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ORIGINAL ARTICLE

Treatment of extracapsular fractures of the mandibular condylar process: A retrospective evaluation of 377 cases

Michael Maurer | Tabea Klaes | Johannes K. Meier | Josef Maximilian Gottsauner | Jürgen Taxis | Johannes Schuderer | Torsten E. Reichert | Tobias Ettl

Department of Oral and Maxillofacial Surgery, University Hospital Regensburg, Regensburg, Germany

Correspondence
Michael Maurer, Department of Oral and Maxillofacial Surgery, University Hospital Regensburg, Franz-Josef-Strauss-Allee 11, 93042 Regensburg, Germany.
Email: michael.maurer@ukr.de

Abstract

Background/Aim: Mandibular condylar fractures represent 25%–35% of all mandibular fractures. Despite profound research, there is still a controverse debate about treating these fractures conservatively or by open reduction and internal fixation (ORIF).

The aim of this study is to analyse the outcome after open and closed treatment of extracapsular mandibular condyle fractures regarding general characteristics, post-treatment malocclusion, facial nerve palsy (FNP), maximum mouth opening (MMO) and parotid complications.

Methods: A retrospective cohort of 377 fractures (350 open, 27 closed treatment) was reviewed by reference to clinical and radiological pre- and postoperative documentation. Follow-up period was 12 months. Pearsons' chi-square-test, correlations, Kruskal–Wallis test and *t*-test were carried out for statistical analysis.

Results: The dominant type of fracture was type II in Spiessl and Schroll classification (50.1%). In the open treated fractures, the most common approach was retromandibular transparotid (91.7%). Post-treatment malocclusion occurred in 18.0% and was significantly increased in bilateral fractures ($p = .039$), in luxation fractures ($p = .016$) and in patients with full dentition ($p = .004$). After open reduction and internal fixation (ORIF), temporary FNP was documented in 7.1% whereas a permanent paresis occurred in 1.7%. FNP was significantly associated with high fractures ($p = .001$), comminution ($p = .028$) and increased duration of surgery ($p = .040$). Parotid complications were significantly associated with revision surgery ($p = .009$). Post-treatment reduction of MMO mainly occurred in female patients ($p < .001$) as well as in patients with bilateral fractures ($p < .001$), high fractures ($p = .030$) and concomitant mandibular ($p = .001$) and midfacial fractures ($p = .009$).

Conclusion: Malocclusion seems to be the most frequent long-term complication after open reduction and osteosynthesis of extracapsular mandibular condyle fractures. We suggest ORIF by a transparotid approach to be an appropriate treatment

with a low complication rate regarding especially FNP for extracapsular fractures of the mandibular condyle.

KEYWORDS
facial nerve palsy, malocclusion, mandibular condylar fracture, parotid complications, retromandibular transparotid approach

1 | INTRODUCTION

Fractures of the mandibular condyle represent 25–35% of all mandibular fractures.[1,2] In adult patients, treatment possibilities vary according to the location and dislocation of the fracture.[1] The treatment of mandibular condyle fractures remains controversial despite many studies regarding this type of fracture.[3] Some authors reported no differences between the surgical and conservative treatment for ranges of motion, occlusion, contour, and motor or sensory function.[4] In general, ORIF is suggested to lead to better occlusal results, anatomic restoration and faster recovery rates than non-surgical techniques.[1] Other studies suggest that open surgical treatment should be indicated in cases of displaced and dislocated condylar fractures.[5] Nevertheless, potential surgical complications such as facial nerve palsy, salivary fistula and deranged occlusion cannot be denied.[5,6] These risks of ORIF must be weighed properly against its potential benefits.[6] The purpose of this retrospective study was to evaluate the results and complications after ORIF and conservative treatment of extracapsular fractures of the mandibular condylar process regarding the cases treated in our institution over a 15-year period.

2 | PATIENTS AND METHODS

Medical records and clinical notes regarding patients presenting with unilateral or bilateral subcondylar fractures and fractures of the condylar neck treated in our department of oral and maxillofacial surgery at Regensburg University Hospital between 2005 and 2019 were retrospectively analysed. Patients with incomplete clinical and radiological pre- and postoperative documentation were not included. Fracture classification was accomplished according to Spiessl and Schroll, and only fracture types I–V were included in the study[7] (Table 1). If more than 50% of the fracture was above the sigmoid notch line, it was declared a high fracture; if more than 50% of the fracture was below the sigmoid notch line, it was declared a low fracture. Surgery was mainly performed for cases with dislocation or displacement (II–V; Figure 1). For class I, surgery was discussed with the patient individually and was often performed in order to prevent delayed displacement and to enable early jaw mobilization. At-risk patients with type II to V fractures who were not apt for general anaesthesia underwent conservative treatment. Preoperative dental chart was established. According to our experience, this is an important step to make a decision between open and closed treatment as for instance in cases of minimally displaced condylar fractures in the edentulous atrophic mandible minor occlusal changes could be corrected by fabrication of new dentures instead of ORIF. Moreover, small deviations in mandibular motion and aesthetics are commonly of minor importance for edentulous patients.[8] The same applies to patients with severely reduced dentition. Before treatment, fracture related malocclusion and accompanying mandibular and midfacial fractures were assessed. By reference to preoperative imaging,

TABLE 1 Spiessl and Schroll classification.[7]

Type I	Fractures without displacement
Type II	Low fractures with displacement
Type III	High fractures with displacement
Type IV	Low fractures with dislocation
Type V	High fractures with dislocation
Type VI	Intracapsular fractures

