Closed Versus Open Reduction of Mandibular Condylar Fractures in Adults: A Meta-Analysis

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Purpose: A review of the literature shows a difference of opinion regarding whether open or closed reduction of condylar fractures produces the best results. It would be beneficial, therefore, to critically analyze past studies that have directly compared the 2 methods in an attempt to answer this question.

Materials and Methods: A Medline search for articles using the key words “mandibular condyle fractures” and “mandibular condyle fracture surgery” was performed. Articles that compared open and closed reduction were selected for further evaluation. Additional articles were obtained from reference lists in the Medline-selected articles. Of the 32 articles identified, 13 met the final selection criteria. These contained data on at least one of the following: postoperative maximum mouth opening, deviation on opening, lateral excursion, protrusion, asymmetry, and joint or muscle pain.

Results: Numerous problems were found with the information presented in the various articles. These included lack of patient randomization, failure to classify the type of condylar fracture, variability within the surgical protocols, and inconsistencies in choice of variables and how they were reported. However, the results from the meta-analyses were explored in a general sense.

Conclusions: Because of the great variation in the manner in which the various study parameters were reported, it was not possible to perform a reliable meta-analysis. There is a need for better standardization of data collection as well as randomization of the patients treated in future studies to accurately compare the 2 methods.

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Whereas there are clearly defined guidelines for when an open or closed reduction is indicated in the management of fractures in most areas of the mandible, there is still a continuing debate over how to best manage fractures of the condylar process. This dilemma is partly related to the fact that one cannot use the occlusion to re-establish alignment of the segments as in the body of the mandible, and partly related to the increased risk of open reduction related to the presence of the facial nerve in the surgical field. A review of the literature shows that most of the studies on this subject have been retrospective case series using a single approach rather than a comparison of the 2 techniques. In those case series in which the 2 methods have been compared, there are frequent differences in the selection criteria as well as the criteria by which the outcomes were judged. In such instances, the use of a meta-analysis can serve to combine information to form an overall conclusion. By including a group of studies in this manner, the power of detecting an overall treatment effect is increased, making it easier to show any differences that may not be shown by individual studies.

