Closed treatment of unilateral mandibular condyle fractures in adults: a systematic review


Abstract. Of all mandibular fractures, 25–35% are condylar. Many studies have focused on whether to treat such fractures via open or closed modalities. A uniform protocol for closed treatment is lacking, but such a protocol could ensure good clinical practice. The aims of this systematic review were to provide an overview of the published studies exclusively pertaining to closed treatment and to summarize the existing modalities for closed treatment and their clinical outcomes. Sixteen studies were selected for detailed analysis. The treatments given were highly variable, ranging from doing nothing to applying maxillomandibular fixation with stainless steel wires. The results of the different studies and the treatment modalities used were difficult to interpret; however, no clear differences in the outcome measures were seen between the treatment modalities applied. Complications encountered after closed treatment included malocclusion, limited mouth opening, reduced range of motion, and persistent pain. Due to the heterogeneity between groups, high loss-to-follow-up, poor descriptions of the treatments given, and variability in outcome measurement methods, no clear associations between adverse outcomes and the treatments applied could be determined. This review suggests that due to the high level of methodological variability in the relevant studies published to date, there are currently no uniform standards for the closed treatment of condylar fractures that can be expected to yield good clinical results. The establishment of such standards could potentially improve treatment outcomes.

The mandible is prone to external forces as a result of its exposed position in the maxillofacial skeleton. Thus, mandibular fractures are one of the most common facial fractures (42–66%).1–3 Of all mandibular fractures, 25–35% are fractures of the mandibular condyle.3–6 This can be explained by the fact that the mandible is similar to a hunting bow in shape—strongest in the midline (symphysis) and weakest at the ends (condyles).

Treatment options for fractures of the mandibular condyle consist of either closed treatment or open reduction with internal fixation (ORIF).7,8 Several studies have reported favourable clinical results with closed treatment of condylar fractures.9

Some of these studies have even concluded that the closed approach should be regarded as the first choice of treatment for condylar fractures,10–12 based on the assumption that closed treatment methods are favourable in terms of the potential complications arising from surgical treatment.

Potential complications of closed treatment include malocclusion (particularly
open bite), reduced posterior facial height, facial asymmetry, chronic pain, and reduced mobility.\textsuperscript{3,13}

Conservative treatment normally consists of a period of maxillomandibular fixation (MMF). It is widely held that immobilization is likely to maintain and/or re-establish normal occlusion and relieve post-traumatic pain.\textsuperscript{14} Recent studies have generally focused on whether to treat mandibular condyle fractures via open or closed methods. However, none of these studies has focused on the outcomes of different closed treatment procedures.\textsuperscript{15,16}

Due to the substantial diversity of definitions of closed treatment, a uniform protocol/guideline for closed treatment is required. Most closed therapy interventions require expert experience. The aims of this systematic review were to provide an overview of the literature published exclusively on closed treatment, to generate a summary of the existing closed treatment modalities, and to define what the outcomes of these modalities are.

\textbf{Methods}

Systematic literature searches were performed in PubMed (all indexed years, Appendix) and Embase (all indexed years, Appendix) on 19 May 2015, with multiple search terms. The searches excluded case reports with 10 or fewer subjects, and only reports in English, German, or Dutch were considered. All remaining prospective and retrospective human clinical studies reporting data relating to any form of closed treatment of unilateral fractures of the mandibular condyle and the outcomes of those treatments were included. A flow diagram of the inclusion process is given in Fig. 1.

In the primary review process, conducted in accordance with the PRISMA criteria, two authors (RB and AR) first screened the titles and abstracts of the articles retrieved to determine potential relevance.\textsuperscript{17} Next, the full-text articles were retrieved and relevant articles were designated for inclusion. The references sections of all of these articles were hand-searched for further relevant articles; as a result, four additional articles were identified and assessed. Any disagreements relating to inclusion were resolved by discussion with a third person (LD). The articles included were critically appraised via a checklist of key criteria (Table 1).\textsuperscript{18}

