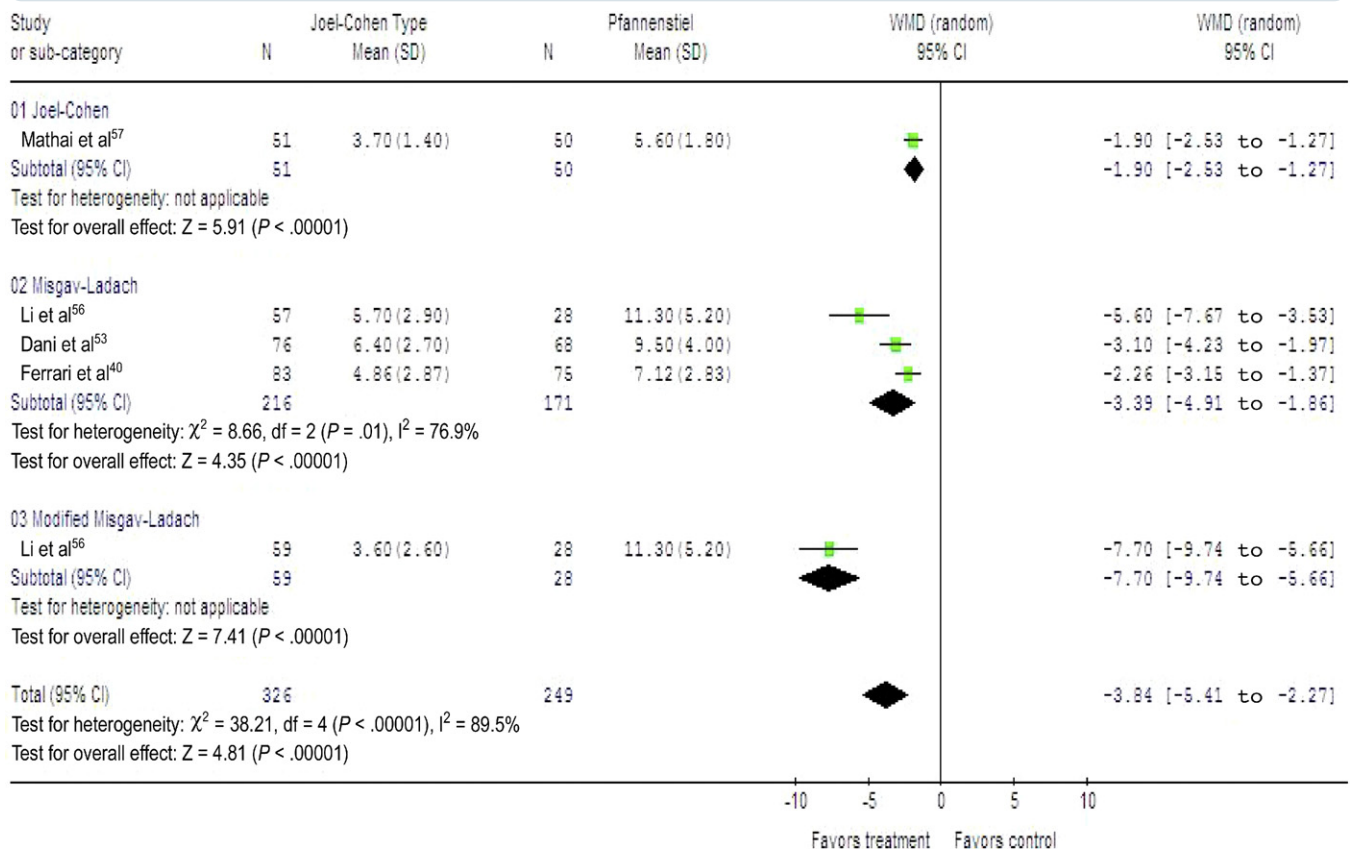
**Description of studies**

We identified 23 studies, which compared different techniques of CS based on the search strategies. We excluded 4 trials from the analyses as allocation to intervention groups was not based on randomization in these trials.<sup>42-45</sup>

Five studies<sup>46-51</sup> were presented at various meetings and conferences and contain only limited results of the studies. We have not obtained the further details on the results of the above-mentioned trials from the authors.

FIGURE 4

### Time (minutes) from skin incision to delivery of baby using Joel-Cohen and Pfannenstiel techniques for cesarean section



CI, confidence interval; WMD, weighted mean difference.

