

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

ABSTRACT

Purpose

Facial trauma may lead to temporomandibular dysfunction. The aim of this study was to clarify the occurrence and characteristics of temporomandibular dysfunction in patients surgically treated for mandibular fractures **not involving mandibular condyle**.

Methods

This prospective, single-center follow-up study was comprised of patients who underwent surgery for a non-condylar mandibular fracture. Patients were first evaluated at presentation, and again six months post-surgery to assess the function of the masticatory system, using the Helkimo index. Specifically, this index incorporates two complementary sub-indices: the subjective symptomatic (anamnestic) index (A_i), and the objective clinical dysfunction index (D_i). The A_i was recorded both at presentation and the six month follow-up. The D_i was recorded at the six month follow-up.

Results

Thirty-one patients completed the study. All patients were men (mean age 26.2, range 18–47 years). Four (12.9%) patients developed severe symptoms of dysfunction during the study period according to the A_i . Clinical findings (D_i) were observed in 25 (80.6%) patients, but these were not associated with symptoms of dysfunction.

Conclusions

Temporomandibular dysfunction is common six months after surgery in patients with non-condylar mandibular fractures. Patients with such fractures should be evaluated for dysfunction

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

during follow-ups, and referred for further treatment if necessary.

INTRODUCTION

Facial trauma such as mandibular fracture has been considered as a possible etiological factor in temporomandibular joint (TMJ) dysfunction (TMD)¹⁻⁶. Direct or indirect trauma of the TMJ can cause mechanical changes within the joint, including effusion, hemarthrosis, dislocation, internal derangement, fibrous adhesion, ankylosis, fracture, and limitation or deviation of jaw opening⁶.

Histologically, TMD effects have been presented as degeneration of the articular cartilage, synovitis, intra-articular adhesions, and production of inflammatory and pain mediators⁴. Other screening methods that have detected changes related to TMD include magnetic resonance imaging (MRI), arthroscopy, histomorphologic examination, and synovial fluid analysis^{4,7,8}.

Moreover, degenerative alterations in the mechanical properties of the articular disc have been documented⁹. Depending on the magnitude and direction of the impact, trauma may also cause inflammation of the adjacent muscles¹⁰. Malocclusion may disturb the balance of the TMJ and therefore cause TMD^{11,12}. Cross-bite and TMJ displacement are proven risk factors in TMD development¹¹.

It is well known that condylar fracture of the mandible can cause TMD^{8,13-15}. Direct trauma of the TMJ affects all structures of the joint, and treatment often requires immobilization. However, the effects of non-condylar mandibular fracture (caused by trauma) on the TMJ remain poorly studied.

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

Indeed, when the trauma is severe enough to cause mandibular fracture, it could be hypothesized that the force of the trauma may directly or indirectly disturb the temporomandibular structures, hence causing TMD. Nevertheless, this has yet to be explored. Therefore, the aim of this study was to clarify the occurrence and characteristics of TMD in patients surgically treated for non-condylar mandibular fractures.

METHODS

Inclusion and exclusion criteria

The patients included in this study were drawn from a larger cohort of adult patients (aged 18 years or older), who had been surgically treated for facial fractures. Specifically, the selected patients had sustained a single or double non-comminuted, non-complicated mandibular fracture in the teeth-bearing region. The fracture types included were: 1) single fracture in the angle, 2) single fracture in the body, 3) single fracture in the symphysis/parasymphysis, and 4) double mandibular fracture (i.e., angle + body fracture, angle + symphysis/parasymphysis fracture). All patients underwent an open surgical reduction with intraoral fixation, using 2.0mm titanium miniplates and non-locking monocortical screws. Two miniplates were used in the symphysis/parasymphysis fractures, and one miniplate in the mandibular body and angle fractures, according to the technique presented by Champy and Lodde¹⁶. All patients were treated at the Helsinki University Hospital, Finland.

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

For the final analysis, patients with condylar fractures, infected fractures, or any other facial fractures that required surgical treatment were excluded. In addition, patients with any history of TMD were excluded.

