Anterior Decompression and Fusion Versus Posterior Laminoplasty for Multilevel Cervical Compressive Myelopathy

XUZHOU LIU, MM; HEHUI WANG, MM; ZHILAI ZHOU, MD; ANMIN JIN, MD

The optimal surgical strategy for anterior or posterior approaches remains controversial for multilevel cervical compressive myelopathy caused by multisegment cervical spondylotic myelopathy (MCSM) or ossification of the posterior longitudinal ligament (OPLL). A systematic review and meta-analysis was conducted evaluating the clinical results of anterior decompression and fusion (ADF) compared with posterior laminoplasty for patients with multilevel cervical compressive myelopathy. PubMed, Embase, and the Cochrane Library were searched for randomized controlled trials and nonrandomized cohort studies conducted from 1990 to May 2013 comparing ADF with posterior laminoplasty for the treatment of multilevel cervical compressive myelopathy due to MCSM or OPLL. The following outcome measures were extracted: Japanese Orthopedic Association (JOA) score, recovery rate, complication rate, reoperation rate, blood loss, and operative time. Subgroup analysis was conducted according to the mean number of surgical segments. Eleven studies were included in the review, all of which were prospective or retrospective cohort studies with relatively low quality indicated by GRADE Working Group assessment. A definitive conclusion could not be reached regarding which surgical approach is more effective for the treatment of multilevel cervical compressive myelopathy. Although ADF was associated with better postoperative neural function than posterior laminoplasty in the treatment of multilevel cervical compressive myelopathy due to MCSM or OPLL, there was no apparent difference in the neural function recovery rate between the 2 approaches. Higher rates of surgery-related complication and reoperation should be taken into consideration when ADF is used for patients with multilevel cervical compressive myelopathy. The surgical trauma associated with corpectomy was significantly higher than that associated with posterior laminoplasty.

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Multilevel cervical compressive myelopathy due to multisegment cervical spondylotic myelopathy (MCSM) or ossification of the posterior longitudinal ligament (OPLL) is frequently encountered in clinical practice and leads to a declining quality of the patient’s life. The natural course without surgical treatment is generally poor, resulting in neurological deficits. Inversely, a stabilization of neurological deficit or even recovery may be obtained through surgical decompression in a majority of patients. The 2 major surgical strategies used to treat multilevel cervical compressive myelopathy are anterior decompression via discectomy or corpectomy and posterior decompression via laminoplasty. Regarding single segment of spinal cord compression, anterior cervical discectomy and fusion (ACDF) is considered the gold standard surgical approach. However, there is considerable controversy regarding which surgical approach will lead to the best clinical outcome in multilevel cervical compressive myelopathy.

The anterior approach has been advocated when ventral constriction of the spinal cord should be removed to obtain direct sufficient decompression, especially when the spinal canal is severely narrow or the protuberant mass is large. In addition, anterior spinal fusion can establish a solid cervical stability that is conducive to relieving pressure on the level of compressed spinal cord. However, the reconstruction of the cervical spine after multisegment ACDF or corpectomy (CORP) is technically demanding for the surgeon and more bone grafts are needed for fusion, resulting in an increased rate of graft-, instrumentation-, and surgery-related complications. Compared with the anterior approach, posterior laminoplasty is less technically demanding. Decompression via posterior laminoplasty and cervical lordosis alignment allow the spinal cord to float away from ventral compression, thus receiving an indirect decompression of the whole cervical cord. If posterior shift of the cord is not sufficient, ventral constriction of the cord may persist, leading to decreased recovery from myelopathy.

Because no standards or guidelines exist for the treatment of multilevel cervical compressive myelopathy, the current systematic review and meta-analysis was performed to assess the clinical results of ADF compared with posterior laminoplasty for patients with multilevel cervical compressive myelopathy in terms of neurological function outcome, surgical complications, reoperation rate, and surgical trauma.