\textbf{Results}

A total of 16 studies were identified in the systematic search.\textsuperscript{3,11,19–32} These studies included a combined total of 1535 patients with mandibular condyle fractures (Tables 2–4). The year of publication of the selected studies ranged from 1952 to 2015. The sample size in almost 50\% of the studies was more than 100 patients. The mean age of the patients in the studies was 31 years, but unfortunately some of the studies did include children. A clear distinction between children and adults was not made in any of the studies. The male to female ratio was 3:1. Both mandibular joints were fractured in 20\% of the cases; the fractures were unilateral in 80\% of the cases. In the cases of unilateral fracture, 53.6\% were on the left side and 46.4\% were on the right side. Of these fractures, the location was intracapsular in 17\% and extracapsular in 83\%. Follow-up periods varied substantially. Silvennoinen et al. reported the shortest mean follow-up period (5.4 months),\textsuperscript{5} while Andersson et al. reported the longest (31 years).\textsuperscript{19}
Table 1. Critical appraisal of the studies included.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andersson et al.</td>
<td>2007</td>
<td>Unilateral mandibular condyle fractures: a 31-year follow up of non-surgical treatment</td>
</tr>
<tr>
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<td>2005</td>
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</tr>
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<td>[Results of the conservative treatment of fractures of the mandibuloclydoid process] (Article in German)</td>
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<td>1952</td>
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</tr>
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<td>Analysis of possible factors leading to problems after nonsurgical treatment of condylar fractures</td>
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<tr>
<td>Smets et al.</td>
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</tr>
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<td>Factors affecting mandibular function after conservative treatment of condylar fractures</td>
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Table 2. Overview of the studies included.

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Table 3. Overview of retrospective studies on closed treatment of mandibular condyle fractures.

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<td>2004</td>
<td>Factors affecting mandibular function after conservative treatment of condylar fractures</td>
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</tbody>
</table>

ND, not described.

*a+: in the study; --: not in the study.

*b: clinical examination; T: telephone; CR, clinical report files.
Table 4. Overview of prospective studies on closed treatment of mandibular condyle fractures.

<table>
<thead>
<tr>
<th>Study</th>
<th>Number</th>
<th>Adults (&lt;16 years)</th>
<th>Bilateral</th>
<th>Unilateral</th>
<th>Intra-capular</th>
<th>Extra-capular</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dijkstra et al., 2005</td>
<td>116</td>
<td>+ +</td>
<td>+ +</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>1.2 years (mean)</td>
</tr>
<tr>
<td>Marker et al., 2000</td>
<td>348</td>
<td>+ + (4+)</td>
<td>+ +</td>
<td>+</td>
<td>ND</td>
<td>ND</td>
<td>1 year</td>
</tr>
<tr>
<td>Murakami et al., 2009</td>
<td>18</td>
<td>+ –</td>
<td>+ –</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>6 months</td>
</tr>
<tr>
<td>Niezen et al., 2010</td>
<td>114</td>
<td>+ +</td>
<td>+ +</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>6 months</td>
</tr>
<tr>
<td>Silvennoinen et al., 1998</td>
<td>18</td>
<td>+ –</td>
<td>–</td>
<td>–</td>
<td>ND</td>
<td>ND</td>
<td>1 year</td>
</tr>
</tbody>
</table>

ND, not described.

*+: in the study; -: not in the study.

The methods used in these studies were poorly described.

Overview of the treatment modalities applied in the studies included

Table 5 shows an overview of the treatment modalities applied in the studies. In most studies, the closed treatment of fractures consisted of a period of MMF with elastic bands,5,19,20,23,25,27–29 often fixed on arch bars.20,21,23,25,27,30 The mean duration of MMF was approximately 3 weeks, and ranged from 5 days to 49 days.11

Table 5. Overview of the treatment modalities applied in the studies included.