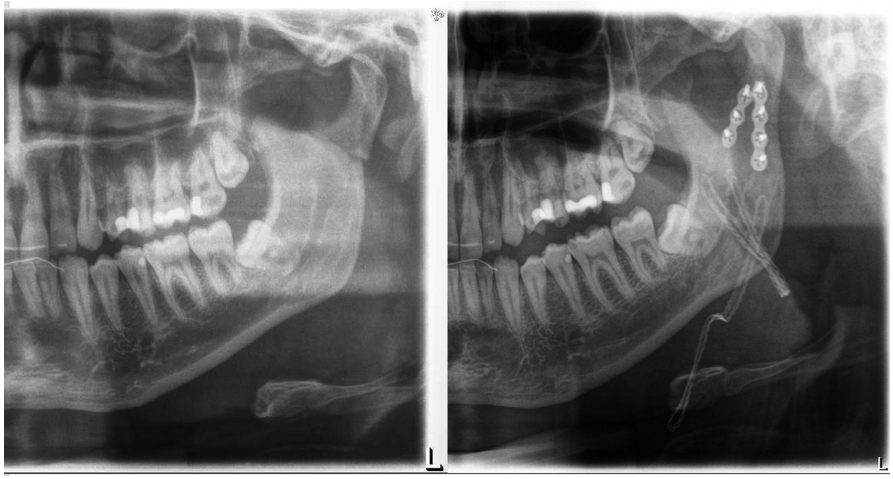

FIGURE 1 Type II fracture, before and after ORIF in double-plating-technique.

the type of fracture according to Spiessl and Schroll, comminution and luxation of the condyle from the glenoid fossa were observed. Isolated intracapsular condylar head fractures were not included in the study. In case of an intracapsular fracture on one side and an extracapsular fracture on the other side, the extracapsular fracture was included in the study and regarded as part of a bilateral fracture. Surgical treatment was predominantly analysed regarding the type of approach: In our department, the retromandibular transparotid approach is preferred (Figure 2A–E); in some cases, intraoral, preexisting, preauricular and submandibular approaches were performed. ORIF was accomplished by two straight miniplates in most cases (DePuy Synthes Matrix Mandible Adaption Plate thickness 1.0 mm combined with 6 mm screws). Usually, a 4-hole-plate was located along the posterior aspect and a 3 or 4-hole-plate along the anterior aspect of the condylar neck diverging to the posterior plate (Figures 1 and 2D). The double-plating technique offers sufficient stability in all loading conditions.[9] It is a widely accepted concept, and it is reported to be the gold standard in osteosynthesis of condylar fractures.[10]

In some cases of oblique fractures, lag screws were used while resorbable plates were inserted in two paediatric patients. Extracorporeal fixation technique was avoided and accordingly not deployed to minimize the risk of condylar resorption or avascular necrosis.[11,12] Information about approach, osteosynthesis and intraoperative neuromonitoring was gathered from operative reports. Overall operation time was assessed for condylar fractures with accompanying mandibular and midfacial fractures together. Data concerning facial nerve palsy (FNP), occlusion disturbances and parotid complications were retrieved from the charts. Facial nerve function was assessed post-surgically and in case of FNP followed-up during the next 12 months for evaluation of permanent damage. The House–Brackmann facial nerve grading system was used for classification of FNP (Table 2). Occlusion disturbance and parotid complications were assessed during the first 6 weeks after surgery. Comorbidities that affected the results could not be identified. Data were analysed by the use of SPSS 26.0. Significant differences were identified in cross tabulation using Pearsons' chi-square-test, correlations and Kruskal–Wallis test. *T*-test was carried out for comparing of mean values. A *p*-value less than .05 was considered statistically significant.

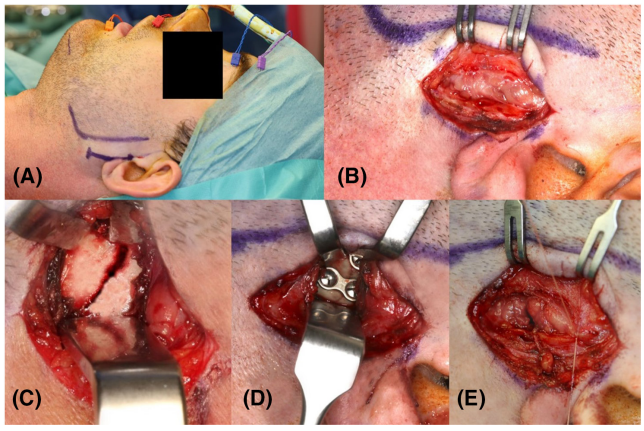

FIGURE 2 A Skin marking for retromandibular approach, 4-channel-neuromonitoring was placed into the frontalis, orbicularis oculi and oris, and mentalis muscles, B incision of the parotid capsule, C Type II fracture in situ, D ORIF by one plate along the posterior aspect of the mandibular ramus and another plate diverging to the first one in anterior-caudal direction. E Watertight closure of the parotid capsule.