Materials and Methods

Search Strategy

An extensive literature search was performed in PubMed, Embase, and the Cochrane Library. The language was restricted to English and the year of publication from 1990 to May 2013. The following search terms and strategies were used: (1) cervical myelopathy or CSM or myelopathy or cervical spondylosis or cervical stenosis or OPLL; (2) anterior cervical discectomy and fusion or ACDF or corpectomy or CORP or anterior decompression and fusion or anterior decompression or ventral decompression or ventral approach or ventral; (3) laminoplasty or LAMP or posterior decompression or posterior decompression and fusion or dorsal decompression or dorsal approach or dorsal; and (1) and (2) or (3). The aim was to find randomized controlled trials and observational studies comparing anterior decompression with posterior laminoplasty for multilevel cervical compressive myelopathy. Reference lists from the studies selected were checked to identify additional articles meeting the inclusion criteria.

Inclusion Criteria and Quality Evaluation

The following inclusion criteria were adopted: (1) randomized controlled trials or cohort studies; (2) study population: multilevel cervical compressive myelopathy due to MCSM or OPLL (2 or more segments), excluding tumors, trauma, soft disk herniation, or previous surgery; (3) purpose of intervention: to compare clinical outcome differences between anterior decompression and fusion and posterior laminoplasty; and (4) outcome measurements: neurological function outcomes, surgical complications, reoperation rate, and surgical trauma. Studies that did not meet the above criteria were excluded. Two of the authors (X.L., H.W.) independently assessed titles and abstracts for possible inclusion. If they could not reach agreement, the opinion of a third reviewer (Z.Z.) was adopted. Only articles published in English were included. The risk of bias was assessed using the criteria proposed by the Cochrane Back Review Group. The level of evidence was assessed according to the guidelines of the GRADE Working Group.

Data Extraction and Subgroups

The following outcome measurements were extracted as primary outcomes: preand postoperative Japanese Orthopedic Association (JOA) score and neurological recovery rate [recovery rate (%) = (postoperative JOA–preoperative JOA)/(17–preoperative JOA)×100%]. Secondary outcomes were surgery-related complications, reoperation rate, and surgical trauma indicators, including blood loss and operative time. The included studies were divided into 2 subgroups according to the mean number of surgical segments: subgroup A included the studies in which the mean number of surgical segments was between 2 and 3, and subgroup B included the studies in which the mean number of surgical segments was equal to or more than 3.

Data Analysis

A systematic review and meta-analysis of cohort studies was performed to determine which surgical strategy is more effective for the treatment of multilevel cervical compressive myelopathy caused by MCSM or OPLL. Heterogeneity was tested using the chi-square test and quan-
tified by calculating the $I^2$ statistic, for which a $P$ value less than .1 and an $I^2$ value greater than 50% was considered to be statistically significant. For the pooled effects, weighted mean difference or standard mean difference was calculated for continuous variables according to the consistency of measurement units, and the odds ratio (OR) was calculated for dichotomous variables. Continuous variables are presented as mean differences and 95% confidence intervals (CI), whereas dichotomous variables are presented as OR and 95% CI. Random-effects or fixed-effects models were used depending on the heterogeneity of the studies included. All statistical tests were performed with SPSS version 18.0 statistical software (SPSS Inc, Chicago, Illinois) and Review Manager version 5.1 software (The Cochrane Collaboration, Oxford, United Kingdom).

RESULTS

Search Results

A total of 1030 citations were found in PubMed, 670 in Embase, and 25 in the Cochrane Library. These articles were reviewed, and a total of 836 titles and abstracts were screened after removing duplicates. Secondary screening of abstracts was based on study design, population, purpose of interventions, and outcome index. A total of 27 articles were obtained in full and screened, yielding a total of 11 articles for this systematic review and meta-analysis (Figure).6-16

Quality Assessment

No randomized controlled trial was identified. All studies included were prospective6,12,14,16 or retrospective6,11,13,15 cohort studies with relatively low quality (Table A, available at the end of the PDF of this article). The quality of evidence using GRADE Working Group guidelines was not upgraded and remained low due to the unspecific description of study design and the less rigorous methodology in observational studies.17

Baseline Characteristics

These 11 studies contained 11 cohorts with a total of 712 patients; 349 underwent anterior surgery (260 underwent CORP and 89 underwent ACDF) and 363 underwent posterior surgery. Weighted mean age was 56.4 years (range, 46 to 65 years), and weighted mean follow-up was 61.6 months (range, 12 to 180 months). Three articles did not report the male-to-female ratio. In the remaining 566 patients, the male-to-female ratio was 381 to 185. There were no significant differences between the 2 groups in terms of age, follow-up, and male-to-female ratio. Baseline characteristics of the 2 treatment groups are presented in Table 1.

