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A Prospective Follow-Up Research Assessing and Evaluating Temporomandibular Joint Dysfunction in Postoperative Patients with Zygomatic Complex Fractures

Aananya Mishra[1], Dharnappa Poojary[*2], Mohan Baliga[3], Ananya Jha[4], Srikant N[5]

[1]Postgraduate student, Department of Oral and Maxillofacial Surgery, Manipal college of Dental Sciences Mangalore, Manipal Academy of Higher Education, Manipal, Karnataka, India-576104
[2]Professor, Department of Oral and Maxillofacial Surgery, Manipal college of Dental Sciences Mangalore, Manipal Academy of Higher Education, Manipal, Karnataka, India-576104
[3]Professor, Department of Oral and Maxillofacial Surgery, Manipal college of Dental Sciences Mangalore, Manipal Academy of Higher Education, Manipal, Karnataka, India-576104
[4]Intern, Manipal college of Dental Sciences Mangalore, Manipal Academy of Higher Education, Manipal, Karnataka, India-576104
[5]Professor and Head, Department of Oral Pathology and Microbiology, Manipal college of Dental Sciences Mangalore, Manipal Academy of Higher Education, Manipal, Karnataka, India-576104

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KEYWORDS
mid-face fracture; surgery; temporomandibular Joint dysfunction; trauma; zygomaticomaxillary complex fracture.

Abstract:

Background: The zygomaticomaxillary complex (ZMC) fracture is the second most prevalent fracture of the mid-face skeleton owing to its craniofacial growth, surface texture, and proximity to the maxillary sinus; therefore, any trauma to that region leads to indirect injury to the temporomandibular joint (TMJ) region, leading to TMJ dysfunction that generally goes unnoticeable.

Aims and objectives: In this study, our goal was to identify the prevalence and features of TMJ dysfunction in patients treated surgically for ZMC fractures.

Methodology: A prospective follow-up study on 60 patients with ZMC fractures was performed, who were managed surgically and clinically examined 6 months post-operatively using the Helkimo index and its sub-indices.

Results: Results showed a majority with no subjective symptoms (50/60), but around 44 patients had mild to moderate dysfunction of the TMJ, whereas none had severe clinical signs. There was a moderately positive correlation between the three indices of the Helkimo index. No significant association was found between the demographic variables and clinical findings of temporomandibular disorders (TMD).

Conclusion: To conclude, following a ZMC fracture, physicians should be especially watchful for minor TMJ dysfunction. TMJ function should be assessed throughout the follow-up phase, and if required, referrals for TMD treatment should be made.

1. INTRODUCTION: Any trauma to the ZMC region often goes unnoticed after an injury owing to the presence of oedema and ecchymosis of the surrounding tissues. Moreover, the zygoma bone lies in close proximity to the head of the mandible and TMJ; therefore, any trauma to the ZMC region leads to dysfunction of the TMJ [1].

Zygoma is a major buttress of the facial skeleton that is frequently injured because of its prominent location, weak connections with its adjacent bones, craniofacial

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growth, its surface texture, and proximity to the maxillary sinus. As a result, the malar eminence is classically depressed inward by the kinetic energy applied through injury and downward by the pull of the muscles.

The ZMC fracture, also known as a tetrapod fracture or tri-malar fracture, comprises four processes: temporal, orbital, frontal, and maxillary, and any breakdown in its continuity or displacement of this bone leads to disruption to any of these suture lines and causes fractures of that region along with its articulating surfaces [2]. The zygomatic arch commonly fractures at its weakest point, i.e., 1.5 cm behind the zygomaticotemporal suture.

The term dysfunction refers to any impairment or deformity of a body structure or organ. Ever since 1978, there has been a significant change in the understanding of the aetiologic features, pathophysiology, diagnosis, and management of temporomandibular disorders (TMDs). TMDs are defined as a part of craniofacial disorders that involve the TMJ, muscles of mastication, and accompanying musculoskeletal structures [3]. Even though TMJ dysfunction is not a life-threatening condition, it affects the quality of life of the individual. TMDs are multifactorial. Stressful incidents and anxiety have been recognized as imperative causes of the muscular form of TMD.