TABLE 2 House–Brackmann facial nerve grading system.[31]

Grade	Description	Characteristics
I	Normal	Normal facial function in all areas

II	Mild dysfunction	• Gross: slight weakness noticeable on close inspection; may have very slight synkinesis
		• At rest: normal symmetry and tone
		• Motion:
		  • Forehead: moderate to good function
		  • Eye: complete closure with minimum effort
		  • Mouth: slight asymmetry

III	Moderate dysfunction	• Gross: obvious but not disfiguring difference between two sides; noticeable but not severe synkinesis, contracture, and/or hemifacialspasm
		• At rest: normal symmetry and tone
		• Motion
		  • Forehead: slight to moderate movement
		  • Eye: complete closure with effort
		  • Mouth: slightly weak with maximum effort

IV	Moderate severe dysfunction	• Gross: obvious weakness and/or disfiguring asymmetry
		• At rest: normal symmetry and tone
		• Motion
		  • Forehead: none
		  • Eye: incomplete closure
		  • Mouth: asymmetric with maximum effort

V	Severe dysfunction	• Gross: only barely perceptible motion
		• At rest: asymmetry
		• Motion
		  • Forehead: none
		  • Eye: incomplete closure
		  • Mouth: asymmetric with maximum effort

VI	Total paralysis	• No movement

3 | RESULTS

Between 1 January 2005 and 31 December 2019, 347 patients (129 female, 33.7%, 248 male, 66.3%) presented with in total 377 uni or

bilateral condylar fractures in our department of oral and maxillofacial surgery at Regensburg University Hospital. Baseline characteristics are presented in Table 3. The mean age was 36.51 ± 17.38 years with a range from 13 to 85 years. Included patients were consecutive cases. Thirty-one patients (9.0%) suffered from polytrauma. In 37 patients (10.7%), excessive consumption of alcohol or drugs before the trauma was documented.

TABLE 3 General characteristics.

Sample size: Patients/Total fractures	347/377
Male	230 (66.3%)
Female	117 (33.7%)
Age	36.51 ± 17.38 years
Aetiology	
Road traffic accidents	126 (33.4%)
Assaults	87 (23.1%)
Fall	60 (15.9%)
Sports accidents	25 (6.6%)
Work related accidents	18 (4.8%)
Syncopation	17 (4.5%)
Other	44 (11.7%)
Fracture classification (Spiessl and Schroll)	
Type I	63 (16.7%)
Type II	189 (50.1%)
Type III	77 (20.4%)
Type IV	15 (4.0%)
Type V	33 (8.8%)
Anatomic location	
Unilateral left	107 (28.4%)
Unilateral right	129 (34.2%)
Bilateral	141 (37.4%)
Concomitant mandibular fractures	
None	125 (33.2%)
Paramedian left	91 (24.1%)
Paramedian right	56 (14.9%)
Median	36 (9.5%)
Body left	12 (3.2%)
Body right	10 (2.7%)
Angle left	18 (4.8%)
Angle right	9 (2.4%)
Coronoid process	1 (0.3%)
Comminuted	19 (5.0%)
Treatment	
Open	350
Closed	27
Approach	
Retromandibular transparotid	321 (91.7%)
Intraoral	23 (6.6%)
Preexisting	1 (0.3%)
Submandibular	2 (0.6%)
Preauricular	3 (0.9%)

Half of the fractures were classified as Spiessl and Schroll Type II, followed by Type III (20.4%) and Type I (16.7%). Two thirds of the fractures ($n = 236$) were unilateral, and one third ($n = 141$) occurred as part of bilateral fractures. 9.5% ($n = 36$) of the condylar fractures were described as comminuted fractures; in 12.7% ($n = 48$), the condyle was luxated out of the glenoid fossa. In 66.8%, condylar fractures were accompanied by further mandibular fractures ($n = 252$). The most common concomitant mandibular fractures were paramedian fractures (39.0%, $n = 147$) followed by median fractures (9.5%, $n = 36$), mandibular angle fractures (7.1%, $n = 27$), fractures of the mandibular body (5.8%, $n = 22$) and comminuted mandibular fractures (5.0%, $n = 19$). 28.4% of the unilateral condylar fractures were associated with contralateral paramedian fractures ($n = 67$; Figure 3). In 17.5% of our cases, patients presented with further midfacial fractures ($n = 66$) whereby zygomatic fractures were the most common fractures among these (7.7%, $n = 29$) followed by panfacial fractures (5.0%, $n = 19$).

In 83.8% of cases, patients presented with full dentition ($n = 316$), 12.2% were partially dentate ($n = 46$) and 3.8% were edentulous ($n = 13$). 9.3% ($n = 35$) presented an initial maximum mouth opening (MMO, interincisal distance) of 1.0 cm or less, 24.9% ($n = 94$) showed an MMO between 1.0 and 2.0 cm, 31.8% ($n = 120$) between 2.0 cm and 3.0 cm and 34.0% ($n = 128$) of 3.0 cm or more. There was no significant correlation between fracture classification and preoperative maximum mouth opening ($p = .79$).

350 (92.8%) condylar fractures were treated by ORIF whereas 27 (7.2%) fractures underwent conservative treatment ($n = 27$). Fracture displacement and luxation of the condylar head were significantly correlated to indication for ORIF ($p < .001$, respectively, $p = 0.035$) whereas comminution of the condyle as well as fracture localization did not correlate significantly with the way of treatment ($p = .495$).

Among the closed treated fractures, type I was the most frequent type (63.0%, $n = 17$) whereas in the open treated cases type II (52.9%, $n = 185$) was the most common type followed by type III (20.6%, $n = 72$). Type IV and V fractures were mainly treated by ORIF; only one type V fracture was treated conservatively (Table 4).

Twelve (3.4%) of the open treated fractures had to be revised.