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There was some variation in the details of techniques defined by the authors as Joel-Cohen, Misgav-Ladach, and modified Misgav-Ladach. All these methods have been based on the surgical principles developed by Joel-Cohen: blunt separation of tissues along natural tissue planes, using a minimum of sharp dissection. For the purposes of this review we have classified the methods as subgroups of the Joel-Cohen–based techniques as follows: (1) Joel-Cohen<sup>38</sup>; (2) Misgav-Ladach<sup>40,52-58</sup>; and (3) modified Misgav-Ladach.<sup>39,55,56,59-61</sup>

Eleven studies investigated the difference between Joel-Cohen–based and Pfannenstiel CS techniques.<sup>38-40,53-57,59-61</sup>

Two studies<sup>52,58</sup> compared the Misgav-Ladach technique with traditional (lower midline abdominal incision) CS.

One study compared extraperitoneal and intraperitoneal CS techniques.<sup>62</sup>

Details of the above-mentioned studies are available in the Table.

#### Methodological quality of included studies

The methodological quality of the included studies was variable. The allocation concealment was unclear in 3 studies.<sup>53,58,61</sup> Refer to the Table for more details on the methodological quality of the individual studies.

One study with inadequate allocation concealment and unexplained differences between group numbers<sup>62</sup> was included for historical interest.

#### Results

##### Joel-Cohen–based vs Pfannenstiel CS

Eleven studies compared Joel-Cohen–based and Pfannenstiel CS. These were subgrouped as follows: Joel-Cohen<sup>38,57</sup>;

Misgav-Ladach<sup>40,53,54,56</sup>; and modified Misgav-Ladach.<sup>39,55,56,59-61</sup>

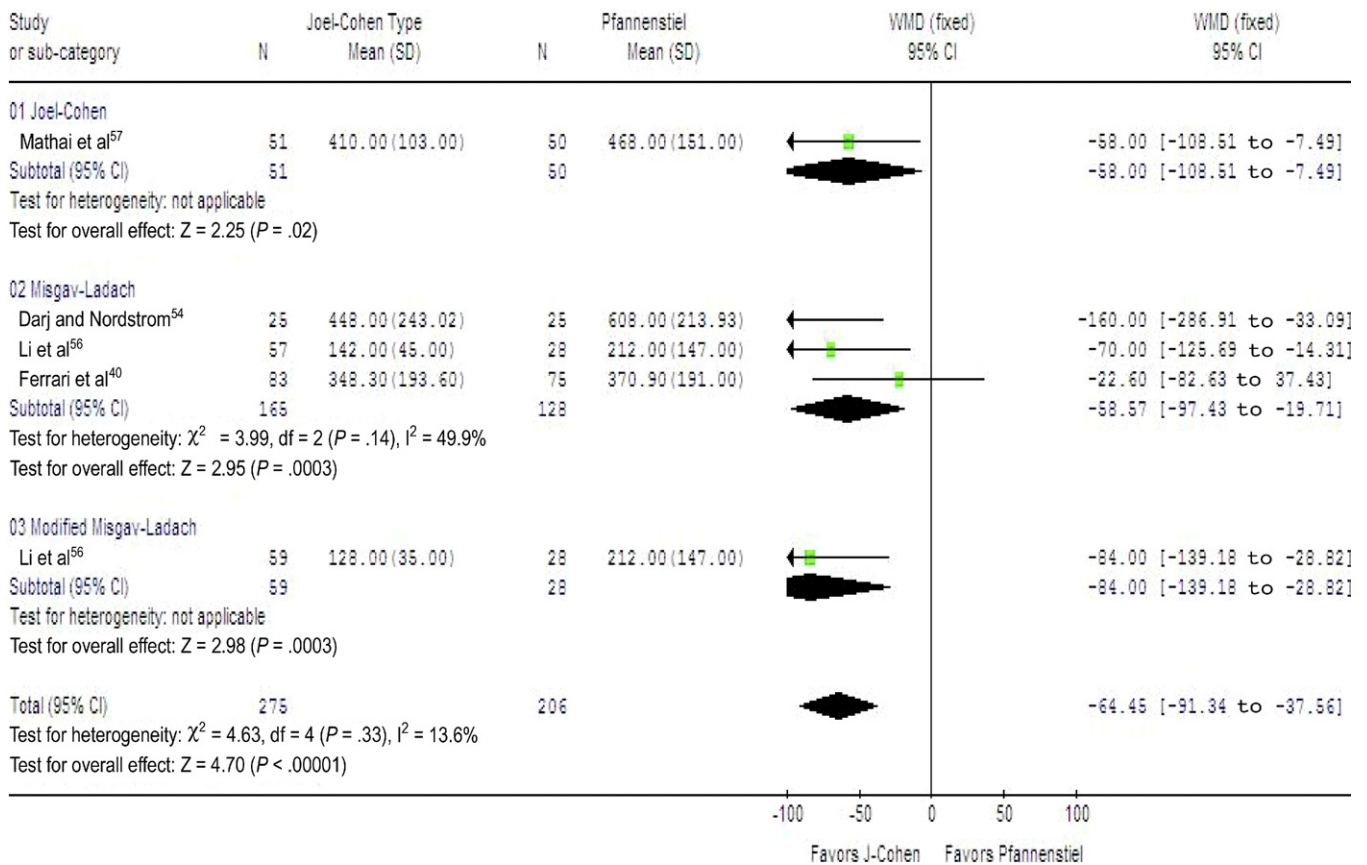
Serious complications were reported in only 4 trials (913 women) in the modified Misgav-Ladach vs Pfannenstiel comparisons, and were too few for meaningful statistical analysis (3 and 2 events, respectively).