Trauma is considered an essential factor associated with intraarticular TMD, considering both the aetiology of the disorder and its responsiveness to nonsurgical management [4]. Also, one of the most important causes of TMJ dysfunction is ZMC fractures. Following facial trauma, temporomandibular joint disorders are generally quite common, and the timing of treatment is crucial for their correction. [5]. Presently, TMD is regarded as a multifactorial complex model due to its somatic and biopsychosocial features. [6]. TMJ dysfunction can present as tenderness over the TMJ area, clicking sounds present during jaw movements, and restricted mouth opening. The intensity of TMD ranges from mildly conspicuous but not clinically relevant signs to sometimes very severe incapacitating pain or dysfunction. [2] More often than not, local conditions affecting the maxillofacial region—such as infections, oral surgeries, and trauma—cause restricted mobility of the TMJ. Although issues intrinsic to the TMJ, such as ankylosis, may also arise, the primary cause of the TMJ's partial or complete incapacity to open is spasm of the masticatory muscles. Regardless of their cause, facial fractures frequently result in limited normal mouth opening because they inflame the masticatory muscles, which are directly linked to the mandible, maxilla, and zygomatic bones. These muscles include the masseter, temporalis, lateral pterygoid, and medial pterygoid.

Any damage to the maxillofacial region tends to impair the integrated functions of the jaw and the structures that surround it, emphasizing the jaw's functional relationship to the head-neck motor system. [1]. The most common indications for the surgical treatment of ZMC fractures comprise aesthetic or functional disturbances [1]. The surgery for ZMC fractures has progressed from the use of steel threads in 1970 to more advanced rigid internal fixation devices (RIF) in recent times [2]. Despite effective surgical reduction and osteosynthesis, at times, momentary or often long-lasting TMJ dysfunction might occur in a few patients [1].

The purpose of our study was to define the incidence and characteristics of TMJ dysfunction in patients who underwent surgery for ZMC fractures.

2. MATERIALS AND METHODS: The prospective follow-up study was performed at the Department of Oral and Maxillofacial Surgery, Manipal College of Dental Sciences, Mangalore, after obtaining the consent guidelines and ethical committee approval. Prior to their inclusion in the study, every patient provided their informed consent. Patients with ZMC fractures for open reduction and internal fixation (ORIF) according to their indication who were judged fit for surgical procedures were included in this study based on particular exclusion and inclusion criteria. Patients with surgically treated zygomatic complex fractures who were recruited for a clinical follow-up and subjects who understood the study's purpose and were likely to comply were the inclusion criteria. Subjects with infected fractures, facial fractures other than the zygomatic complex, individuals with a past history of TMJ dysfunction symptoms, condylar fractures, and/or having psychiatric or physiological problems were excluded from this study.

Preoperative assessment: A detailed clinical evaluation of each patient was carried out to assess the presenting clinical conditions and those that required definitive surgical intervention.

The clinical examination included the following:

1) Evaluation of tenderness in relation to joints, muscles of mastication, and movement of the jaw;

2) Evaluation for abnormal joint sounds in relation to the jaw movements (auscultated by using a stethoscope);

3) Evaluation of movements of the mandible: protrusion, retrusion, lateral excursive, and deviation;

4) Evaluation of occlusion.

The demographic variables and cause of injury were recorded, and an assessment of the fracture of the coronoid process was carried out. The fracture of the coronoid process was assessed radiographically.

Surgical management: All patients were treated within 48 hours of trauma, and there was no delay in treatment. Patients were treated using Gillies' approach for reduction with a minimum of 3-point fixation (depending

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upon the type of fracture) using 1.5mm titanium 4-hole plate (orbital plate in the infraorbital margin and L-plate in the buttress region) and 6mm screws.