<table>
<thead>
<tr>
<th>Study</th>
<th>Expectant (Method)</th>
<th>Conservative (Method)</th>
<th>Fixation method</th>
<th>Duration</th>
<th>Additional care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andersson et al., 2007</td>
<td>– Soft diet only</td>
<td>+ Elastics</td>
<td>ND</td>
<td>2–6 weeks</td>
<td>2 weeks soft diet</td>
</tr>
<tr>
<td>Dijkstra et al., 2005</td>
<td>+ Not further described</td>
<td>+ Guiding elastics</td>
<td>Arch bars</td>
<td>2–3 weeks</td>
<td>3 weeks soft diet, physical therapy if indicated</td>
</tr>
<tr>
<td>Knak and Stoehr, 1967</td>
<td>+ Head chin cap at night</td>
<td>+ Elastics</td>
<td>Arch bars</td>
<td>3–5 weeks</td>
<td>Activators/functional orthodontics</td>
</tr>
<tr>
<td>Krause and Bremirich, 1992</td>
<td>– Not further described</td>
<td>+ Wire</td>
<td>Arch bars/Ernst ligatures</td>
<td>ND</td>
<td>Elastics after release of MMF/functional therapy</td>
</tr>
<tr>
<td>MacLennan, 1952</td>
<td>+ Not further described</td>
<td>+ Wire/ bandage</td>
<td>ND</td>
<td>Most 0–14 days</td>
<td>Elastics/training flange after release of MMF</td>
</tr>
<tr>
<td>Marker et al., 2000</td>
<td>+ Exercises/liquid diet</td>
<td>+ Wire</td>
<td>Arch bars</td>
<td>4–6 weeks</td>
<td>Elastics after release of MMF/instructions</td>
</tr>
<tr>
<td>Murakami et al., 2000</td>
<td>+ Physiotherapy</td>
<td>+ ND Guiding elastics</td>
<td>ND</td>
<td>13–21 days</td>
<td>Physiotherapy</td>
</tr>
<tr>
<td>Niezen et al., 2010</td>
<td>+ Not further described</td>
<td>+ Guiding elastics</td>
<td>Arch bars</td>
<td>2–3 weeks</td>
<td>3 weeks soft diet</td>
</tr>
<tr>
<td>Niezen et al., 2015</td>
<td>+ Not further described</td>
<td>+ Guiding elastics</td>
<td>Arch bars</td>
<td>2–3 weeks</td>
<td>3 weeks soft diet, physical therapy if indicated</td>
</tr>
<tr>
<td>Oikarinen et al., 1991</td>
<td>– Not further described</td>
<td>+ ND</td>
<td>Head chin cap/splint</td>
<td>ND</td>
<td>25.0–33.7 days Not described</td>
</tr>
<tr>
<td>Rahn et al., 1989</td>
<td>+ Functional therapy plus activator</td>
<td>+ ND</td>
<td>Head chin cap/splint</td>
<td>ND</td>
<td>3 weeks Functional therapy</td>
</tr>
<tr>
<td>Rutges et al., 2007</td>
<td>+ Soft diet only</td>
<td>+ Wire/elastics</td>
<td>ND</td>
<td>27 days</td>
<td>Elastics after release of MMF</td>
</tr>
<tr>
<td>Silvennoinen et al., 1998</td>
<td>+ Not further described</td>
<td>+ ND</td>
<td>ND</td>
<td>14–30 days</td>
<td>Functional instructions/ physiotherapy</td>
</tr>
<tr>
<td>Silvennoinen et al., 1994</td>
<td>+ Soft diet/functional therapy</td>
<td>+ Wire/elastics</td>
<td>ND</td>
<td>2–4 weeks</td>
<td>Elastic traction after release of MMF</td>
</tr>
<tr>
<td>Smet et al., 2003</td>
<td>+ Instructions regarding opening exercises</td>
<td>+ ND</td>
<td>Rigid</td>
<td>5–49 days</td>
<td>Guiding elastics, instructions/ physiotherapy</td>
</tr>
<tr>
<td>Yamamoto et al., 2004</td>
<td>+ Restriction mandibular movement/active functional therapy (pivot type splint)</td>
<td>+ ND</td>
<td>Bite block</td>
<td>7–26 days</td>
<td>Active functional therapy</td>
</tr>
</tbody>
</table>