Materials and Methods

An initial literature search was conducted in PubMed using the keyword phrases “mandibular con-
<table>
<thead>
<tr>
<th>Study No.</th>
<th>Authors</th>
<th>Follow-Up</th>
<th>Sample Size</th>
<th>MMO (mm)</th>
<th>Deviation (mm)</th>
<th>Excursion (Lateral Movement) (mm)</th>
<th>Protrusion (mm)</th>
<th>Asymmetry</th>
<th>Joint or Muscle Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Worsaae and Thorn3</td>
<td>Median, 2 yr; minimum, 6 mo</td>
<td>24 28</td>
<td>Mean, 46; range, 34-61</td>
<td>Mean, 50; range, 34-65</td>
<td>Count, 8</td>
<td>Mean, 10; range, 5-15</td>
<td>Count, 0</td>
<td>Count, 5</td>
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<tr>
<td>2</td>
<td>Yang et al4</td>
<td>1 wk, 2 wk, 1 mo, 2 mo, 3 mo, 4 mo, 6 mo, 1 yr</td>
<td>36 30</td>
<td>Mean, 41.57; range, 29-44</td>
<td>Mean, 46; range, 31-53</td>
<td>Count, 8</td>
<td>Mean, 8.5; range, 3.5</td>
<td>Count, 0</td>
<td>Count, 2</td>
</tr>
<tr>
<td>3</td>
<td>Santler et al5</td>
<td>Mean, 2.5 yr; minimum, 6 mo</td>
<td>37 113</td>
<td>Mean, 47; SD, 6.8; range, 26-70</td>
<td>Mean, 47; SD, 6.8; range, 26-70</td>
<td>Count, 8</td>
<td>Mean, 8.7; SD, 3.4; range, 3-17</td>
<td>Count, 1</td>
<td>Count, 1</td>
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<tr>
<td>4</td>
<td>Konstantinovic and Dimitrijevic6</td>
<td>Mean, 2.5 yr</td>
<td>26 54</td>
<td>Mean, 39 mm; range, 25-50</td>
<td>Mean, 39 mm; range, 10-60</td>
<td>Count, 8</td>
<td>Mean, 9.5 mm</td>
<td>Count, 1</td>
<td>Count, 1</td>
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<tr>
<td>5</td>
<td>Takenoshita et al7</td>
<td>2 yr (mean, 11.6 mo)</td>
<td>16 20</td>
<td>Mean, 40 mm; range, 25-50</td>
<td>Mean, 40 mm; range, 25-50</td>
<td>Count, 8</td>
<td>Mean, 9.5 mm</td>
<td>Count, 1</td>
<td>Count, 1</td>
</tr>
<tr>
<td>6</td>
<td>Hidding et al8</td>
<td>1-5 yr</td>
<td>20 14</td>
<td>Count, 0 (&lt;30 mm)</td>
<td>Count, 0 (&lt;30 mm)</td>
<td>Count, 8</td>
<td>Mean, 8.7; SD, 3</td>
<td>Count, 0</td>
<td>Count, 0</td>
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<tr>
<td>7</td>
<td>Oezmen et al9</td>
<td>6-24 mo</td>
<td>20 10</td>
<td>Count, 0 (&lt;40 mm)</td>
<td>Count, 0 (&lt;40 mm)</td>
<td>Count, 8</td>
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<td>8</td>
<td>Throckmorton and Ellis10</td>
<td>6 wk, 6 mo, 1 yr, 2 yr, 3 yr</td>
<td>62 74</td>
<td>Mean, 47; SD, 9.4</td>
<td>Mean, 46; SD, 12.9</td>
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<td>Mean, 8.7; SD, 2.1</td>
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<tr>
<td>9</td>
<td>Widmark et al11</td>
<td>1 yr</td>
<td>19 15</td>
<td>Count, 0 (&lt;30 mm)</td>
<td>Count, 0 (&lt;30 mm)</td>
<td>Count, 8</td>
<td>Mean, 8.7; SD, 3</td>
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<td>10</td>
<td>Villarreal et al12</td>
<td>Mean, 8.45 mo; range, 0-35 mo</td>
<td>10 74</td>
<td>Mean, 38.8; SD, 5.1</td>
<td>Mean, 40.95; SD, 4.13</td>
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<td>Mean, 8.7; SD, 2.1</td>
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<td>Count, 0</td>
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<tr>
<td>11</td>
<td>Haug and Assael13</td>
<td>Minimum, 6 mo; range for open, 3.4-52.4 mo; range for closed, 34.8-70.2 mo</td>
<td>10 10</td>
<td>Mean, 46.9; SD, 9.7</td>
<td>Mean, 42.5; SD, 9.92</td>
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<td>12</td>
<td>De Riu et al14</td>
<td>Range for open, 56 yr; range for closed, 8-12 yr</td>
<td>20 19</td>
<td>Mean, 43.7; SD, 5.9</td>
<td>Mean, 46; SD, 7</td>
<td>Count, 8</td>
<td>Mean, 8.7; SD, 2.1</td>
<td>Count, 0</td>
<td>Count, 0</td>
</tr>
<tr>
<td>13</td>
<td>Joos and Kleinheinz15</td>
<td>10 d, 6 wk, 3 mo, 6 mo, 12 mo</td>
<td>25 26</td>
<td>Mean, 41</td>
<td>Mean, 41</td>
<td>Count, 8</td>
<td>Mean, 8.7; SD, 2.1</td>
<td>Count, 0</td>
<td>Count, 0</td>
</tr>
</tbody>
</table>

Abbreviations: O, open; C, closed; Frac, fractured; Non, nonfractured.