Clinical Outcome

Eleven studies used JOA score to assess clinical outcome, all of which provided a preoperative JOA score. The preoperative JOA score was similar between the anterior and posterior groups. There was no significant difference in the preoperative JOA score between the 2 groups in either subgroup A or subgroup B (Table B, available at the end of the PDF of this article).

Eight studies provided a postoperative JOA score. The postoperative JOA score was significantly higher in the anterior group compared with the posterior group ($P<.05$; weighted mean difference=0.67 [range, 0.25 to 1.09]; heterogeneity: $P=.22$; $I^2=26\%$) (Table C, available at the end of the PDF of this article). There was a significant difference in the postoperative JOA score between the 2 groups in subgroup A ($P<.05$; weighted mean difference=0.68 [range, 0.19 to 1.16]; heterogeneity: $P=.19$; $I^2=35\%$) (Table C, available at the end of the PDF of this article). However, in subgroup B, there was no significant difference in the postoperative JOA score between the 2 groups ($P>.05$; weighted mean difference=0.66 [range, -0.15 to 1.48]; heterogeneity: $P=.20$; $I^2=38\%$) (Table C, available at the end of the PDF of this article).

Nine studies used recovery rate to assess the degree of neurological function improvement. There was significant heterogeneity between the studies, although there was no apparent difference in recovery rate between the anterior and posterior groups ($P>.05$; weighted mean difference=5.78 [range, -0.97 to 12.54]; heterogeneity: $P=.003$; $I^2=65\%$) (Table D, available at the end of the PDF of this article). In addition, there was significant heterogeneity among the groups in subgroup

<table>
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<th>Characteristic</th>
<th>Anterior Group</th>
<th>Posterior Group</th>
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<tr>
<td>No. of patients</td>
<td>349</td>
<td>363</td>
</tr>
<tr>
<td>No. male/female</td>
<td>173/91</td>
<td>208/94</td>
</tr>
<tr>
<td>Mean age (range), y</td>
<td>57 (51.8-60.4)</td>
<td>59 (52-64.8)</td>
</tr>
<tr>
<td>Mean follow-up (range), mo</td>
<td>59 (3-180)</td>
<td>51 (3-140)</td>
</tr>
</tbody>
</table>
Dysphagia/dysphonia & 13 (4.0) & -  
Hardware & 17 (5.2) & -  
Pseudoarthrosis & 16 (4.8) & -  
Adjacent deterioration & 21 (6.4) & -  
Esophageal fistula & 2 (0.6) & -  
CSF leakage & 4 (1.2) & 3 (0.9)  
Hematoma & 3 (0.9) & 1 (0.3)  
C5 paralysis & 5 (1.5) & 25 (7.7)  
Axial neck pain & 3 (0.9) & 16 (5.0)  
Kyphosis change & 5 (1.5) & 28 (8.7)  
Deterioration neurologic deficit & 7 (2.1) & 6 (1.9)  
Reoperation & 27 (8.1) & 3 (0.9)  
Total & 123 (37.3) & 82 (25.4)  

Abbreviation: CSF, cerebrospinal fluid.  
*Excludes 2 studies.

A (heterogeneity: \( P=0.01; I^2=69\% \)) and in subgroup B (heterogeneity: \( P=0.02; I^2=70\% \)). Therefore, meta-analysis was impractical, and only descriptive analysis was performed.

One article did not report complications related to surgery\(^6\); another article only reported the incidence of adjacent deterioration following the 2 operations.\(^9\) Therefore, only 9 studies provided a list of postoperative complications. The postoperative complication rate was significantly higher in the anterior group compared with the posterior group (\( P<0.05; \text{OR}=2.00 \) (range, 1.32 to 3.04); heterogeneity: \( P=0.09; I^2=42\% \)) (Table E, available at the end of the PDF of this article). The postoperative complication rate was significantly higher in the anterior group compared with the posterior group in subgroup A (\( P<0.05; \text{OR}=1.73 \) (range, 0.97 to 3.07); heterogeneity: \( P=0.40; I^2=1\% \)) (Table E, available at the end of the PDF of this article), whereas there was significant heterogeneity between the studies in subgroup B (heterogeneity: \( P=0.03; I^2=67\% \)) (Table E, available at the end of the PDF of this article). The primary complications were graft-, instrumentation- and surgical approach–related complications and higher rates of adjacent deterioration and reoperation in the anterior group and higher rates of postoperative C5 radiculopathy, axial neck pain, and cervical kyphosis change in the posterior group (Table 2).