Only 3 blood transfusions were reported, all in the modified Misgav-Ladach groups (3 trials, 681 women).

Joel-Cohen–based surgery was associated with:

1. Less blood loss in all trials (5 trials, 481 women; WMD, 64.4 mL; 95% confidence interval [CI], -91.3 to -37.6 mL).
2. Shorter operating time in all trials as shown in Figure 1. The overall WMD was a reduction of 18.6 minutes.

**FIGURE 5**  
**Blood loss (mL) during Joel-Cohen–based and Pfannenstiel cesarean sections**

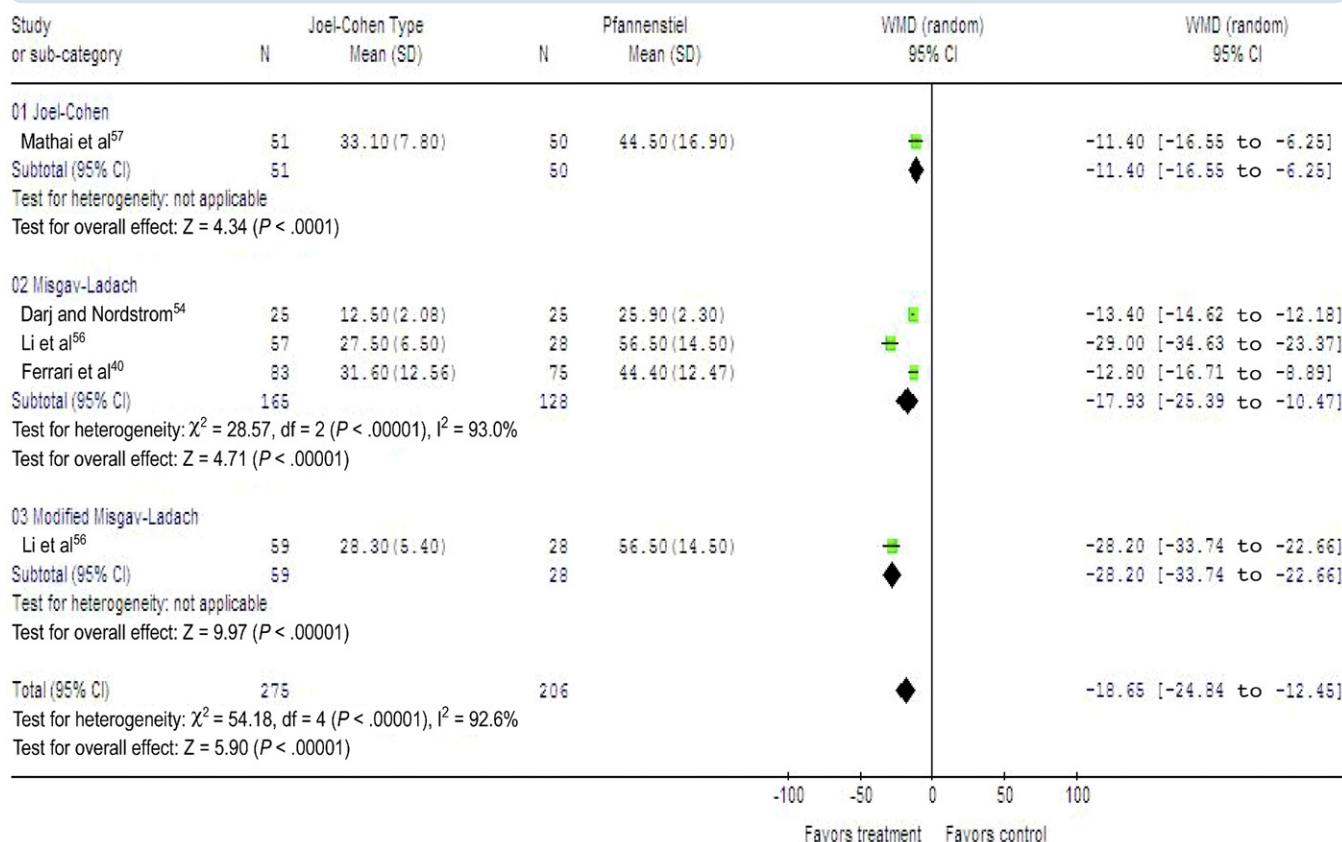


CI, confidence interval; WMD, weighted mean difference.  
 Hofmeyr. *Techniques for cesarean section. Am J Obstet Gynecol* 2009.

3. No overall difference in the occurrence of wound infections (6 trials, 1071 women, considerable heterogeneity).
4. No difference in postoperative hematocrit level and hemoglobin decrease >4 g/dL, reported in 1 trial each<sup>55,57</sup> (101 women and 240 women, respectively).
5. A trend to increased wound hematoma in the modified Misgav-Ladach subgroup in 1 trial in which this outcome was reported<sup>55</sup> as shown in Figure 2.
6. No significant difference in wound breakdown (3 trials, 468 women).
7. Inadequate data on endometritis, reported in only 1 woman, in the Pfannenstiel group (3 trials, 767 women).
8. Postoperatively, an overall reduction with significant heterogeneity ( $I^2 = 90\%$ ) in time to oral intake (5 trials, 481 women; WMD, -3.92; 95% CI, -7.1 to -0.7 hours; random effects model).
9. No significant difference in time to return of bowel function.
10. No significant difference in time to mobilization (2 trials, 208 women; WMD, -2.86; 95% CI, -11.3 to 5.6 hours) or in time to breast-feeding initiation (1 trial, 101 women).
11. Less fever, treated with antibiotics or as defined by trial authors as shown in Figure 3.