Evaluation of temporomandibular function

The Helkimo anamnestic (A_i) and clinical (D_i) indices were used to identify the occurrence and severity of TMD¹⁷. During the pre-operative visits, patients' anamnestic subjective symptoms (A_i) were assessed using a questionnaire and an interview. At the six month follow-up, patients were evaluated again with the same questionnaire and interview. In addition, a comprehensive clinical examination of the masticatory system was performed according to the Helkimo clinical index (D_i). This index was only recorded at the six month follow-up; pre-operative TMD status could not be evaluated due to the effects of the primary trauma. All patients were examined by one person (JS), and only clinically demonstrable findings were included in the index.

For the Helkimo anamnestic index, the patients were divided into three groups (A_{i0} - A_{iII}) according to the severity of the TMD symptoms. Group A_{i0} was the symptom-free category, which included patients that did not have any subjective symptoms. The patients in the A_{iI} group expressed mild symptoms, such as noises in the TMJ, jaw fatigue, and jaw stiffness upon awakening or during jaw movements. Group A_{iII} included patients with severe symptoms, such as difficulty opening the mouth, TMJ locking, luxation, and pain in the region of the TMJ or masticatory muscles.

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

For the Helkimo clinical index, the patients were divided into four groups (D_{i0}- D_{iIII}) according to the severity of the clinical findings. D_{i0} indicated no findings, D_{iI} included mild findings, D_{iII} was moderate findings, and D_{iIII} was severe findings. See **Table 1 and 2** for more detailed criteria for A_i and D_i, respectively.

Data analysis

The primary outcome variables were A_i and D_i. The predictive variables were age, gender, cause of injury (assault, traffic, falling, sport, or other), site of the fracture, and malocclusion.

Ethical approval

The study protocol was approved by the Ethics Committee of the Department of Surgery and the Internal Review Board of the Division of Musculoskeletal Surgery, Helsinki University Hospital, Finland.

CONFLICT OF INTERESTS

The authors confirm that they do not have any conflict of interests.

RESULTS

A total of 49 patients met the inclusion criteria. Of these, four patients refused to participate in the survey. Of the remaining 45 patients, 14 patients were excluded for the following reasons: five

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

patients had an additional condylar fracture, nine patients failed to attend the six month follow-up visit, and one patient reported a history of TMD. Thus, a total of 31 patients were included in the final analysis. **Table 3** lists the characteristics of the 31 patients.

All patients were treated within five days after the trauma (treatment delay average 2.2 days, range 0–5 days). Minor occlusal disharmony or mild malocclusion was found after operation in six (19.0%) patients, all of which were treated with occlusal equilibration by a specialist dentist during the study period.

Most of the patients (87.1%) were symptom-free (Ai0) six months after the trauma (and surgery). Nevertheless, four (12.9%) patients developed symptoms during the six month study period, which were ranked as severe (Aiii) in all four of these patients.

A total of 25 (80.6%) patients had objective clinical findings of TMD (Di) six months after the trauma (and surgery). Mild findings (DiI) were the most common, reported in 19 (61.3%) patients. Six (19.4%) patients reported moderate TMD (DiII), whereas none of the patients had severe findings (DiIII). The majority of the patients (21 of 25; 84.0%) with clinical findings of dysfunction (DiI-II) did not have any TMD symptoms six months after the trauma (i.e. classified as Ai0).

All four patients with subjective symptoms (Ai) also had clinical findings (Di). Specifically, three of the patients with severe symptoms (Aiii) had moderate (DiII) findings, and one reported mild (DiI) findings of TMD. **Table 4** lists the Helkimo anamnestic (Ai) and clinical (Di) indices of the 31

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

patients six months after the trauma. Impaired TMJ function was the most common finding among the patients with both symptoms (Ai) and clinical findings (Di). For a detailed list of the prevalence of different clinical findings, see **Table 5**. **Table 6** show the association between Ai and Di, as well as their association with other predictors, respectively.

All patients that developed TMD symptoms during the six month study period were men, aged 18–36 (mean 24.0). In all four patients that developed severe TMD symptoms during the study period, the trauma mechanism was assault, and the fracture site was in the angle of the mandible. Minor malocclusion after the operation was found in one patient, who then underwent an occlusal equilibration and was referred to a dentist for occlusal splint therapy after the study period.