A total of 330 patients from 9 studies received anterior surgery, with 27 (8.1\%) requiring reoperation: 15 (55.6\%) for pseudoarthrosis/nonunion, 5 (18.5\%) for adjacent deterioration, 4 (14.8\%) for posterior hematoma, 2 (7.4\%) for deteriorative neurologic deficit, and 1 (3.7\%) for fixation loosening. Of the 323 patients who received posterior surgery, only 3 (0.9\%) required reoperation: 2 (66.7\%) for radiculopathy due to new disk herniation and 1 (33.3\%) for posterior hematoma. The reoperation rate was significantly higher in the anterior group compared with the posterior group (\( P<0.05; \text{OR}=7.52 \) (range, 2.90 to 19.52); heterogeneity: \( P=0.70; I^2=0\% \)) (Table F, available at the end of the PDF of this article).

A total of 6 studies reported blood loss and operative time\(^7,10-12,14,16\); however, 1 study was excluded from the meta-analysis for not providing the standard deviation of intraoperative blood loss and operative time.\(^10\) A total of 175 patients from 3 studies were included in the comparison of blood loss and operative time for anterior CORP vs posterior laminoplasty.\(^7,12,14\) Blood loss and operative time were significantly higher in the anterior CORP group compared with the posterior laminoplasty group (\( P<0.05; \text{weighted mean difference}=0.54 \) (range, 0.23 to 0.84); heterogeneity: \( P=0.14; I^2=48\% \); and \( P<0.05; \text{weighted mean difference}=83.62 \) (range, 53.21 to 114.03); heterogeneity: \( P=0.04; I^2=68\% \)) (Tables G-H, available at the end of the PDF of this article). There was significant heterogeneity between the 2 studies comparing blood loss and operative time for ACDF vs posterior laminoplasty (heterogeneity: \( P<0.001; I^2=98\% \); and heterogeneity: \( P<0.001; I^2=98\% \)).\(^11,16\) Thus, meta-analysis was not performed.

**Discussion**

Anterior decompression and fusion and posterior laminoplasty has been reported for the treatment of multilevel cervical compressive myelopathy due to MCSM or OPLL. However, due to a lack of comprehensive studies comparing the clinical outcomes of both surgical approaches, the ideal surgical strategy for multilevel cervical compressive myelopathy remains controversial. Therefore, the current authors searched PubMed, Embase, and the Cochrane Library for relevant studies and performed a systematic review and meta-analysis evaluating the effectiveness of ADF compared with posterior laminoplasty for patients with multilevel cervical compressive myelopathy. Although no randomized controlled trial studies were included in this study and all selected studies were of relatively low quality, the baseline variables (eg, age, sex ratio, follow-up, preoperative JOA score, and surgical segments) were similar. Therefore, the authors considered the included studies to be comparable.

Two neural function outcome endpoints were selected in this meta-analysis. In the meta-analysis of JOA scores, there was no significant difference in preoperative JOA scores between the anterior and posterior groups. Postoperative JOA scores were better in the anterior group.
compared with the posterior group, and
the heterogeneity was low to median.
These findings indicate that the 2 groups
had similar baseline neural function but
that postoperative neural function condi-
tion was better in the anterior group com-
pared with the posterior group.

Subsequent subgroup analysis indi-
cated that postoperative JOA scores were
better in the anterior group compared with
the posterior group in subgroup A and
were similar in subgroup B, indicating that
ADF is superior to posterior laminopa-
lasty in postoperative neural function
condition for patients with fewer than 3
compressed levels; for patients with 3 or
more compressed levels, postoperative
neural function condition was similar be-
tween the 2 approaches.