12. Insufficient data on repeated operative procedure on the wound, which was reported in only 1 woman, in the Pfannenstiel group (2 trials, 228 women).
13. Lower duration of postoperative pain (2 comparisons from 1 trial, 172 women; WMD, -14.18 hours; 95% CI, -18.3 to -10.0 hours) and less use of analgesia, defined as number of analgesic injections<sup>54</sup> or number of injections in the first 24 hours<sup>57</sup> (2 trials, 151 women; WMD, -0.92; 95% CI, -1.2 to -0.6).
14. Shorter time from skin incision to birth of the baby in all trials as shown in Figure 4. There was significant heterogeneity in the magnitude of the reduction ( $I^2 = 89.5\%$ ). The overall WMD was a reduction of 3.84 minutes (5 trials, 575 women; 95% CI, -5.4 to -2.3 minutes; random effects model).
15. Insufficient data on low Apgar scores (2 low scores in the Pfannenstiel group, 1 trial, 158 women).
16. No difference in neonatal intensive care admission (1 trial, 310 women).

FIGURE 6

## Operating time (minutes) using Joel Cohen and Pfannenstiel techniques for cesarean section



CI, confidence interval; WMD, weighted mean difference.

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### Subgroup analyses

Four trials were reported to be limited to women undergoing abdominal surgery for the first time.<sup>38,40,54,57</sup> The results were similar to those for all the trials.

There were insufficient data to conduct further subgroup analyses.

### Misgav-Ladach vs traditional (lower midline abdominal incision)

Only 1 of 2 trials contributed data for each outcome.<sup>52,58</sup>

The Misgav-Ladach method was associated with reduced blood loss (Figure 5), operating time (Figure 6), time to mobilization (Figure 7), and length of postoperative stay for the mother (339 women; WMD, -0.8; 95% CI, -1.1 to -0.6 days).

There were no significant differences in postoperative anemia, wound infection, wound breakdown, endometritis, or fever.