dyle fractures” and “mandibular condyle fracture surgery.” The only restriction was that all articles had to be in the English language. Additional articles were then found by searching the references of those articles discovered in the Medline search. The abstracts of all articles were reviewed, and those identified as off subject, without actual data, or not simultaneously comparing open and closed reduction were excluded. For inclusion in the study, the remaining articles had to contain at least 1 outcome variable of interest in both the open and closed treatment groups. These outcomes were maximum postoperative mouth opening, amount of lateral excursion and protrusion, mandibular deviation on mouth opening, facial symmetry, and joint or muscle pain. All outcomes had to have been determined at least 6 months after treatment.

The 2 primary statistical methods used for the meta-analyses were the weighted average method for fixed effects and the weighted average method for random effects.1 These methods can be used for both continuous and categorical data. The random effects model was chosen if there was significant heterogeneity between studies. In some instances continuous data were converted to dichotomous outcomes by use of Suissa’s method for conversion.2 The Mantel-Haenszel method for fixed effects is a third method that was used for categorical data.

Results

Of the 32 articles identified, 13 met the final selection criteria. Only 1 study was a randomized clinical trial.3 As shown in Table 1, not all studies contained data on all of the outcome variables. Moreover, some studies used continuous measures whereas others used categorical measures for the same outcome. In many instances there were means given without SDs or ranges. The follow-up times were also inconsistent, as was the preoperative classification of the fracture type.

Of the 13 studies, 8 contained continuous data on maximum mouth opening (MMO) that included either SDs or ranges. This analysis used Hedges’ g estimates, which are standardized mean differences between the open and closed treatment groups for each study.16,17 These data showed that those patients who underwent closed treatment had a moderately greater MMO than those who had open surgery (g = 0.35; 95% confidence interval [CI], 0.02 to 0.68; P < .05).

In an effort to use all of the available data, the continuous outcomes were converted to counts.2 These 8 counts, along with the data from the 3 studies that contained original count data, were then analyzed by
use of the Mantel-Haenszel method of fixed effects. The results of this analysis showed no difference between the 2 treatment groups (log odds ratio, $-0.35; 95\% \text{ CI}, -1.11$ to $0.42; P > .05$) (Fig 1, right).

Because only 2 studies reported continuous data on mandibular deviation, a meta-analysis for continuous data was not done. Instead, these data were converted into dichotomous variables by use of Suissa's method, and meta-analysis was done on the log odds ratios of the data (including studies 2, 6, 8, 10, 11, and 12 from Table 1). The weighted average method for random effects was used to test the cumulative effect-size estimate. This analysis was not significant (log odds ratio, $0.36; 95\% \text{ CI}, -0.83$ to $1.54; P > .05$), indicating that the odds of a patient who had closed treatment having postoperative mandibular deviation were the same as for a patient receiving open treatment (Fig 2).

Lateral excursion was commonly reported in the various studies as excursion to the fractured side or nonfractured side of the jaw. In this regard, studies 11 and 13 had to be excluded because they indicated jaw side as “left” and “right” (Table 1). Two separate meta-analyses were performed on the continuous outcomes. The first analysis was for excursion to the fractured side (studies 1, 8, and 12), and the second was for excursion to the nonfractured side (studies 1, 3, 8, and 12). In the first analysis there was no difference between open and closed treatment with respect to excursion to the fractured side ($g = 0.23; 95\% \text{ CI}, -0.03$ to $0.50; P > .05$). However, the second analysis yielded a statistically significant size effect for excursion to the nonfractured side ($g = 0.24; 95\% \text{ CI}, 0.03$ to $0.46; P < .05$), indicating that patients who underwent open treatment had a slightly greater amount of lateral excursion to the nonfractured side than those in the closed treatment group (Fig 3).