DISCUSSION

This prospective, single-center study followed 31 patients with a surgically-operated, non-condylar mandibular fracture, for six months. Four patients (12.9%) developed severe symptoms of TMD during the study period, as determined with the Helkimo anamnestic index (Ai). Six months after the operation, 19.4% had moderate and 61.3% had mild clinical findings of TMD, as determined with the Helkimo clinical index (Di).

The results of this study are similar to those of Görgü et al¹, who concluded that trauma of the mandible was a major factor causing TMD after comparing patients with a non-condylar mandibular fracture to healthy adult patients. On the contrary, Al-Hashmi et al¹⁸ did not find any clinically significant TMD in patients with a mandibular fracture. However, they did suggest that

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

assault and bilateral mandibular fractures might be important risk factors in TMD development.

Similarly, the present study also found that TMD symptoms were associated with assault (trauma mechanism). Several other associations were also made with TMD symptoms, including male gender, and angle of the mandible (site of the fracture). However, it should be noted that all patients were male, and most had an angle fracture. Male gender is typically predominant among trauma patients¹⁹. Tabrizi et al⁵ compared the frequencies of TMD in different types of mandibular fractures, and concluded that patients with a condylar fracture and a contralateral angle/body fracture were more likely to develop TMD than those with a unilateral fracture. These authors suggest that a transmitted force from the contralateral side of the mandible, such as angle or body, is the most common mechanism for TMJ damage. Hence, if the force is strong enough to cause a fracture of the angle or the body, it can also be transmitted to the TMJ with or without a condylar fracture.

Malocclusion has also been considered a causative factor for TMD¹¹. In this study however, there was no clear association between post-operative malocclusion and TMD symptoms. Only one patient who developed TMD symptoms during the study period had mild occlusal disharmony post-operatively, and was treated with occlusal equilibration. That patient was referred to a specialist for occlusal splint therapy after six months. Thus, the main causative factor for TMD would therefore be the trauma itself.

The modern classification of TMD differs from the Helkimo index that was used in the present study. Although the Helkimo index is not suitable for modern diagnostic criteria, it has

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

nevertheless been widely used for research purposes. The main limitation of the Helkimo index is that it does not differentiate between joint and muscle-related symptoms. In addition, it does not account for intensity or frequency of the symptoms. When used alone, neither the clinical index D_i nor the anamnestic index A_i are sufficient, considering the modern definition of TMD.

Nevertheless, when combined, these two indices offer useful information for research purposes.

Hence, the patients with dysfunction can be recognized and referred **to a specialist dentist for stomatognathic examination and treatment, which often includes physiotherapy and occlusal splint therapy.**

It is important to note that the occurrence of TMD among adults varies among different studies according to the definition and criteria of TMD, as well as the age and gender of the patients screened^{20,21}. Similar to this study, the prevalence of clinical findings of TMD is often higher than the symptoms²⁰. Therefore, the majority of patients are symptom-free even though some clinical findings of dysfunction are present, suggesting that all patients recovered relatively well. The indication for treatment is based on the symptoms, which tend to vary over time and are multifactorial²². Thus, a longer follow-up period could offer more definitive conclusions. The signs and symptoms of TMD do not often interfere with the patients' quality of life, but for some patients, TMD can be severe. **Nevertheless, Kaukola et al.²³ have concluded that the overall health related quality of life (HRQoL) in patients with an operated mandibular fracture is significantly lower shortly after the operation, but improves until normal levels in three months.**

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

Earlier studies have shown that TMD is common in patients with a fracture of the zygomatic complex²⁴. Overall, the possibility of TMD after an operated facial trauma should be addressed, and the need for treatment should be evaluated.

CONCLUSION

This study concludes that postoperative TMD is a relatively common disorder in patients with non-condylar fractures of the mandible. It is hence advised that the clinician should be aware of possible TMD when treating patients with facial trauma. Patients with TMD should be referred to a specialist for evaluation and treatment.