However, in the meta-analysis of re-
covery rate, there was significant hetero-
genecity between the studies. Subsequent
subgroup analysis also revealed signifi-
cant heterogeneity in subgroups A and
B. For further sensitivity analysis, there
was significant heterogeneity in 1 study in
subgroup A, with a significantly higher re-
covery rate in the anterior group compared
with the posterior group (72.9%±28.3%
vs 50.2%±26.6%, respectively; \( P<0.05 \)).
Hirai et al\textsuperscript{12} suggested that residual an-
terior compression of the spinal cord after
posterior laminoplasty was the cause of
the lower recovery rate in the posterior
group. Interestingly, the recovery rate
without residual anterior compression
was similar between the anterior and pos-
terior groups \((P>0.05)\). When this study
was excluded, there was no significant
difference in the recovery rate between
the 2 groups \((P>0.05)\); weighted mean dif-
fERENCE=10.19 [range, -0.45 to
20.83]; heterogeneity: \(P=0.24\); \(I^2=29\%\). In
addition, Wada et al\textsuperscript{7} Iwasaki et al\textsuperscript{18} and
Shibuya et al\textsuperscript{10} reported the clinical results
with long-term follow-up greater than 10
years. All studies showed comparable
long-term effectiveness from both surgi-
cal treatments for multilevel cervical my-
elopathy. Hence, although postoperative
neural function condition was better in
the anterior group compared with the poste-
rior group, there was no significant differ-
cence in the recovery rate. Clinical effects
were similar between ADF and posterior
laminoplasty for the treatment of multi-
level cervical compressive myelopathy.

The current authors selected compli-
cation rate and reoperation rate for meta-
analysis in the evaluation of complication-
related outcomes. They found a signifi-
cantly higher incidence of complications
in the anterior group compared with the
posterior group. Subsequent subgroup
analysis findings were similar. This indi-
cates that ADF for the treatment of mul-
tilevel cervical compressive myelopathy
is associated with a higher incidence of
complications. In addition, the reopera-
tion rate related to surgical complications
was significantly higher in the anterior
group compared with the posterior group.
Although the indications for reoperation
between studies were not consistent, ADF
for the treatment of multilevel cervical
compressive myelopathy seemed to have
a higher risk of reoperation.

Considering the main causes of reop-
eration in the anterior group were pseudo-
arthrosis/nonfusion (55.6%) and adjacent
deterioration (18.5%), the former seemed
to be associated with technical reasons (eg,
surgeon’s skill and experience) and qual-
ity of the bone grafts, whereas the latter
was more likely to be associated with ac-
celerated adjacent deterioratio resulting
from anterior long-segment spine fusion.
Wada et al\textsuperscript{7} noted a significant correlation
between pseudoarthrosis and number of
fused segments, demonstrating that the in-
cidence of pseudoarthrosis was augmented
with the increased number of fused seg-
ments. Fraser and Hartl\textsuperscript{19} reported that the
anticipant fusion rate in a single segment
with anterior decompression and fusion
was 97.1%; it was 94.6% in 2 segments
and 82.5% in 3 segments. Thus, taking the
postoperative neural function condition
and the reoperation rate related to pseudo-
arthrosis into consideration, the authors
believe that the anterior approach is appro-
priate for patients with fewer than 3 com-
pressed levels and that posterior laminop-
asty may be a better option for patients
with 3 or more compressed levels.

In addition, there was a higher rate of
cervical kyphosis change observed in pa-
tients treated with the posterior approach
compared with the anterior approach. Sakai et al\textsuperscript{14} found that the average C2-
C7 lordotic angle of the cervical spine
decreased significantly with a poorer
neurological recovery rate in prepara-
tive kyphosis patients treated with pos-
terior laminoplasty compared with an
anterior approach, indicating that there
was a significant correlation between cer-
vical kyphosis change and a decreased
neurological recovery rate. In posterior
laminoplasty, the posterior ligamentous
structures and extensor musculature asso-
ciated with the maintenance of cervical
lordosis alignment are widely dissected or
transected, leading to a decreased lordotic
angle of the cervical spine postopera-
tively. The existence of cervical kyphosis
could result in diminished posterior shift
of the cord, and ventral constriction of the
cord may persist, leading to a poorer re-
covery rate of neurological deficits. Thus,
it is recommended that the use of posterior
laminoplasty be avoided as a single meth-
od of treatment for patients with preopera-
tive kyphosis or instability. The addition
of posterior instrumented fusion would
stabilize the spine and decrease damage
to the spinal cord.