ND, not described.
Table 6. Overview of outcome measures.\textsuperscript{a}

<table>
<thead>
<tr>
<th>Study</th>
<th>Occlusion</th>
<th>Mouth opening</th>
<th>ROM</th>
<th>Pain</th>
<th>Sounds</th>
<th>Deviation</th>
<th>Bite force</th>
<th>Facial deformity</th>
<th>Function/overall complaints (Helkimo/MFIQ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andersson et al., 2007\textsuperscript{19}</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>+ VAS</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>+, MFIQ</td>
</tr>
<tr>
<td>Dijkstra et al., 2005\textsuperscript{20}</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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</tr>
<tr>
<td>Knak and Stoehr 1967\textsuperscript{27}</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Krause and Bremerich 1992\textsuperscript{30}</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>MacLennan 1952\textsuperscript{29}</td>
<td>+?</td>
<td>+</td>
<td>+</td>
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<td>–</td>
<td>+</td>
<td>–</td>
<td>–</td>
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<tr>
<td>Marker et al., 2000\textsuperscript{21}</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>–</td>
<td>–</td>
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<tr>
<td>Murakami et al., 2009\textsuperscript{22}</td>
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<td>+</td>
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<tr>
<td>Niezen et al., 2010\textsuperscript{23}</td>
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<tr>
<td>Niezen et al., 2015\textsuperscript{25}</td>
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<td>–</td>
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<tr>
<td>Oikarinen et al., 1991\textsuperscript{26}</td>
<td>–</td>
<td>+</td>
<td>(+)</td>
<td>(+)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>+, Helkimo index</td>
</tr>
<tr>
<td>Rahn et al., 1989\textsuperscript{31}</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>–</td>
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<td>+</td>
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<td>+</td>
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<td>Silvennoinen et al., 1998\textsuperscript{24}</td>
<td>+</td>
<td>(+)</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>–</td>
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<td>+</td>
<td>(+)</td>
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</tr>
<tr>
<td>Yamamoto et al., 2004\textsuperscript{22}</td>
<td>+</td>
<td>+</td>
<td>(+)</td>
<td>(+)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

ROM, range of motion of the mandible; MFIQ, Mandibular Function Impairment Questionnaire; VAS, visual analogue scale.

\textsuperscript{a}+: outcome was measured in the study, –: outcome was not measured in the study, (+): measured as part of ‘function’, +?: not described as a self-contained measurement.

In the studies included in the final review, little was written about the extent of fixation with elastics. Some studies used elastics primarily for guidance (guiding elastics), while others used elastics in an effort to achieve rigid MMF. In some studies, rigid MMF with stainless steel wires was used.\textsuperscript{5,21,28–30} Others used both stainless steel wires and elastics, and in some studies the method of MMF was not specified.

In most studies, the choice between expectant and conservative treatment was made based on occlusion. In cases where the patient could potentially reach maximal occlusion, or if the occlusion was only minimally disturbed, expectant treatment was initiated. In most studies this consisted of a soft diet, without MMF, sometimes complemented by functional therapy by a physiotherapist.

Other indications for closed treatment with MMF were swelling, deviation on mouth opening, simultaneous mandibular fractures, and pain and restriction associated with mandibular movements.

Fixation methods of MMF other than arch bars were also described. Rahn et al. used Schuchardt splints and head chin caps to achieve MMF.\textsuperscript{31} Yamamoto et al. applied MMF with a bite block in the molar region of the affected side in patients with malocclusion, particularly those with an open bite.\textsuperscript{32} In most cases, functional therapy with guiding elastics was initiated after a period of MMF.

Some exceptions were reported. For example, Knak and Stoehr used activators to restore mandibular function after a period of MMF.\textsuperscript{27} Others used some form of bandage.\textsuperscript{29} Furthermore, MacLennan suggested that where necessary, a training flange could be used.\textsuperscript{29} Both of these studies were reported more than 50 years ago. In most reports, however, the functional therapy administered by a physiotherapist and any other additional therapies used were not described in detail.

Outcome measures

Table 6 shows an overview of the outcome measures. The most frequently described outcome measures were occlusion, mouth opening, range of motion of the mandible (ROM), pain, temporomandibular joint

Table 7. Most relevant outcome measures.