TABLES

Table 1. Anamnestic Index (A_i)

Symptom-free	A _{i0}	Patients reported no symptoms of the masticatory system.
Mild symptoms	A _{iI}	Patients reported one or more of the following mild symptoms: temporomandibular joint sounds, jaw fatigue, stiffness of the jaws upon awakening or when moving the lower jaw.
Severe symptoms	A _{iII}	Patients reported one or more of the following severe symptoms: difficulty opening the mouth wide, jaw locking, luxations, pain when moving the mandible, pain in the region of the temporomandibular joint or the masticatory musculature.

Table 2. Clinical Index (D_i)

A Impaired range of movement, mobility index*:	
Normal range of movement	0
Slightly impaired mobility	1

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

Severely impaired mobility	5
B Impaired temporomandibular joint (TMJ) function	
Smooth movement without TMJ sounds or deviations upon opening and closing of the mouth	0
TMJ sounds in one or both joints and/or deviations ≥ 2 mm	1
Locking and/or luxations of the TMJ	5
C Muscle pain	
No tenderness on palpation	0
Tenderness upon palpation in 1-3 palpation sites	1
Tenderness upon palpation in 4 or more palpation sites	5
D Temporomandibular joint (TMJ) pain	
No tenderness upon palpation	0
Tenderness upon lateral palpation	1
Tenderness upon posterior palpation	5
E Pain upon movement of the mandible	
No pain upon movement	0
Pain in 1 movement	1
Pain in 2 or more movements	5
F Sum A+B+C+D+E Dysfunction score	0-25
G Dysfunction group 0-5	0-5
H Clinical index D_i according to the code	
The Code:	
0 points	Dysfunction group 0 clinically symptom-free D_i0
1-4 points	1 mild findings D_iI
5-9 points	2 moderate findings D_iII
10-13 points	3 severe findings D_iIII
15-17 points	4 severe findings D_iIII
20-25 points	5 severe findings D_iIII

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

* For more details, see Helkimo¹⁷.

Table 3. Characteristics of the 31 patients with an operated non-condylar mandibular fracture

Predictor	Average	Range
Age (years)	26.2	18–47
	Number of patients	Percentage of all patients %
Gender		
men	31	100
women	0	0
Cause of injury		
assault	26	85
falling	2	6
sport	1	3
traffic	1	3
other	1	3
Fracture site		
angulus	13	42
angulus + symphysis/parasymphysis	9	30
angulus + corpus	2	6
corpus	1	3
symphysis/parasymphysis	6	19
Malocclusion after operation	6	19

Table 4. Subjective symptoms (A_i) and objective clinical findings (D_i) of dysfunction in 31 patients six months after the surgery of a non-condylar mandibular fracture

Anamnestic index (A _i)	Number of patients	% of all
A _i 0 no symptoms	27	87

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

A _i I-A _i III	symptoms present	4	12.9
A _i I	mild symptoms	0	0
A _i III	severe symptoms	4	12.9
Clinical index (D_i)			
D _i 0	no clinical findings	6	19.4
D _i I-D _i III	clinical findings present	25	80.6
D _i I	mild clinical findings	19	61.3
D _i II	moderate clinical findings	6	19.4
D _i III	severe clinical findings	0	0

Table 5. Association between subjective symptoms (A_i) and objective clinical findings (D_i) six months after surgery

Clinical findings	All patients with clinical findings (n=25)	Patients with TMD symptoms (n=4)
Impaired range of movement	10	1
Impaired TMJ function	17	4
Muscle pain	9	3
TMJ pain	7	3
Pain on movement	2	1

Table 6. Association between subjective symptoms (A_i), objective clinical findings (D_i), age, gender, cause of injury, fracture site, and malocclusion after operation

Predictor	A _i I-A _i III (symptoms present)	A _i 0 (no symptoms)	D _i I-D _i III (clinical findings present)	D _i 0 (no clinical findings)
Age (years)				