In the evaluation of surgical trauma,
blood loss and operative time were select-
ed for meta-analysis, which revealed that
blood loss and operative time were significantly higher in the anterior CORP group compared with the posterior laminoplasty group. This indicates that, in the treatment of multilevel cervical compressive myelopathy, the surgical trauma associated with anterior corpectomy and fusion is higher than that associated with posterior laminoplasty. Meta-analysis of surgical trauma between ACDF and posterior laminoplasty was not performed because only 2 relevant studies were identified.

This systematic review and meta-analysis has some limitations. None of the studies included in the meta-analysis were randomized controlled trials, and the authors had to rely on data from observational studies. In addition, the indicators evaluating postoperative clinical effects were inconsistent among the studies. This reflects the lack of a standard outcome measure. Moreover, most of the studies focused on the evaluation of neurological function improvement but neglected to evaluate the overall quality of life. Finally, follow-up time varied between the studies and thus may have influenced the current results. Therefore, it was not appropriate to draw a strong conclusion about one procedure’s superiority to the other in terms of clinical outcomes.

**Conclusion**

Although ADF was associated with better postoperative neural function than posterior laminoplasty in the treatment of multilevel cervical spondylotic myelopathy due to MCSM or OPLL, there was no apparent difference in the neural function recovery rate between the 2 surgical approaches. The complication and reoperation rates were significantly higher in the anterior group compared with the posterior group. The surgical trauma associated with CORP was significantly higher than that associated with posterior laminoplasty.

**REFERENCES**


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* Prospective cohort study +1. The rest are retrospective cohort study.
Table B Weighted mean difference of preoperative JOA between anterior group and posterior group
### Table C

Weighted mean difference of postoperative JOA between anterior group and posterior group

<table>
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<tr>
<th>Study or Subgroup</th>
<th>anterior approach</th>
<th>posterior approach</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>IV, Fixed, 95% CI Year</th>
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<td>Eiji Wada 2001</td>
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<td>Bo Wang 2006</td>
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<td>Takashi Hirai 2011</td>
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<td>Subtotal (95% CI)</td>
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<td>Heterogeneity: Chi² = 6.16, df = 4 (P = 0.19); I² = 35%</td>
<td>Test for overall effect: Z = 2.72 (P = 0.007)</td>
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</tr>
<tr>
<td><strong>2.2.2 Subgroup B</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Yutaka Masaki 2007</td>
<td>14.2 2.3 19 13 2.6 40 10.1% 1.20 [-0.11, 2.51] 2007</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tao Liu 2011</td>
<td>13.2 2.73 25 13.7 2.7 27 8.0% -0.47 [1.95, 1.01] 2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kenichiro Sakai 2012</td>
<td>15.1 2.2 20 14 2.6 22 8.3% 1.10 [-0.35, 2.55] 2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>64 89 26.4% 0.66 [-0.15, 1.48]</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Heterogeneity: Chi² = 3.25, df = 2 (P = 0.20); I² = 38%</td>
<td>Test for overall effect: Z = 1.60 (P = 0.11)</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td>229 237 100.0% 0.67 [0.25, 1.09]</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Heterogeneity: Chi² = 9.41, df = 7 (P = 0.22); I² = 26%</td>
<td>Test for overall effect: Z = 3.15 (P = 0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for subgroup differences: Chi² = 0.00, df = 1 (P = 0.98), I² = 0%</td>
<td></td>
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</tr>
</tbody>
</table>
Table D Weighted mean difference of recovery rate between anterior group and posterior group