The most frequent approach was retromandibular transparotid (91.7%, $n = 321$) followed by intraoral (6.6%, $n = 23$), preexisting (1.1%, $n = 0.3\%$), preauricular (0.9%) and submandibular (0.6%). ORIF was carried out by miniplates (96.6%, $n = 338$), traction screws (1.7%, $n = 6$), miniplate and traction screw (1.1%, $n = 4$) and resorbable plates (0,6%, $n = 2$). Neuromonitoring with stimulation electrodes was documented in 95.1% during ORIF to protect the facial nerve.

The most frequent postoperative, respectively, post-treatment complications were malocclusion (18.0%, $n = 68$), reduction of MMO (13.5%, $n = 61$), FNP (8.9%, $n = 31$), haematoma (6.0%, $n = 21$), parotid complications such as salivary fistula and sialocele (3.7%, $n = 13$), surgical site infection (2.0%, $n = 7$) and pseudarthrosis (0.9%, $n = 3$).

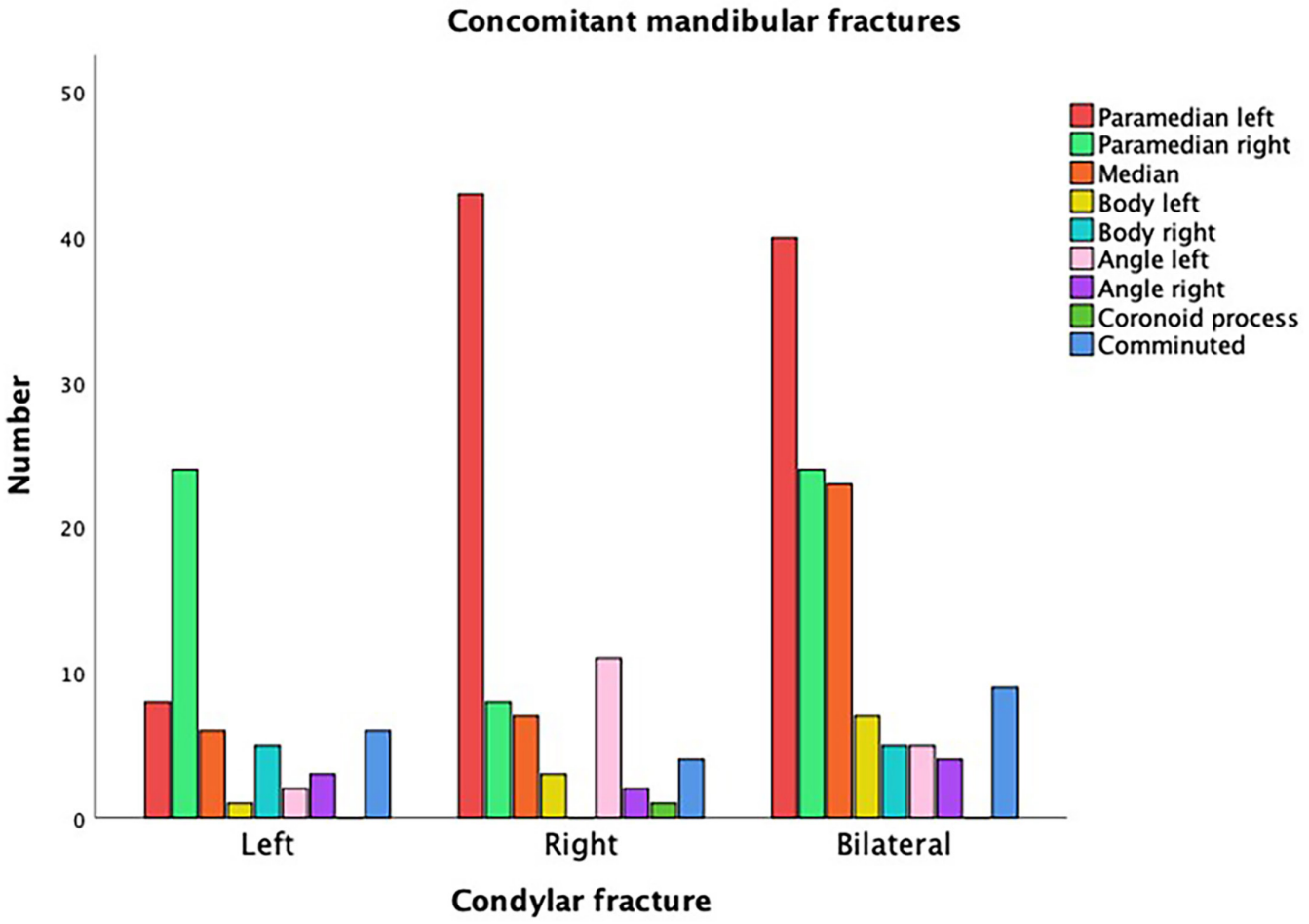

FIGURE 3 Distribution of condylar and concomitant mandibular fractures.

Post-treatment malocclusion, FNP, parotid complications and reduction of MMO were assessed (Table 5A–D).