<table>
<thead>
<tr>
<th>Study</th>
<th>Number\textsuperscript{a}</th>
<th>No occlusal disturbances</th>
<th>Good mouth opening</th>
<th>ROM</th>
<th>Pain</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andersson et al., 2007\textsuperscript{19}</td>
<td>23 C/18 T</td>
<td>–</td>
<td>96%</td>
<td>–</td>
<td>13%</td>
<td>31 years</td>
</tr>
<tr>
<td>Dijkstra et al., 2005\textsuperscript{20}</td>
<td>116</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>9%</td>
<td>1.2 years (mean)</td>
</tr>
<tr>
<td>Knak and Stoehr 1967\textsuperscript{27}</td>
<td>94</td>
<td>90%</td>
<td>95% (&gt;35 mm)</td>
<td>85%</td>
<td>15%</td>
<td>5 years (mean)</td>
</tr>
<tr>
<td>Krause and Bremerich 1992\textsuperscript{30}</td>
<td>128</td>
<td>90%</td>
<td>81% (&gt;40 mm)</td>
<td>81%</td>
<td>16%</td>
<td>7.8 years (mean)</td>
</tr>
<tr>
<td>MacLennan 1952\textsuperscript{29}</td>
<td>67 C/53 T</td>
<td>Not calculated</td>
<td>100%</td>
<td>–</td>
<td>2%</td>
<td>3.1 years (mean)</td>
</tr>
<tr>
<td>Marker et al., 2000\textsuperscript{21}</td>
<td>348</td>
<td>98%</td>
<td>90%</td>
<td>89%</td>
<td>3%</td>
<td>1 year</td>
</tr>
<tr>
<td>Murakami et al., 2009\textsuperscript{22}</td>
<td>18</td>
<td>Not calculated</td>
<td>100% (&gt;40 mm)</td>
<td>Not calculated</td>
<td>6 months</td>
<td></td>
</tr>
<tr>
<td>Niezen et al., 2010\textsuperscript{23}</td>
<td>114</td>
<td>76%</td>
<td>Mean 51.9 mm</td>
<td>97%</td>
<td>9%</td>
<td>6 months</td>
</tr>
<tr>
<td>Niezen et al., 2015\textsuperscript{25}</td>
<td>142</td>
<td>–</td>
<td>Mean 52.6 mm</td>
<td>–</td>
<td>–</td>
<td>1 year</td>
</tr>
<tr>
<td>Oikarinen et al., 1991\textsuperscript{26}</td>
<td>37</td>
<td>–</td>
<td>Mean 48.4 mm</td>
<td>Not calculated</td>
<td>Not calculated</td>
<td>44 months (mean)</td>
</tr>
<tr>
<td>Rahn et al., 1989\textsuperscript{31}</td>
<td>116</td>
<td>100%</td>
<td>96% (&gt;30 mm)</td>
<td>100%</td>
<td>4%</td>
<td>3.8 years</td>
</tr>
<tr>
<td>Rutges et al., 2007\textsuperscript{28}</td>
<td>28 C (60 CR)</td>
<td>82%</td>
<td>68% (&gt;40 mm)</td>
<td>65%</td>
<td>11%</td>
<td>3.0 years</td>
</tr>
<tr>
<td>Silvennoinen et al., 1998\textsuperscript{24}</td>
<td>18</td>
<td>78%</td>
<td>100%</td>
<td>–</td>
<td>6%</td>
<td>1 year</td>
</tr>
<tr>
<td>Silvennoinen et al., 1994\textsuperscript{25}</td>
<td>92</td>
<td>87%</td>
<td>100% (&gt;40 mm)</td>
<td>Not calculated</td>
<td>–</td>
<td>5.4 months (mean)</td>
</tr>
<tr>
<td>Smets et al., 2003\textsuperscript{31}</td>
<td>60</td>
<td>92%</td>
<td>78%</td>
<td>71%</td>
<td>0%</td>
<td>6 months to 4 years</td>
</tr>
<tr>
<td>Yamamoto et al., 2004\textsuperscript{22}</td>
<td>49</td>
<td>94%</td>
<td>92% (&gt;35 mm)</td>
<td>88%</td>
<td>4%</td>
<td>12 months</td>
</tr>
</tbody>
</table>

ROM, range of motion of the mandible.