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Mean Difference</th>
<th>IV, Random, 95% CI</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2.3.1 Subgroup A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Kazuo Yonenobu 1992</td>
<td>55.3</td>
<td>20.7</td>
<td>41</td>
<td>44.9</td>
<td>16.4</td>
<td>15</td>
<td>11.3%</td>
<td>10.40 [-1.78, 22.58]</td>
<td>1992</td>
</tr>
<tr>
<td>Bo Wang 2006</td>
<td>60.8</td>
<td>20.7</td>
<td>42</td>
<td>57.1</td>
<td>16.4</td>
<td>15</td>
<td>12.5%</td>
<td>3.70 [-6.70, 14.10]</td>
<td>2006</td>
</tr>
<tr>
<td>Takashi Hirai 2011</td>
<td>72.9</td>
<td>28.3</td>
<td>39</td>
<td>50.2</td>
<td>26.6</td>
<td>47</td>
<td>11.6%</td>
<td>22.70 [11.01, 34.39]</td>
<td>2011</td>
</tr>
<tr>
<td>Sah S 2012</td>
<td>60.67</td>
<td>20.6</td>
<td>42</td>
<td>61.08</td>
<td>11.25</td>
<td>20</td>
<td>15.1%</td>
<td>-0.41 [-7.18, 6.36]</td>
<td>2012</td>
</tr>
<tr>
<td>Chusheng Seng 2013</td>
<td>51.9</td>
<td>20.9</td>
<td>64</td>
<td>53.1</td>
<td>24.3</td>
<td>52</td>
<td>10.2%</td>
<td>-1.20 [-14.97, 12.57]</td>
<td>2013</td>
</tr>
<tr>
<td><strong>Subtotal (95% CI)</strong></td>
<td>51.9</td>
<td>20.9</td>
<td>206</td>
<td>53.1</td>
<td>24.3</td>
<td>176</td>
<td>10.2%</td>
<td>6.71 [-1.77, 15.19]</td>
<td></td>
</tr>
<tr>
<td><strong>Heterogeneity:</strong> Tau² = 62.69; Chi² = 12.85, df = 4 (P = 0.01); I² = 69%</td>
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<tr>
<td><strong>Test for overall effect:</strong> Z = 1.55 (P = 0.12)</td>
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<tr>
<td><strong>2.3.2 Subgroup B</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Yutaka Masaki 2007</td>
<td>68.4</td>
<td>27.3</td>
<td>19</td>
<td>52.5</td>
<td>12.5</td>
<td>40</td>
<td>9.2%</td>
<td>15.90 [5.00, 31.30]</td>
<td>2007</td>
</tr>
<tr>
<td>S Shibuya 2010</td>
<td>41</td>
<td>26.6</td>
<td>34</td>
<td>50.9</td>
<td>25.9</td>
<td>49</td>
<td>11.7%</td>
<td>-9.90 [-21.41, 1.61]</td>
<td>2010</td>
</tr>
<tr>
<td>Tao Liu 2011</td>
<td>59.79</td>
<td>23.43</td>
<td>25</td>
<td>59.54</td>
<td>29.37</td>
<td>27</td>
<td>9.8%</td>
<td>0.25 [-14.14, 14.64]</td>
<td>2011</td>
</tr>
<tr>
<td>Kenichiro Sakai 2012</td>
<td>71.4</td>
<td>26</td>
<td>20</td>
<td>55.3</td>
<td>29.6</td>
<td>22</td>
<td>8.5%</td>
<td>16.10 [-0.72, 32.92]</td>
<td>2012</td>
</tr>
<tr>
<td><strong>Subtotal (95% CI)</strong></td>
<td>71.4</td>
<td>26</td>
<td>99</td>
<td>55.3</td>
<td>29.6</td>
<td>138</td>
<td>8.5%</td>
<td>4.74 [-8.36, 17.84]</td>
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</tr>
<tr>
<td><strong>Heterogeneity:</strong> Tau² = 124.01; Chi² = 9.97, df = 3 (P = 0.02); I² = 70%</td>
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<tr>
<td><strong>Test for overall effect:</strong> Z = 0.71 (P = 0.48)</td>
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<td></td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td>51.9</td>
<td>20.9</td>
<td>304</td>
<td>53.1</td>
<td>24.3</td>
<td>314</td>
<td>100.0%</td>
<td>5.78 [-0.97, 12.54]</td>
<td></td>
</tr>
<tr>
<td><strong>Heterogeneity:</strong> Tau² = 66.76; Chi² = 23.18, df = 6 (P = 0.003); I² = 65%</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Test for overall effect:</strong> Z = 1.68 (P = 0.09)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test for subgroup differences:</strong> Chi² = 0.06, df = 1 (P = 0.80), I² = 0%</td>
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</tr>
</tbody>
</table>