Postoperative assessment: A detailed postoperative assessment after 6 months was done using the Helkimo index. [7]

The sample size of this study was calculated by the following:

$N = (Z\ \alpha /2\ d)\ 2p\ (1-p)$

(N = number of samples; Z = Z score; α/2= error D= the minimum difference in the values that will be clinically relevant).

According to Rajantie H. et al.'s (2018) article [1], the appropriate z value is Z= -1.95996398454005, and the proportion used to measure the parameter subjective symptoms is 13.333% with an alpha of 5%. By applying the aforementioned calculation, which sets 9% as the minimal percentage change to be considered critically significant, the study would need a sample size of 55.

The analysis of all the data was done with SPSS 17.0. Every tabulated result was assessed, and Pearson's chi-squared test and the independent t-test were used for statistical analysis.

EVALUATION OF TMJ FUNCTION: Six months after surgery, the masticatory system's performance was assessed using a questionnaire and a clinical examination of the masticatory system. The Helkimo index was used to determine the incidence and severity of dysfunction. There are three components of the Helkimo index: occlusal indices, clinical dysfunction (Di), and subjective (anamnestic/Ai). For new cases, the subjective symptoms (Ai) were measured six months after surgery using a questionnaire.

The patients' traumatised presentation made it impractical to record the clinical findings (Di) prior to surgery; instead, they were noted during the sixth month of follow-up. Questionnaire: Patients were evaluated on the following questions:

1.Does your TMJ make noise? Certainly or no

2. Do you experience jaw stiffness when you wake up or move your mandible? Certainly or no

3. Do you feel worn out around your jaw? In agreement or disagreement

4. Do you find it difficult to open your jaw? Certainly or no

5. When you open your mouth, is your mandible locked? Certainly or no

6. Do you experience pain in your masticatory muscles or in your TMJ? Certainly or no

7. Do you experience pain when moving your jaw? Certainly or no

8. Do you suffer from mandibular luxation? Certainly or no

Following a clinical examination, only results that could be clinically verified were noted and added to the index. Patients' subjective symptoms were measured using a yes-or-no questionnaire and the anamnestic index (Ai). The following was the anamnestic index patient assessment scale:

Ai0: no symptoms are evident;

Ai I - one or more mild symptoms (e.g., jaw fatigue, TMJ sounds, jaw stiffness during waking hours or during mandibular movement);

Ai II – the presence of one or more severe symptoms (like locking, luxation, restriction in mouth opening, pain on mandible movement, tenderness in the TMJ region, or masticatory muscles).

After the subjective symptoms were identified, the clinical evaluation was conducted in compliance with the Helkimo clinical dysfunction index (Di), which takes into account the presence or absence of the following signs: pain with movement of the mandible, impaired range of motion, muscle pain, and impaired TMJ function. Individuals received zero points for not having any symptoms, one point for moderate pain or dysfunction, and five points for severe pain or dysfunction.

To assess the severity of symptoms, each patient's score was added together and used as follows (for Di codes):

Di 0 (0 points): no signs of a clinical nature; mild dysfunction is represented by Di I (1–4 points) and moderate dysfunction by Di II (5–9 points). Di III denotes acute or serious dysfunction (10–25 points).

In order to evaluate any occlusal disturbance present in patients, the occlusal index (Oi) was used, which included the following 4 criteria: number of teeth, number of occluding teeth, and articular and occlusal interferences. The patients were scored between 0-5 points and the total of the points given was then determined. The following was noted about the Oi: Oi 0 (0 points) denoted the absence of occlusal disturbance, while Oi I (1–4 points) suggested a moderate disturbance, and Oi II (5–20 points) indicated severe disturbance.