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

	range	18–36	18–47	18–47	19–40				
	mean	24.0	26.5	25.8	27.7				
		Number of patients	% of 4	Number of patients	% of 27	Number of patients	% of 25	Number of patients	% of 6
Gender									
male (n=31)		4	100	27	100	25	100	6	100
Cause of injury									
assault (n=26)		4	100	22	81.4	20	80.0	6	100
falling (n=2)		0	0	2	7.4	2	8.0	0	0
traffic (n=1)		0	0	1	3.7	1	4.0	0	0
sport (n=1)		0	0	1	3.7	1	4.0	0	0
other (n=1)		0	0	1	3.7	1	4.0	0	0
Fracture site									
angulus (n=13)		4	100	9	33.3	12	48.0	1	16.7
angulus + corpus (n=2)		0	0	2	7.4	2	8.0	0	0
angulus + symphysis/parasymphysis (n=9)		0	0	9	33.3	6	24.0	3	50.0
corpus (n=1)		0	0	1	3.7	1	4.0	0	0
symphysis/parasymphysis (n=6)		0	0	6	19.4	4	16.0	2	33.3
Malocclusion after operation		1	25	5	18.5	5	20.0	1	16.7

REFERENCES:

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

1. Gorgu M, Deren O, Sakman B, Ciliz D, Erdogan B. Prospective comparative study of the range of movement of temporomandibular joints after mandibular fractures: Rigid or non-rigid fixation.

Scand J Plast Reconstr Surg Hand Surg. 2002;36(6):356-361.

2. Nabil Y. Evaluation of the effect of different mandibular fractures on the temporomandibular joint using magnetic resonance imaging: Five years of follow-up. *Int J Oral Maxillofac Surg.*

2016;45(11):1495-1499.

3. Plesh O, Gansky SA, Curtis DA, Pogrel MA. The relationship between chronic facial pain and a history of trauma and surgery. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 1999;88(1):16-

21.

4. Yun PY, Kim YK. The role of facial trauma as a possible etiologic factor in temporomandibular joint disorder. *J Oral Maxillofac Surg.* 2005;63(11):1576-1583.

5. Tabrizi R, Bahramnejad E, Mohaghegh M, Alipour S. Is the frequency of temporomandibular dysfunction different in various mandibular fractures? *J Oral Maxillofac Surg.* 2014;72(4):755-761.

6. Pullinger AG, Seligman DA. Trauma history in diagnostic groups of temporomandibular disorders. *Oral Surg Oral Med Oral Pathol.* 1991;71(5):529-534.

7. Goss AN, Bosanquet AG. The arthroscopic appearance of acute temporomandibular joint trauma. *J Oral Maxillofac Surg.* 1990;48(8):780-3; discussion 784.

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, *Journal of Oral and Maxillofacial Surgery*, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

8. Gerhard S, Ennemoser T, Rudisch A, Emshoff R. Condylar injury: Magnetic resonance imaging findings of temporomandibular joint soft-tissue changes. *Int J Oral Maxillofac Surg*.

2007;36(3):214-218.

9. Nickel JC, Iwasaki LR, Feely DE, Stormberg KD, Beatty MW. The effect of disc thickness and trauma on disc surface friction in the porcine temporomandibular joint. *Arch Oral Biol*.

2001;46(2):155-162.

10. Hettinga DL. I. normal joint structures and their reaction to injury*. *J Orthop Sports Phys Ther*.

1979;1(1):16-22.

11. Barrera-Mora JM, Espinar Escalona E, Abalos Labruzzi C, et al. The relationship between malocclusion, benign joint hypermobility syndrome, condylar position and TMD symptoms. *Cranio*.

2012;30(2):121-130.

12. Kim SY, Choi YH, Kim YK. Postoperative malocclusion after maxillofacial fracture management: A retrospective case study. *Maxillofac Plast Reconstr Surg*. 2018;40(1):27.

13. Dwivedi AN, Tripathi R, Gupta PK, Tripathi S, Garg S. Magnetic resonance imaging evaluation of temporomandibular joint and associated soft tissue changes following acute condylar injury. *J Oral*

Maxillofac Surg. 2012;70(12):2829-2834.

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

14. Suhas S, Ramdas S, Lingam PP, Naveen Kumar HR, Sasidharan A, Aadithya R. Assessment of temporomandibular joint dysfunction in condylar fracture of the mandible using the helkimo index. *Indian J Plast Surg.* 2017;50(2):207-212.