Post-treatment malocclusion was reported in 18.0% ($n=63$) after ORIF versus 18.5% ($n=5$) after conservative treatment ($p=1.00$). In cases of malocclusion after open treatment, postoperative IMF by elastics was offered to the affected patients. In 20 cases, IMF was declined or non-compliance was documented. In 31 cases, postoperative IMF was carried out, in 17 of them as a solitary measure. In 11 cases, orthodontic treatment and in three cases prosthetic treatment was subsequently required. Twelve cases had to undergo revision surgery. Postoperative malocclusion was not associated with displacement ($p=.721$), comminution ($p=.255$), concomitant mandibular fractures ($p=.570$) and concomitant midfacial fractures ($p=1.00$). Although statistically not associated with overall fracture classification ($p=.078$), luxation of the condylar head (Type IV, V) significantly correlated to post-treatment malocclusion ($p=.016$). For type V fractures, postoperative malocclusion was documented in 36.4%. Moreover, fully dentate patients show postoperative occlusional disharmony more frequently than partially dentate patients ($p=.004$). Bilateral fractures were significantly more often associated with postoperative malocclusion than unilateral fractures ($p=.039$; Table 5A).

Postoperative complications affecting the facial nerve were documented in 31 cases (8.9%), in detail one House–Brackmann grade I, 14 grade II, 7 grade III, 7 grade IV and 2 grade V cases. In 25 patients (7.1%), FNP was temporary, in six patients (1.7%) permanent. Mean duration of temporary FNP after surgery was 8.90 ± 7.63 weeks. The zygomatic branch was violated most frequently ($n=16$, 51.6%), followed by the temporal ($n=9$, 29.0%) and the buccal branch ($n=4$, 12.9%). More than one branch was affected in 6.5% of FNPs ($n=2$). Facial nerve impairment was significantly associated with prolonged time of surgery ($p=.040$) and comminuted fractures ($p=.028$). Additionally, FNP correlated to postoperative malocclusion ($p=.001$) and to high condylar fractures compared to low condylar fractures ($p=.001$). By contrast, facial nerve violation was independent from use of a neuromonitoring device ($p=1.00$; Table 5B).

Thirteen patients (3.7%) revealed postoperative parotid complications (10 salivary fistulae and 3 sialocele) after retromandibular transparotid approach. Revision surgery was significantly associated with parotid complications ($p=.009$). Neither fracture displacement ($p=.695$), comminution ($p=.377$), luxation of the condylar head ($p=.087$) or fracture localization ($p=1.00$) were significantly associated with parotid disturbances (Table 5C).

TABLE 4 Open versus closed treatment.

	Open treatment	Closed treatment	*p*-value
Sample size	350 (92.8%)	27 (7.2%)	–
Fracture classification			
Type 1	46 (13.1%)	17 (63.0%)	–
Type 2	185 (52.9%)	4 (14.8%)	
Type 3	72 (20.6%)	5 (18.5%)	
Type 4	15 (4.3%)	0 (0%)	
Type 5	32 (9.1%)	1 (3.7%)	
Fracture displacement			
Yes	304 (86.9%)	10 (37.0%)	**<.001**
No	46 (13.1%)	17 (63.0%)	
Comminuted fracture			
Yes	35 (10%)	1 (3.7%)	.495
No	315 (90%)	26 (96.3%)	
Luxation of condylar head			
Yes	47 (13.4%)	0 (0%)	**.035**
No	303 (86.6%)	27 (100%)	
Fracture localization			
High	104 (29.7%)	6 (22.2%)	.513
Low	246 (70.3%)	21 (77.8%)	
Postoperative maloclusion			
Yes	63 (18.0%)	5 (18.5%)	1.000
No	287 (82.0%)	22 (81.5%)	
MMO reduction to 2.5 cm or less			
After 6 months			
Yes	5 (18.5%)	46 (13.1%)	.389
No	22 (81.5%)	304 (86.9%)	
After 12 months			
Yes	3 (11.1%)	29 (8.3%)	.490
No	24 (88.9%)	321 (91.7%)	

Note: Significant associations in bold.
Abbreviation: MMO, maximum mouth opening.

After ORIF haematoma occurred in 6.0% ($n=21$) and surgical site infection was documented in 2.0% ($n=7$). Wound healing disturbances were not associated with increased occurrence of postoperative FNP ($p=.560$). Referring to this, there was no significant association between a certain kind of approach and the cumulative appearance of wound healing disturbances.

In 16.7% of all cases ($n=63$), a post-treatment-reduction of MMO to 2.5 cm or less after 6 months was documented. There was no significant association with fracture displacement ($p=.224$), dislocation of the condylar head ($p=.261$), surgical approach ($p=.583$) and comminution ($p=.303$). Moreover, the way of treatment did not significantly influence post-treatment mouth opening reduction (13.1% after ORIF, 18.5% after conservative treatment, $p=.389$). However, a significant correlation between reduction of MMO and high fractures (type 3 and 5; $p=.030$) as well as bilateral fractures

TABLE 5 Post-treatment complications.

(A) Post-treatment malocclusion		
Study variable	**Ratio malocclusion/sample size**	***p*-value**
Total	68/377 (18.0%)	–
Sex		
Female	22/129 (17.1%)	.779
Male	46/248 (18.5%)	
Treatment		
Open	63/350 (18.0%)	1.000
Closed	5/27 (18.5%)	
Unilateral fractures	35/236 (14.8%)	**.039**
Bilateral fractures	33/141 (23.4%)	
Side of fracture		
Left	36/182 (19.7%)	.423
Right	32/195 (16.4%)	
Fracture classification		
Type 1	10/63 (15.9%)	.078
Type 2	30/189 (15.9%)	
Type 3	13/77 (16.9%)	
Type 4	3/15 (20%)	
Type 5	12/33 (36.4%)	
Fracture displacement		
Yes	58/314 (18.5%)	.721
No	10/63 (15.9%)	
Luxation of condylar head		
Yes	15/48 (31.3%)	**.016**
No	53/329 (16.1%)	
Comminuted fracture		
Yes	8/36 (22.2%)	.496
No	60/341 (17.6%)	
Fracture localization		
High	25/110 (22.7%)	.142
Low	43/267 (16.1%)	
Dentition		
Full	66/316 /20.8%)	**.004**
Partial	2/46 (4.3%)	
Edentulous	0/15 (0%)	
Concomitant mandibular fractures		
Yes	43/251 (17.1%)	.570
No	25/126 (19.8%)	
Concomitant midfacial fractures		
Yes	12/66 (18.2%)	1.000
No	56/311 (18.0%)	
(B) Facial nerve palsy (FNP) in open treated patients		
Study variable	**Ratio FNPs/sample size**	***p*-value**
Total FNPs	31/350 (8.9%)	–
Temporary FNPs	25/350 (7.1%)	–