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Figure1: 3D CT scan & axial view showing left ZMC fracture

Figure 2: Post-operative inter-incisal mouth opening and

Post-operative auscultation for joint sounds

3. RESULTS: Inclusion criteria were met by 81 individuals who presented with zygomatic complex fractures. Of these, 14 participants were eliminated due to their nonattendance at the sixth-month follow-up appointment, and 7 were excluded because of a history of symptoms of TMJ dysfunction. Therefore, 60 patients were included in the final study. The study evaluated the incidence of TMJ dysfunction after surgical treatment of

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zygomatic complex fractures, the severity of TMJ dysfunction using the Helkimo index, and the correlation between subjective, clinical, and occlusal symptoms. Out of the total 60 patients who participated in the study, 51 were male and 9 were female, with an age group between 15 and 65 years. The results obtained were statistically analyzed using an independent t-test, Pearson's chi-squared test, and Spearman's correlation test.

The Helkimo indices in 60 patients postoperatively showed 50 patients symptom-free, 10 patients with subjective symptoms, and 9 patients presenting with severe symptoms at the time of examination. 44 patients had clinical findings of TMD, of which the majority, 37

patients, had mild clinical findings. A total of 23 patients had occlusal disturbances. On the other hand, no patient experienced occlusal disturbance or "severe" clinical dysfunction. The majority of the clinical findings of occlusal disturbance and dysfunction were mild.

Table 1 shows the correlation between clinical findings (Di) six months after surgery and symptoms of temporomandibular joint dysfunction (Ai). Every one of the ten patients with subjective symptoms also had dysfunctional clinical findings.

Subjective symptoms were absent in the majority of patients (34/44) with clinical findings of dysfunction.

- With a p value of 0.133, impaired range of motion is statistically not significant.
- Impaired TMJ function shows a highly significant difference with a p value of 0.001.
- Muscular pain shows a significant difference with a p value of 0.005.
- TMJ pain has a significant difference (p = 0.006).
- A comparison of the pain experienced during mandibular movement following surgery revealed statistically significant results, with a p-value of 0.001.

TABLE 1:-

CLINICAL FINDINGS (Di)			**SUBJECTIVE SYMPTOMS/ ANAMNESTIC INDEX (AI)**		**TOTAL**	**VALUE**	**df**	**P VALUE**
			ABSENT (n=50)	PRESENT (n=10)				
IMPAIRED RANGE OF MOVEMENT	Normal	count	35	4	39	4.028	2	0.133
		% within clinical signs	70.00%	40.00%	65.00%			
	Moderate	count	14	5	19			
		% within clinical signs	28.00%	50.00%	31.70%			
	Severe	count	1	1	2			
		% within clinical signs	2.00%	10.00%	3.30%			
IMPAIRED TMJ FUNCTION	Normal	count	30	0	30	15.31	2	**<0.001**
		% within clinical signs	60.00%	0.00%	50.00%			
	Moderate	count	20	9	29			
		% within clinical signs	40.00%	90.00%	48.30%			
	Severe	count	0	1	1			
		% within clinical signs	0.00%	10.00%	1.70%			
MUSCLE PAIN	Normal	count	37	3	40	10.462	2	**0.005**
		% within clinical signs	74.00%	30.00%	66.70%			
	Moderate	count	13	6	19			
		% within clinical signs	26.00%	60.00%	31.70%			
	Severe	count	0	1	1			
		% within clinical	0.00%	10.00%	1.70%			

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		signs						
TMJ PAIN	Normal	count	23	0	23			
		% within clinical signs	46.00%	0.00%	38.30%			
	Moderate	count	27	10	37			
		% within clinical signs	54.00%	100.00%	61.70%	7.459	1	**0.006**
PAIN ON MOVEMENT OF MANDIBLE	Normal	count	49	7	56			
		% within clinical signs	98.00%	70.00%	93.30%			
	Moderate	count	1	3	4			
		% within clinical signs	2.00%	30.00%	6.70%	10.5	1	**0.001**

The association between the dysfunction index and the anamnestic index was done using the Pearson chi square test.