### Misgav-Ladach vs modified Misgav-Ladach methods

In 1 trial (116 women),<sup>56</sup> the Misgav-Ladach method was associated with a longer time from skin incision to birth of the baby (WMD, 2.1; 95% CI, 1.1–3.1 minutes), and no significant differences in blood loss, time to oral intake, time to return of bowel function, postoperative pain score, operating time, or length of postoperative stay of the mother.

### Extraperitoneal vs intraperitoneal CS

One study with poor methodology by current standards compared extraperitoneal and intraperitoneal CS techniques.<sup>62</sup> One woman of 173 had serious complications during or after extraperitoneal CS in comparison with 12 women of 239 in the group who had intraperitoneal CS (relative risk [RR], 0.12; 95% CI, 0.02–0.88). Maternal mortality did not differ between these 2 groups. The rate of

fever treated with antibiotics was lower in the extraperitoneal CS group (RR, 0.42; 95% CI, 0.27–0.65). There was no significant difference in the numbers who had repeated procedures on the wound. The results should be interpreted with caution.

### Comment

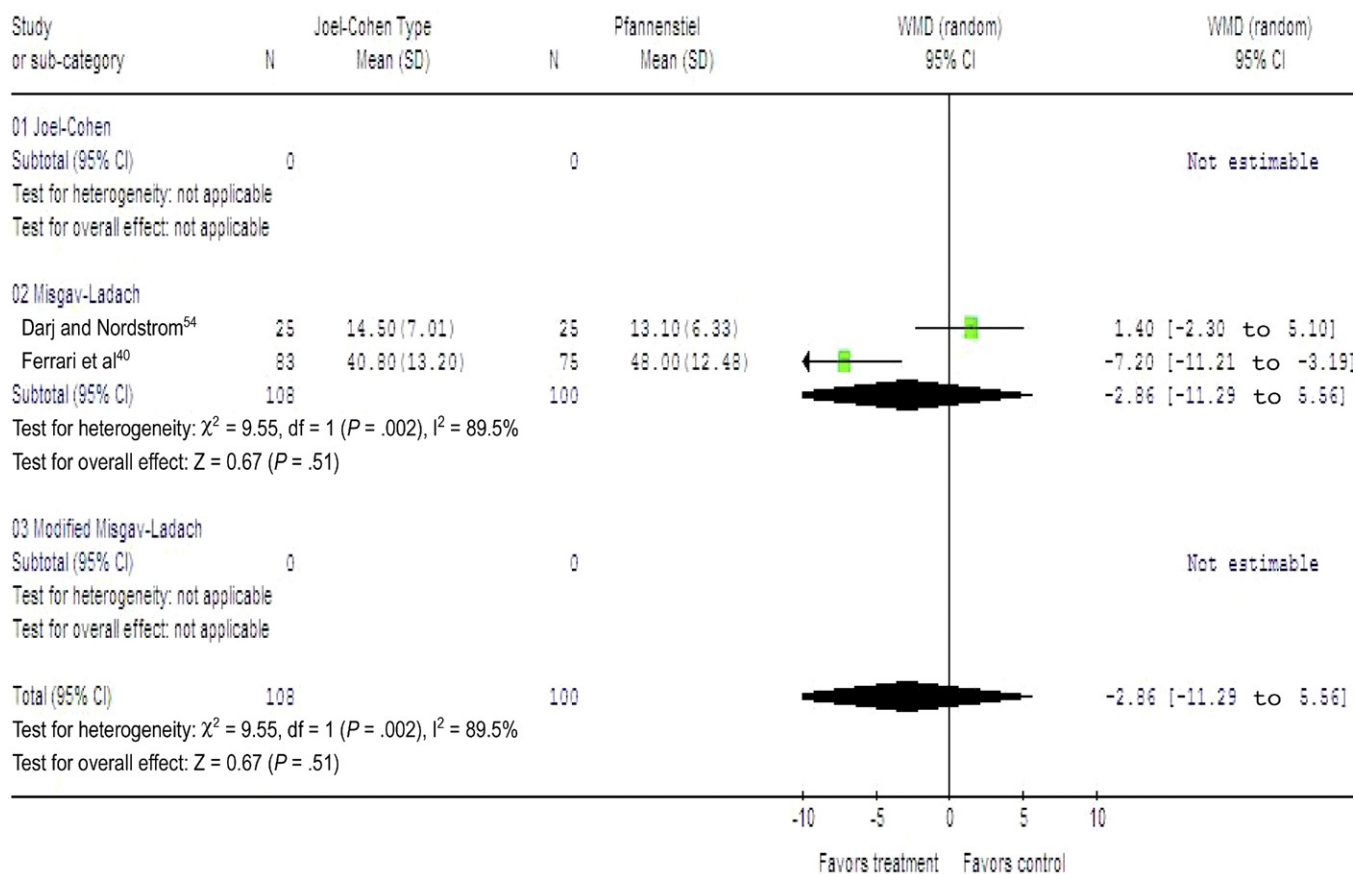
Four groups of comparison were undertaken in this review. No studies investigating the Pelosi-type CS were identified.