\textsuperscript{a}C, clinical examination; T, telephone; CR, clinical report files.
have a propensity to fracture through the
condylar head, rather than the low neck
pattern seen in adults. In addition, the
mandible is the last bone in the face to
reach skeletal maturity. Fractures of the
condyle in children can therefore have
consequences for the growth of the man-
dible.47 On the other hand, children do
have an increased remodelling capacity.
While in adults closed treatment mostly
results in reduced distraction of the altered
anatomy, in children rapid and progressive
remodelling of the condylar unit is com-
mon.38

Closed treatment is generally not a
complex procedure, and it is associated
with reduced overall morbidity.39 Ellis
stated in a review article that the incidence
of post-traumatic dysfunction after con-
dylar fractures varied between 9% and
85%.40 This percentage reportedly
increases with the degree of displacement,
duration of MMF, and the age of the
patient. In most of the studies included
in the final analysis, the definition of
‘closed treatment’ was not described in
precise terms, and there was a lack of
detail reported with regard to treatment
protocols. This rendered the results of the
studies difficult to interpret and compare.
In addition, no randomized controlled
trials were identified during this systemat-
ic review process, and while four prospec-
tive follow-up studies were identified,
most of the studies adhering to the inclu-
sion criteria were retrospective.

‘Closed treatment’ refers to any treat-
ment that does not involve open treatment.
In the majority of the studies reviewed, no
distinction was made between expectant
and conservative treatment. In the authors’
opinion, a distinction has to be made
between expectant and conservative treat-
ment. In this review, all treatments that did
not entail MMF were considered expect-
ant. The circumstances described in the
studies assessed that were deemed to war-
rant expectant treatment as a treatment
modality, i.e., no placement of MMF,
were for the most part the same: patients
who were able to bring their teeth into
normal occlusion and in whom mandibu-
lar excursions were assessed as normal.

In some studies, expectant treatment
was prescribed in conjunction with the
recommendation of a soft diet and instruc-
tions relating to movement of the jaw and
associated exercises.15,19,21,28 Others pre-
scribed physiotherapy.5,22,31,32 On this ba-
sis, it could be argued that the exact
demarcation between expectant and con-
servative treatment remains undefined.

There seems to be a general consensus
that expectant treatment (without MMF)
may be sufficient in patients who are able
to bring their teeth into normal occlusion
and/or have normal mandibular excursions.
The need for follow-up was not ade-
quately addressed in the studies assessed.
Ellis et al. reported that fractures
of the head of the condylar process tend
to become more displaced over the first
6 weeks.41 Therefore, it was concluded
that it is imperative to control occlusion
during this period. The need for functional
therapy should be made on a case-by-case
basis. In cases of restricted function, e.g.,
for recovery of mouth opening, functional
therapy should be initiated as soon as possible.

The closed treatments described in the
studies analyzed consisted mainly of a
period of MMF, and the choice to use
MMF was generally based on the presence
of malocclusion. Other reasons for using
MMF were swelling, deviation on mouth
opening, simultaneous mandibular frac-
tures, pain, and restriction of mandibular
movements.

The duration of immobilization
reported in prior studies is variable,
ranging from 2 weeks to 6 weeks.5,42 It has also
been suggested that no immobilization is
required, and that active physiotherapy
with strict follow-up is sufficient.43 Others
recommend early mobilization of the jaw
in all cases, and suggest that functional
rehabilitation is an essential part of the
treatment.2 Longer periods of immobi-
lization are reportedly associated with an
increased risk of ankylosis.44,45

With regard to the mechanism of action
of closed treatment, various explanations
exist. According to Ellis and Throckmor-
ton,43 adaptations on three levels are nec-
 essary to maintain a normal occlusion: the
neuromuscular level, the skeletal level,
and the dentoalveolar level. Neuromuscu-
lar adaptation consists of masticatory
adaptations. Skeletal adaptation comprises
condylar regeneration and remodelling of
the joint.36 The ability of the condyle to
remodel and regenerate is impaired and
less predictable following dislocation of
the condyle,47 and is age-dependent.34
When skeletal growth has ceased, the
condylar cartilage is mature and remodell-
ing will generally be absent. In these
cases, only functional remodelling will
occur.48 Lastly, fine tuning of the occlu-
sion will occur via extrusion of the ante-
 rior teeth and/or intrusion of the posterior
teeth.49

Where the fixation method for MMF
was reported, arch bars were used in the
majority of studies. Other choices were
Ernst ligatures and head chin caps, or the
use of a splint or a bite block.
Recently, van den Bergh et al.\textsuperscript{50} reported that the use of MMF screws as a closed treatment for condylar fractures led to a higher quality of life during the 6-week period of fracture healing than when arch bars were used. Krause and Bremerich,\textsuperscript{30, 40} Marker et al.,\textsuperscript{21, 50} and Rutges et al.\textsuperscript{51} used stainless steel wires for MMF, whereas Niezen et al.\textsuperscript{21} used guiding elastics. The strain of the elastics used was not described in most studies, with the exceptions of the reports by Dijkstra et al.\textsuperscript{20} and Niezen et al.\textsuperscript{24} In the other reports included in the final analysis, the MMF method was not described.