15. Zachariades N, Mezitis M, Mourouzis C, Papadakis D, Spanou A. Fractures of the mandibular condyle: A review of 466 cases. literature review, reflections on treatment and proposals. *J Craniomaxillofac Surg.* 2006;34(7):421-432.

16. Champy M, Lodde JP. Mandibular synthesis. placement of the synthesis as a function of mandibular stress. *Rev Stomatol Chir Maxillofac.* 1976;77(8):971-976.

17. Helkimo M. Studies on function and dysfunction of the masticatory system. II. index for anamnestic and clinical dysfunction and occlusal state. *Sven Tandlak Tidskr.* 1974;67(2):101-121.

18. Al-Hashmi A, Al-Azri A, Al-Ismaily M, Goss AN. Temporomandibular disorders in patients with mandibular fractures: A preliminary comparative case-control study between south australia and oman. *Int J Oral Maxillofac Surg.* 2011;40(12):1369-1372.

19. Pita Neto IC, Franco JMPL, Junior JLA, et al. Factors associated with the complexity of facial trauma. *J Craniofac Surg.* 2018;29(6):e562-e566.

20. Al-Jundi MA, John MT, Setz JM, Szentpetery A, Kuss O. Meta-analysis of treatment need for temporomandibular disorders in adult nonpatients. *J Orofac Pain.* 2008;22(2):97-107.

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, *Journal of Oral and Maxillofacial Surgery*, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

21. Rutkiewicz T, Kononen M, Suominen-Taipale L, Nordblad A, Alanen P. Occurrence of clinical signs of temporomandibular disorders in adult finns. *J Orofac Pain*. 2006;20(3):208-217.

22. Schiffman E, Ohrbach R, Truelove E, et al. Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: Recommendations of the international RDC/TMD consortium network* and orofacial pain special interest group†. *J Oral Facial Pain Headache*. 2014;28(1):6-27.

23. Kaukola L, Snall J, Lindqvist C, et al. Health-related quality of life after surgical treatment of mandibular fracture. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2015;119(4):402-407.

24. Rajantie H, Snall J, Thoren H. Postoperative temporomandibular dysfunction in patients with fractures of the zygomatic complex: A prospective follow-up study. *Br J Oral Maxillofac Surg*. 2018;56(7):573-577.

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

TABLES

Table 1. Anamnestic Index (A_i)

Symptom-free	A _{i0}	Patients reported no symptoms of the masticatory system.
Mild symptoms	A _{iI}	Patients reported one or more of the following mild symptoms: temporomandibular joint sounds, jaw fatigue, stiffness of the jaws upon awakening or when moving the lower jaw.
Severe symptoms	A _{iII}	Patients reported one or more of the following severe symptoms: difficulty opening the mouth wide, jaw locking, luxations, pain when moving the mandible, pain in the region of the temporomandibular joint or the masticatory musculature.

Table 2. Clinical Index (D_i)

A Impaired range of movement, mobility index*:	
Normal range of movement	0
Slightly impaired mobility	1
Severely impaired mobility	5
B Impaired temporomandibular joint (TMJ) function	
Smooth movement without TMJ sounds or deviations upon opening and closing of the mouth	0
TMJ sounds in one or both joints and/or deviations ≥ 2 mm	1
Locking and/or luxations of the TMJ	5
C Muscle pain	
No tenderness on palpation	0
Tenderness upon palpation in 1-3 palpation sites	1
Tenderness upon palpation in 4 or more palpation sites	5
D Temporomandibular joint (TMJ) pain	
No tenderness upon palpation	0
Tenderness upon lateral palpation	1
Tenderness upon posterior palpation	5

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

E	Pain upon movement of the mandible	
	No pain upon movement	0
	Pain in 1 movement	1
	Pain in 2 or more movements	5
F	Sum A+B+C+D+E Dysfunction score	0-25
G	Dysfunction group 0-5	0-5
H	Clinical index D_i according to the code	D_i I-III

The Code:

0 points	Dysfunction group 0	clinically symptom-free	D _i 0
1-4 points	1	mild findings	D _i I
5-9 points	2	moderate findings	D _i II
10-13 points	3	severe findings	D _i III
15-17 points	4	severe findings	D _i III
20-26 points	5	severe findings	D _i III

* For more details, see Helkimo¹⁷.