Mandibular protrusion was assessed by use of Hedges’ $g$ estimators of the continuous data from 5 studies (studies 1, 3, 8, 11, and 12). This analysis showed no difference between the 2 groups ($g = 0.18; 95\% \text{ CI}, -0.03$ to $0.39; P > .05$). The continuous
data were then converted to cell counts, and the log odds ratios were calculated for the 6 studies (studies 1, 3, 6, 7, 8, and 11). The cutoff was set at 5 mm so that the odds ratios were calculated from the proportions of patients with protrusion greater and less than this amount. These results also showed no significant difference (log odds ratio, 0.31; 95% CI, −0.20 to 0.81; \( P > .05 \)) (Fig 4).

The data for facial asymmetry were given as counts in 4 reports that contained such information, making it a subjective observation and giving the analysis low power. Log odds ratios were calculated for each study, and continuity corrections were applied. No statistically significant differences were found (log odds ratio, −0.74; 95% CI, −2.56 to 1.07; \( P > .05 \)) (Fig 5). However, an additional study using quantitative measures of symmetry found that in patients treated by closed reduction, more asymmetries developed.18

In some studies the presence of joint or muscle pain was verified by the reaction to manual palpation, whereas in others it was reported as “yes” or “no” by the patient. In comparing these present/not present responses, the overall odds of a patient who had closed treatment having joint or muscle pain postoperatively were over 3 times greater than in the open treatment group (log odds ratio, 3.19; 95% CI, 1.234 to 8.240; \( P < .05 \)) (Fig 6).

In summary, most of the variables did not show significant differences between open and closed treatment. Of the 3 analyses that showed a difference, 2 favored open reduction (excursion to the nonfractured side and presence of joint or muscle pain) and 1 favored closed treatment (MMO) when one statistical method was used but no difference when another method was used.

**Discussion**

A meta-analysis is only as good as the data in the studies that comprise it. If the individual studies are flawed, the findings from a review of these studies will also be flawed. Under ideal circumstances, the trials included in a meta-analysis should be of high methodologic quality and free from bias so that any differences in outcomes between the groups can be confidently attributed to the intervention under investigation.1 There are several types of bias that can potentially occur. These include systematic differences in the patients’ characteristics at baseline (selection bias), unequal provision of care apart from the treatment under evaluation (performance bias), biased assessment of outcomes (detection bias), and bias resulting from exclusion of patients after they have been allocated to treatment groups (attrition bias). The single most important limitation of the data in this meta-analysis is that only 1 study was a prospective, randomized clinical trial. This introduces selection bias, because retrospective studies are not randomized.

There were considerable differences in the manner in which treatments were performed in the various studies. This included aspects of the surgical protocols as well as the materials used for fixation. The length of time for maxillomandibular fixation in the closed treatment group was also variable (0-6 weeks). Thus performance bias was introduced.

Detection bias was certainly present in several of the studies. For the most part, outcome measures were given in millimeters, but asymmetry and joint and muscle pain data were collected subjectively. Attrition bias was also present in nearly all of the studies, because many patients were lost to long-term follow-up. Finally, publication bias is always a limitation when conducting a systematic review, because...
favorable results are generally more likely to be submitted and accepted for publication. The results of this meta-analysis are inconclusive regarding whether open or closed treatment should be used for the management of mandibular condylar fractures. Because of the relatively poor quality of the available data and the lack of other important information, the question of preferred treatment still remains unanswered, and there is clearly a need for further research. However, such studies need to be done properly to provide useful information. First, in future investigations, the patients need to be randomized into treatment groups, and the examiners need to be blinded to the manner in which the patients are treated. Second, similar methods of treatment need to be used. Third, standardized methods of fracture classification, as well as data collection and reporting, need to be established so that valid comparisons among studies can be made. Fourth, studies with adequate sample sizes to determine clinically meaningful effects should be undertaken. It is only through such coordinated efforts that the final answer to the question of how to successfully treat mandibular condylar fractures will eventually be established.

References