The average period of MMF was approximately 2–3 weeks, but ranged from 5 days to 49 days.\textsuperscript{11} The reasoning behind the duration of MMF applied in the studies analyzed was not explained. It is reported that occlusion must be maintained by MMF until fibrous union of the fractured fragments is established.\textsuperscript{51} Longer periods of MMF were in most cases associated with a need to correct the bite in patients with persistent malocclusion.

In recent publications, particularly studies reported after 2005, there seems to be a trend towards less rigid MMF and more functional treatment policies. One exception is Rutges et al.\textsuperscript{51} In their study published in 2007, rigid fixation with MMF wiring was used.

As shown in Table 7, no clear difference in outcome measures was apparent between those studies that applied stainless steel wires and those that used elastics.

In agreement with previously published statements, the authors of the current review are of the opinion that in cases of malocclusion, a short period of MMF with guiding elastics is appropriate, so that early mobilization can be realized. Early mobilization of the jaw and functional rehabilitation are reportedly considered to be important.\textsuperscript{20, 39, 52, 54} It has been proposed that in some cases it may be best not to use MMF at all, to allow the patient to obtain some mobility in as short a time as possible.\textsuperscript{41} However, Silvervloenen et al. cautioned that one should use a period of MMF in cases of displaced fractures.\textsuperscript{5} Whether MMF is necessary remains an unanswered question.\textsuperscript{41}

Additional treatment (or the lack thereof) after the removal of MMF was poorly described in the studies analyzed. Treatments that were repeatedly mentioned were the use of guiding elastics and physiotherapy. Neither the potential benefits nor the benefits actually achieved via either of these two treatment modalities were clarified in the reports. Zide and Kent stated that appropriate physiotherapy should be started in the early phase of non-surgical treatment.\textsuperscript{9} It is important to consider the ultimate aims of physiotherapy, specifically increased mouth opening, a reduction in pain during functioning of the jaw, improvement of occlusion, and extension of the range of motion.

The need for follow-up and the duration of follow-up after treatment were not mentioned in the studies. In a study by Throckmorton et al.,\textsuperscript{55} it was reported that after 12 months of follow-up no substantial reformation could be expected.\textsuperscript{55} According to the authors of that study, a minimum follow-up period of 12 months is therefore justified.

To informatively evaluate the results of closed treatment reported in the different studies, the outcome variables need to be compared. Unfortunately, parameters such as ‘overall function’ have been described differently in most of the studies reported to date. Some studies used the MFIQ to evaluate the functional outcome, while others used the Helkimo index.\textsuperscript{56–58} Other outcome measures of closed treatment reported in the studies analyzed included the degree of malocclusion, mouth opening, ROM, and pain.

As shown in Table 7, most studies reported good results with regard to these outcome measures. The recovery of occlusion ranged from 76% to 100%. Similar results were shown for the full recovery of mouth opening, which ranged from 68% to 100%. Lateral movements, which are included in the ROM, were fully restored in 65–100% of patients. Pain as a late symptom was not often seen. However, Krause and Bremerich reported that 16% of patients perceived pain.\textsuperscript{30} The study by Rutges et al. reported the most adverse outcomes with regard to mouth opening and ROM,\textsuperscript{57} followed by the study by Smets et al.\textsuperscript{11}

Nevertheless, the descriptions of these measurements were insufficient in most studies. No clear associations between the adverse outcomes and the treatments applied could be determined.