Table 3. Characteristics of the 31 patients with an operated non-condylar mandibular fracture

Predictor	Average	Range
Age (years)	26.2	18–47
	Number of patients	Percentage of all patients %
Gender		
men	31	100
women	0	0
Cause of injury		
assault	26	85
falling	2	6
sport	1	3
traffic	1	3

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

other	1	3
<hr/>		
Fracture site		
angulus	13	42
angulus + symphysis/parasymphysis	9	30
angulus + corpus	2	6
corpus	1	3
symphysis/parasymphysis	6	19
<hr/>		
Malocclusion after operation	6	19
<hr/>		

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

Table 4. Subjective symptoms (A_i) and objective clinical findings (D_i) of dysfunction in 31 patients six months after the surgery of a non-condylar mandibular fracture

Anamnestic index (A_i)		Number of patients	% of all
A _i 0	no symptoms	27	87
A _i I-A _i III	symptoms present	4	12.9
A _i I	mild symptoms	0	0
A _i II	severe symptoms	4	12.9
Clinical index (D_i)			
D _i 0	no clinical findings	6	19.4
D _i I-D _i III	clinical findings present	25	80.6
D _i I	mild clinical findings	19	61.3
D _i II	moderate clinical findings	6	19.4
D _i III	severe clinical findings	0	0

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

Table 5. Association between subjective symptoms (A_i) and objective clinical findings (D_i) six months after surgery

Clinical findings	All patients with clinical findings (n=25)	Patients with TMD symptoms (n=4)
Impaired range of movement	10	1
Impaired TMJ function	17	4
Muscle pain	9	3
TMJ pain	7	3
Pain on movement	2	1

This is final draft/author's accepted manuscript.

Original publication: Hanna Rajantie, Johanna Snäll, Hanna Thorén, Temporomandibular Dysfunction After Surgery of Mandibular Fractures Not Involving the Mandibular Condyle: A Prospective Follow-Up Study, Journal of Oral and Maxillofacial Surgery, Volume 77, Issue 8, 2019, Pages 1657-1662, ISSN 0278-2391,

<https://doi.org/10.1016/j.joms.2019.03.034>

(<http://www.sciencedirect.com/science/article/pii/S027823911930360X>)

License: CC BY-NC-ND

Table 6. Association between subjective symptoms (A_i), objective clinical findings (D_i), age, gender, cause of injury, fracture site, and malocclusion after operation

Predictor	A _i I-A _i III (symptoms present)		A _i 0 (no symptoms)		D _i I-D _i III (clinical findings present)		D _i 0 (no clinical findings)	
Age (years)								
range	18–36		18–47		18–47		19–40	
mean	24.0		26.5		25.8		27.7	
	Number of patients	% of 4	Number of patients	% of 27	Number of patients	% of 25	Number of patients	% of 6
Gender								
male (n=31)	4	100	27	100	25	100	6	100
Cause of injury								
assault (n=26)	4	100	22	81.4	20	80.0	6	100
falling (n=2)	0	0	2	7.4	2	8.0	0	0
traffic (n=1)	0	0	1	3.7	1	4.0	0	0
sport (n=1)	0	0	1	3.7	1	4.0	0	0
other (n=1)	0	0	1	3.7	1	4.0	0	0
Fracture site								
angulus (n=13)	4	100	9	33.3	12	48.0	1	16.7
angulus + corpus (n=2)	0	0	2	7.4	2	8.0	0	0
angulus + symphysis/parasymphysis (n=9)	0	0	9	33.3	6	24.0	3	50.0
corpus (n=1)	0	0	1	3.7	1	4.0	0	0
symphysis/parasymphysis (n=6)	0	0	6	19.4	4	16.0	2	33.3
Malocclusion after operation								
	1	25	5	18.5	5	20.0	1	16.7