TABLE 5 (Continued)

(B) Facial nerve palsy (FNP) in open treated patients		
Study variable	**Ratio FNPs/sample size**	***p*-value**
Permanent FNPs	6/350 (1.7%)	–
Sex		
Female	14/117 (12.0%)	.165
Male	17/233 (7.3%)	
Unilateral fractures	21/228 (9.2%)	.845
Bilateral fractures	10/122 (8.2%)	
Side of fracture		
Left	16/181 (8.8%)	1.000
Right	15/169 (8.9%)	
Fracture classification		
Type 1	3/47 (6.4%)	**.002**
Type 2	10/185 (5.4%)	
Type 3	10/70 (14.3%)	
Type 4	0/15 (0%)	
Type 5	8/33 (24.2%)	
House–Brackmann Score		
Grade I	1/31 (3.2%)	–
Grade II	14/31 (45.2%)	
Grade III	7/31 (22.6%)	
Grade IV	7/31(22.6%)	
Grade V	2/31 (6.5%)	
Fracture displacement		
Yes	28/302 (9.3%)	.783
No	3/48 (6.3%)	
Luxation of condylar head		
Yes	8/48 (16.7%)	.053
No	23/302 (7.6%)	
Comminuted fracture		
Yes	7/36 (19.4%)	**.028**
No	24/314 (7.6%)	
Fracture localization		
High	18/103 (17.4%)	**.001**
Low	13/247 (5.2%)	
Neuromonitoring		
Yes	30/333 (9.0%)	1.000
No	1/17 (5.9%)	
Revision surgery		
Yes	2/13 (15.4%)	.323
No	29/337 (8.6%)	
Approach		
Retromandibular transparotid	29/320 (9.1%)	1.000
Other	2/30 (6.7%)	

(Continues)

TABLE 5 (Continued)

(B) Facial nerve palsy (FNP) in open treated patients		
Study variable	**Ratio FNPs/sample size**	***p*-value**
Localization of FNP		
Temporal branch	9/31 (29.0%)	–
Zygomatic branch	16/31 (51.6%)	
Buccal branch	4/31 (12.9%)	
More than one	2/31 (6.5%)	
Association localization of FNP/localization of fracture		
High fractures		
Temporal branch	6/103 (5.8%)	**.001**
Zygomatic branch	7/103 (6.8%)	
Buccal branch	3/103 (2.9%)	
More than one	2/103 (1.9%)	
Low fractures		
Temporal branch	3/247 (1.2%)	
Zygomatic branch	9/247 (3.6%)	
Buccal branch	1/247 (0.4%)	
More than one	0/247 (0%)	
Overall operation time for condylar and concomitant fractures		
<60 min	0/12 (0%)	**.040**
60–90 min	0/37 (0%)	
90–120 min	4/69 (5.8%)	
>120 min	27/201 (13.4%)	
Postoperative malocclusion		
Yes	13/63 (20.6%)	**.001**
No	18/287 (6.3%)	

(C) Parotid complications in open treated patients		
Study variable	**Ratio parotid complications/sample size**	***p*-value**
Total	13/350 (3.7%)	–
Sex		
Female	1/117 (0.9%)	.068
Male	12/233 (5.2%)	
Unilateral fractures	10/228 (4.4%)	.555
Bilateral fractures	3/122 (2.5%)	
Side of fracture		
Left	4/181 (2.2%)	.160
Right	9/169 (5.3%)	
Fracture classification		
Type 1	1/46 (2.2%)	.356
Type 2	7/185 (3.8%)	
Type 3	1/72 (1.4%)	
Type 4	1/15 (6.7%)	
Type 5	3/32 (9.4%)	

(Continues)

TABLE 5 (Continued)

(C) Parotid complications in open treated patients		
Study variable	**Ratio parotid complications/sample size**	***p*-value**
Approach		
Retromandibular transparotid	13/320 (4.0%)	.613
Other	0/30 (0%)	
Fracture displacement		
Yes	11/302 (3.6%)	.695
No	2/48 (4.2%)	
Comminuted fracture		
Yes	0/36 (0%)	.377
No	13/314 (4.1%)	
Luxation of condylar head		
Yes	4/48 (8.3%)	.087
No	9/302 (2.9%)	
Fracture localization		
High	4/103 (3.9%)	1.000
Low	9/247 (3.6%)	
Revision surgery		
Yes	3/13 (23.1%)	**.009**
No	10/337 (3.0%)	