A potential shortcoming of this review is that the studies included focused on closed treatment only. Therefore, data on closed treatment from studies investigating open versus closed treatment were omitted. On the other hand, it is the authors’ opinion that studies on open versus closed treatment tend to focus on the controversy rather than on the separate treatment modalities, and that each centre in these studies would most probably have a specific treatment that they focus on, whether open or closed, resulting in a skewed impression.\textsuperscript{53}

In conclusion, based on the literature studied in this review, a treatment protocol with respect to closed treatment is proposed, as outlined below. This treatment protocol will be used in a prospective trial implemented in the authors’ institution.

First, for patients who are able to bring their teeth into normal occlusion or almost normal occlusion (open bite with a maximum of 2 mm on the non-fractured side) and/or who have normal mandibular excursions, expectant treatment should be recommended. In cases of expectant treatment, patients should be advised to adhere strictly to a soft diet, they should be given instructions regarding active but careful movement of the jaw, and they should be prescribed adequate pain medication. In the authors’ department, a non-steroidal anti-inflammatory drug (600 mg ibuprofen three times a day) with a stomach protector (omeprazole 20 mg a day) in combination with paracetamol (maximum 2000 mg per day) is used for 2 weeks. The use of a patient brochure describing exercises to practice at home is also suggested. The patient should be advised to mobilize the jaw but not load it. Furthermore, thorough follow-up should be provided, with the first appointment after 5–7 days. If there is a change to an open bite, or a persistent open bite, then either orthodontic brackets or MMF screws should be applied; if these are not applicable, arch bars with guiding elastics should be applied for 3 weeks.

Second, in cases of malocclusion with an open bite of more than 2 mm on the non-fractured side, conservative treatment consisting of a short period of MMF should be advised. The MMF should include guiding elastics fixed on brackets or MMF screws, or arch bars if these are not available; this should be done for a duration of 3 weeks so that early mobilization can be achieved. The MMF should put the patient into a correct occlusion, but should never induce total immobilization. Rigid fixation with stainless steel wires or elastics should not be used, otherwise degeneration of the TMJ by immobilization and ultimately fibrous or bony ankylosis can occur. After this 3-week period of MMF on guiding elastics, the occlusion can be guided with loose elastics for a further 6 weeks if necessary, and active physiotherapy should be started. As in cases of expectant treatment, patients should be advised to adhere to a soft diet, instructions regarding movement of the jaw should be given, adequate pain medication
should be prescribed, and a brochure describing exercises to practice at home should be provided. Again, the patient should be instructed to mobilize the jaw but not load it. After the first contact, follow-up visits are normally scheduled at 5–7 days, 3 weeks, 6 weeks, and 12 weeks. If the patient has recovered well by this time, then follow-up is finished.

If there are still complaints such as a persistent open bite, limited mouth opening, or pain, then follow-up can be extended to 6 months or even 1 year.

Due to the heterogeneity of the groups in the studies reviewed, the high loss-to-follow-up rates, the poor descriptions of the different treatments given, and the variability in the methods used to measure outcomes, no solid evidence-based conclusions or guidelines can be formulated with regard to the most appropriate closed treatment. A clear differentiation between expectant and conservative treatment is determined by the use or not of MMF in closed treatment. Further reproducible trials are needed to develop guidelines for closed treatment of fractures of the mandibular condyle.

Funding
None.

Competing interests
None.

Ethical approval
Not required.

Patient consent
Not required.

Appendix

PubMed search


Embase search in Ovid

1. exp mandible condyle/ 7329
2. Fracture reduction/ 8180
3. exp mandible fracture/ 6326
4. 2 or 3 14,205
5. 1 and 4 1214
6. (((mandibular condyle or collum mandibula* or mandibular neck) adj3 fracture*) or condylar fracture*)ti,ab,kw.
7. 5 or 6 1964
8. ((closed or conservative or non invasive or non-surgical or nonsurgical) adj5 (treatment* or therap* or reduction))ti,ab,kw.
9. 7 and 8 311

References


**Address:**
Antoinette Rozeboom  
Department of Oral and Maxillofacial Surgery  
Academic Medical Centre of Amsterdam  
University of Amsterdam  
Meibergdreef 9  
1105 AZ Amsterdam ZO  
The Netherlands  
Tel: +31 20 5661364; Fax: +31 20 5669032  
E-mail: A.V.Rozeboom@amc.uva.nl