Mean Difference Mean Difference
IV, Random, 95% CI Year
-50 -25 0 25 50
anterior approach posterior approach
Table E Odds ratio of postoperative complication rates between anterior group and posterior group
<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>anterior approach</th>
<th>posterior approach</th>
<th>Odds Ratio</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Events</td>
<td>Total</td>
<td>Events</td>
<td>Total</td>
</tr>
<tr>
<td>Eiji Wada 2001</td>
<td>7</td>
<td>23</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>S Shibuya 2010</td>
<td>10</td>
<td>34</td>
<td>0</td>
<td>49</td>
</tr>
<tr>
<td>Takashi Hirai 2011</td>
<td>1</td>
<td>39</td>
<td>0</td>
<td>47</td>
</tr>
<tr>
<td>Yu Chen 2011</td>
<td>1</td>
<td>22</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>Tao Liu 2011</td>
<td>3</td>
<td>25</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>Kenichiro Sakai 2012</td>
<td>3</td>
<td>20</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>Chusheng Seng 2013</td>
<td>2</td>
<td>64</td>
<td>0</td>
<td>52</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>227</td>
<td>246</td>
<td>100.0%</td>
<td>7.52</td>
</tr>
</tbody>
</table>

Heterogeneity: Ch² = 3.84, df = 6 (P = 0.70); I² = 0%
Test for overall effect: Z = 4.15 (P < 0.0001)

**Table F** Odds ratio of reoperation rates between anterior group and posterior group
Table G  Standard mean difference of blood loss between anterior CORP group and posterior LAMP group

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>IV, Fixed, 95% CI</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eiji Wada 2001</td>
<td>986</td>
<td>751</td>
<td>23</td>
<td>608</td>
<td>212</td>
<td>24</td>
<td>26.7%</td>
<td>0.68 [0.09, 1.27]</td>
<td>2001</td>
</tr>
<tr>
<td>Takashi Hirai 2011</td>
<td>340</td>
<td>287</td>
<td>39</td>
<td>188</td>
<td>92.1</td>
<td>47</td>
<td>48.1%</td>
<td>0.74 [0.30, 1.18]</td>
<td>2011</td>
</tr>
<tr>
<td>Kenichiro Sakai 2012</td>
<td>292.8</td>
<td>192.8</td>
<td>20</td>
<td>289.6</td>
<td>215.8</td>
<td>22</td>
<td>25.3%</td>
<td>0.02 [-0.59, 0.62]</td>
<td>2012</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>82</td>
<td>93</td>
<td>100.0%</td>
<td>0.54</td>
<td>[0.33, 0.84]</td>
<td>2012</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: CH² = 3.86, df = 2 (P = 0.14); I² = 48%
Test for overall effect: Z = 3.47 (P = 0.0005)
### Table H: Weighted mean difference of operation time between anterior CORP group and posterior LAMP group

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Mean (SD)</th>
<th>Total</th>
<th>Mean (SD)</th>
<th>Total</th>
<th>Weight</th>
<th>IV, Random, 95% CI</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eiji Wada 2001</td>
<td>264 (65)</td>
<td>23</td>
<td>182 (43)</td>
<td>43</td>
<td>24</td>
<td>32.2%</td>
<td>82.00 [50.35, 113.65] 2001</td>
</tr>
<tr>
<td>Takashi Hirai 2011</td>
<td>211 (55.3)</td>
<td>39</td>
<td>149 (38.7)</td>
<td>47</td>
<td>47</td>
<td>40.3%</td>
<td>62.00 [41.42, 82.58] 2011</td>
</tr>
<tr>
<td>Kenichiro Sakai 2012</td>
<td>300.3 (78.6)</td>
<td>20</td>
<td>183.2 (41.1)</td>
<td>22</td>
<td>22</td>
<td>27.6%</td>
<td>117.10 [78.61, 155.59] 2012</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td></td>
<td>82</td>
<td></td>
<td>93</td>
<td>100.0%</td>
<td>83.62 [53.21, 114.03]</td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 487.67; Chi² = 6.29, df = 2 (P = 0.04); I² = 68%
Test for overall effect: Z = 5.39 (P < 0.00001)