(D) Post-treatment reduction of maximum mouth opening (MMO)		
Study variable	**Ratio reduction of MMO/ sample size**	***P*-value**
Total	51/377 (13.5%)	–
Sex		
Female	35/129 (27.1%)	**<.001**
Male	16/248 (6.5%)	
Treatment		
Open	46/350 (13.1%)	.389
Closed	5/27 (18.5%)	
Unilateral fractures	20/236 (8.4%)	**.001**
Bilateral fractures	31/141 (22.0%)	
Side of fracture		
Left	27/182 (14.8.7%)	.547
Right	24/195 (12.3%)	
Fracture classification		
Type 1	5/63 (7.9%)	**.030**
Type 2	22/189 (11.6%)	
Type 3	15/77 (19.4%)	
Type 4	2/15 (13.3%)	
Type 5	7/33 (21.2%)	
Fracture displacement		
Yes	46/314 (14.6%)	.224
No	5/63 (7.9%)	

TABLE 5 (Continued)

(D) Post-treatment reduction of maximum mouth opening (MMO)		
Study variable	**Ratio reduction of MMO/ sample size**	***P*-value**
Luxation of condylar head		
Yes	9/48 (18.8%)	.261
No	42/329 (12.8%)	
Comminuted fracture		
Yes	7/36 (19.4%)	.485
No	44/341 (12.9%)	
Fracture localization		
High	22/110 (20.0%)	**.030**
Low	29/267 (10.9%)	
Approach		
Retromandibular transparotid	43/320 (13.4%)	.583
Other	2/30 (6.7%)	
Concomitant mandibular fractures		
Yes	44/251 (17.5%)	**.001**
No	7/126 (5.6%)	
Concomitant midfacial fractures		
Yes	16/66 (24.2%)	**.009**
No	35/311 (11.3%)	

Note: Significant associations in bold.

Abbreviations: FNP, facial nerve palsy; MMO, maximum mouth opening.

($p < .001$) could be displayed. Also in patients with concomitant mandibular and midfacial fractures, post-treatment MMO was significantly decreased ($p = .001$; $p = .009$). Female patients came up with a significant post-therapeutic reduction of MMO ($p < .001$; Table 5D).

4 | DISCUSSION

Today, open approaches are considered the treatment of choice for dislocated fractures of the mandibular condylar process in many units. However, for moderately displaced condylar fractures, open treatment is still controversial.[13] Treatment decision-making depends on expert opinion and varies notably among maxillofacial surgeons worldwide.[3] Facial nerve palsy, salivary fistula, sialoceles, surgical site infection, malocclusion and persisting pain are reported to be the major complications after surgical treatment of condylar fractures.[14–16] Some authors suggest that both treatment options yield acceptable results for unilateral displaced condylar fractures but operative treatment was superior in most objective and subjective functional parameters.[17] Al-Moraissi et al. confirm that ORIF provides superior subjective and objective functional clinical outcome in comparison to closed treatment.[18]

In the present study, we evaluated 377 extracapsular fractures of the mandibular condylar process presenting in our unit between 2005 and 2019. A total of 350 fractures were treated by ORIF, mainly by retromandibular transparotid approach (91.7%, $n = 321$), whereas 27 fractures underwent conservative therapy. Neff et al. described ORIF to be the gold standard for condylar base and condylar neck fractures.[19] Ellis stated that open treatment of condylar fractures was associated with faster recovery of mandibular movements.[20] Other authors recommend ORIF at least in all condylar fractures with a deviation of 10–45°, or a shortening of the ascending ramus of ≥2 mm, irrespective of the fracture level.[21]

With this in mind, every patient was informed about treatment options and open treatment was offered to patients in acceptable general health condition. This resulted in the distribution of open and closed treatment where type I was the most frequent type among the closed treated fractures whereas types II–V were mainly treated by ORIF.

In 18.0% of all patients, malocclusion was documented after treatment without a significant difference between open and closed treatment. However, comparison of the two treatment options is not reasonable at all as 61% of conservatively treated fractures were Type I without displacement and altered occlusion whereas 87% of surgically treated fractures were displaced or dislocated (Type II–IV) and presented with pre-surgical malocclusion. Overall malocclusion after ORIF was 18.0%. A meta-analysis comparing the outcome after open and closed treatment of condylar fractures including post-treatment malocclussion refers similar numbers after conservative treatment and lower numbers after ORIF (Berner et al., 2015), but it must be remembered that the selected studies present a maximum of 30 patients in the open treated group which is lower than a tenth of our cohort. Patients with bilateral condylar fractures show a significantly higher risk to develop dysocclusion ($p = .039$). This result does not surprise as reduction is more challenging to different biomechanics and minor inaccuracies increase with number of fractures.[22,23] Moreover, luxation of the condylar head was significantly associated with postoperative malocclusion ($p = .016$) which is of course also due to a more difficult reduction and to a violation of the TMJ capsule.