The methodological quality of 14 included trials appeared generally satisfactory. However, some of the outcomes assessment was subject to bias (eg, operating time, blood loss).

The data reported in the studies comparing CS techniques were limited to short-term outcomes. They have favored Joel-Cohen–based techniques (Joel-Cohen, Misgav-Ladach, and modified Mis-

**FIGURE 7**

**Time to mobilization (hours) after Joel Cohen and Pfannenstiel cesarean sections**



CI, confidence interval; WMD, weighted mean difference.

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gav-Ladach) over the Pfannenstiel techniques and over the traditional (lower midline abdominal incision) CS techniques. The only advantage of modified Misgav-Ladach techniques over Misgav-Ladach technique was shorter time from skin incision to delivery of baby.

Extraperitoneal CS in women with abdominal sepsis is of historical interest. There were no data from robust trials to provide reliable evidence.

None of the included trials have provided data on the mothers' satisfaction, health service use, and long-term outcomes, particularly with respect to subsequent fertility, morbidly adherent placenta, and uterine rupture.

**Conclusions**

Available evidence suggests that the Joel-Cohen–based techniques (Joel-Cohen,

Misgav-Ladach, and modified Misgav-Ladach) have advantages over Pfannenstiel and traditional CS techniques in relation to short-term outcomes. There is no evidence in relation to long-term outcomes. In view of the evidence from several observational studies that single-layer uterine closure may be associated with increased risk of uterine rupture in subsequent pregnancies (see above), a case can be made for use of double-layer uterine closure pending results from RCTs, particularly in resource-poor settings where women may not have access to CS facilities in subsequent pregnancies.

The results of this review together with other Cochrane reviews of specific aspects of technique for CS and other abdominal surgery support the following options for routine CS:

1. No preoperative hair removal; or clipping or depilatory creams on the day of surgery or the preceding day (no shaving).
2. No specific antiseptic for preoperative bathing.
3. Antibiotic prophylaxis with ampicillin or a first-generation cephalosporin.
4. Spinal, epidural, or general anesthesia.
5. Chlorhexidine for skin preparation.
6. Double gloving is advised in areas with high rates of blood-borne infections to achieve fewer perforations in inner glove and prevent needle stick injuries.
7. Transverse lower abdominal wall opening and uterine opening using Joel-Cohen–based methods.<sup>20</sup>

8. Bladder peritoneum may be reflected downward or not.<sup>21</sup>
9. Placental removal with cord traction.<sup>23</sup>
10. Intraabdominal or extraabdominal repair of the uterus.<sup>24</sup>
11. Uterine closure with interrupted or single-layer continuous locking suture has short-term benefits. However, the evidence from observational studies of an increased risk of scar rupture may favor the use of double-layer closure pending evidence on this outcome from randomized trials.<sup>28</sup>
12. Nonclosure of both peritoneal layers.<sup>31</sup>
13. No specific method for closure of the fascia was assessed in these reviews.
14. Closure of the subcutaneous tissues.<sup>35</sup>
15. No routine drainage of the subcutaneous tissues.<sup>63</sup>
16. Skin closure with subcuticular or interrupted sutures, staples, or tissue adhesive.<sup>36</sup>
17. No withholding of oral fluids after surgery.<sup>64</sup>

Where no clear benefits of 1 method over another have been shown, the choice may have been influenced by the clinical setting. For example, in a resource-constrained environment where large numbers of CS are performed by junior surgical teams, a cost-effective choice may be spinal analgesia and Joel-Cohen–based surgical methods, which require only 2 lengths of suture material for the operation, and double-layer closure of the uterus. ■

#### ACKNOWLEDGMENT

We acknowledge Denise Atherton, Lynn Hampson, and Sonja Henderson for technical support.

This review has been published in The Cochrane Library.<sup>41</sup>

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