In 7.1%, a temporary palsy of the facial nerve was documented after surgery whereas a permanent nerve damage occurred in 1.7%. This is similar to previous studies. In the review by Rozeboom et al. on complications after ORIF of condylar fractures by extraoral approach, a rate of 12% was found for postoperative facial weakness, 95% being temporary and 5% permanent.[24] In the current study, duration of temporary facial nerve weakness was 8.90 ± 7.63 weeks. 45.2% of FNPs were House–Brackmann-Score grade II with the zygomatic branch most often affected. In view of our results, we suggest that cases of FNP after ORIF are mainly mild palsies of transient duration caused by neurapraxia. Facial nerve damage was not associated to a certain approach. Of course, the comparison of approaches is also not reasonable as nearly all fractures (92%) were treated by retromandibular transparotid approaches. Kommers et al. also described the retromandibular approach as the most often chosen approach for condylar fractures.[3] Gerbino et al. consider the retromandibular approach superior to other approaches regarding visibility and complication rate.[25] According to other studies, we consider the risk to produce a permanent paresis of the facial nerve to be very low using the transparotid approach. Fortunately, in most cases facial weakness is transient due to hook traction and tissue strechting.[24,25] However, we suggest that distension of nerval tissue is acceptable in retromandibular transparotid approach. For example submandibular approach is considered to cause higher tension forces on the facial nerve.[25] A significant advantage of using neuromonitoring during surgery could not be outlined; nevertheless, we recommend to use it. According to our experience, it is a sensible device for protection of the facial nerve. Surgical treatment of high fractures (type III and V) was strongly associated with occurrence of FNPs ($p = .001$), particularly impairment of the zygomatic branch (52% of all FNPs). This finding distinguishes from other studies where the buccal branch was identified to be most frequently affected.[16,26] In these studies, according to the classic retromandibular approach, skin incision was placed below the ear lobe and dissection was predominantly performed between buccal and mandibular branches. In our department, skin incision is sometimes placed more cranially in front of the ear lobe guiding blunt dissection between the zygomatic and buccal branch which provides the most direct way to the majority of condylar neck fractures. Comminution of the condylar process also seems to endanger the facial nerve probably due to a more demanding repositioning and the need for wider approaches ($p = .028$). The association of postoperative malocclusion and FNP ($p = .001$) may also be a result of complex fracture patterns and challenging reduction combined with wider approaches and prolonged time of surgery. In complex fractures, reposition may cause higher traction exerted on the nerval tissues which is also identified as a risk factor for postoperative palsy like mentioned above.[24]

Parotid complications such as salivary fistula or sialocele occurred in 3.7% of the open treated fractures and were significantly more frequent in cases of revision surgery ($p = .009$). Obviously, all parotid complications occurred in cases treated by retromandibular transparotid approach without significance ($p = .613$). According to previous authors, complications addressing the parotid gland are very rare and avoidable by precise and 'watertight' reconstruction of the parotid gland capsule[6,27] (Figure 2E). Revision surgery might rule this out by an enhanced traumatization of the parotid gland capsule.

Post-therapeutic reduction of MMO was significantly cumulated in patients with bilateral fractures ($p < .001$) as well as with concomitant mandibular and midfacial fractures ($p = .001$; $p = .009$). Niezen et al. also identified additional mandibular fractures as a factor for MMO reduction.[28] Joint and incisional pain or scarring during healing of the surgical site was identified to be a potential reason for post-therapeutic decrease of MMO.[29] Due to more extensive surgery required in patients with multiple concomitant fractures, higher postoperative pain levels, muscle stripping, intensified scarring and

wider condylar remodelling may cause diminished MMO.[25,30] High condylar fractures were significantly associated with a reduced post-therapeutic MMO ($p = .030$). High fractures probably affect the temporomandibular joint by postoperative tissue alteration and scarring more than low fractures. A greater reduction of MMO after treatment of condylar fractures in female patients has also been mentioned by previous authors; however, reasons remain elusive.[28] In our study, concordantly 27.1% of female patients presented with post-treatment MMO reduction compared to 6.5% male patients ($p < .001$). 13.1% of the open treated patients showed post-treatment reduction of MMO compared to 18.5% of the closed treated patients without statistical significance. 13 of 15 edentulous patients underwent open treatment, and none of them showed a post-treatment mouth opening limitation. Therefore, we suggest that ORIF is also an option for condylar fractures in edentulous patients to minimize the risk of MMO reduction. However, an individualized risk–benefit assessment in edentulous patients who often present with poor medical conditions and high age should be carried out.[8]

Of course, this study has several limitations. One limitation is the retrospective design based on clinical documentation. Exact data for important variables like extent of malocclusion, mouth opening or degree of pain or facial weakness were sometimes missing. For this reason, incompletely documented cases had to be excluded from this study. However, this missing data are compensated by the large cohort of 350 surgically treated condylar fractures which is one of the largest cohorts to date and therefore allows reliable statements. Another possible bias is that intracapsular fractures were separated from extracapsular fractures and basically not included in evaluation as treatment guidelines are different, for example different approach. Instead, additional contralateral intracapsular fractures were documented as bilateral fractures. Moreover, individual experience of the involved surgeons could not be evaluated despite it may have a major impact on postoperative outcome. True comparison between closed and open treatment was not possible as almost all dislocated fractures were treated by open approaches whereas closed treatment was predominantly preserved for non-displaced grade I fractures.

5 | CONCLUSION

The findings demonstrate that malocclusion seems to be the most frequent long-term complication after open reduction and osteosynthesis of extracapsular mandibular condyle fractures. The risk of permanent facial nerve palsy or parotid gland disturbances by ORIF seems to be very low using a retromandibular transparotid approach. In our view, open surgery is the appropriate treatment for extracapsular condylar fractures of the mandible.

AUTHOR CONTRIBUTIONS

MM and TE contributed equally to the conception and the design of the study. TK, JMG, JT and JS collected the data. MM and TE analyzed the collected data. MM drafted the first version of the article. TE, TER and JKM critically reviewed and edited it. All authors finally approved the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS STATEMENT

Ethical approval was given by the local ethics committee of Regensburg University under number 20-2014-104.

PATIENT CONSENT

Patient consent for photograph material was given.

ORCID

Michael Maurer https://orcid.org/0000-0003-0905-178X

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