• In anamnestic index (Ai 0), out of 50 patients, 16 had no clinical signs of dysfunction (32%), 32 had mild symptoms (64%), and 2 had moderate symptoms (4%);

• In anamnestic index (Ai I-II), out of 10 patients, 5 had mild symptoms (50%) and 5 had moderate symptoms (50%), which is highly significant with a p value of <0.001.

Table 2 shows the relationship between the occlusal index (Oi) six months after surgery and symptoms of temporomandibular joint dysfunction (Ai). Out of 10 patients who had subjective symptoms, nine had mild occlusal disturbance. Most of the patients with occlusal disturbances (14/23) did not have subjective symptoms. A p value of 0.45 indicates that the number of teeth is statistically non-significant. The number of occluding teeth shows a significant difference with a p value of 0.002. Occlusal and articular interferences show a highly significant difference with a p value < 0.001.

TABLE 2:-

OCCLUSAL FINDINGS(Oi)			**SUBJECTIVE SYMPTOMS (ANAMNESTIC)**		**Total**	**Value**	**df**	**P value**
			ABSENT	PRESENT				
NUMBER OF TEETH	28-32	count	36	6	42	0.571	1	0.45
		% within clinical signs	72.00%	60.00%	70.00%			
	20-27	count	14	4	18			
		% within clinical signs	28.00%	40.00%	30.00%			
NUMBER OF OCCLUDING TEETH	24-32	count	36	2	38	9.703	1	**0.002**
		% within clinical signs	72.00%	20.00%	63.30%			
	16-23	count	14	8	22			
		% within clinical signs	28.00%	80.00%	36.70%			
OCCLUSAL INTERFERENCES	no interference	count	50	6	56	21.429	1	**<0.001**
		% within clinical signs	100.00%	60.00%	93.30%			
	mild interference	count	0	4	4			
		% within clinical signs	0.00%	40.00%	6.70%			
ARTICULATION	no interference	count	50	6	56	21.429	1	**<0.001**

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INTERFERENCES		% within clinical signs	100.00%	60.00%	93.30%			
	mild interference	count	0	4	4			
		% within clinical signs	0.00%	40.00%	6.70%			

Table 3 shows the correlation between the anamnestic index, dysfunctional index, and occlusal index.

• A moderate positive correlation between all indices is seen with a rho value >0.5; • TMD symptoms were statistically and favourably correlated with occlusal factors ($r = 0.571$, $p < 0.001$).

TABLE 3:-

			ANAMNESTIC INDEX	**DYSFUNCTIONAL INDEX**
Spearman's rho	**DYSFUNCTIONAL INDEX**	Correlation Coefficient	.535	
		Sig. (2-tailed)	**<0.001**	
		N	60	
	OCCLUSAL INDEX	Correlation Coefficient	.510	.571
		Sig. (2-tailed)	**<0.001**	**<0.001**
		N	60	60

4. DISCUSSION: The purpose of this research was to observe the prevalence of TMJ disorder in surgically treated ZMC fracture patients. There were no signs of TMJ dysfunction in the majority of the patients. Around 10 patients had symptoms, out of which nine had severe symptoms six months postoperatively. A total of 44 patients had clinical signs of dysfunction, but the majority had mild clinical findings. On evaluation of TMJ dysfunction by using the Helkimo index, it was concluded that no patients had severe dysfunction or occlusal disturbance, which supports the view that most of the ZMC fracture patients fully recover. There was a moderate correlation present between all three indices of the Helkimo index.

The Helkimo's Anamnestic Index is a measure of the general perception of symptoms of TMD by the patient. In this study, at least one symptom was identified by 16.67% of patients, while 73 percent were afflicted with TMD. To be specific, 56.33% of patients were unaware of their TMJ dysfunction. This outcome coincides with that observed in other research work. According to Loster et al. [8], only 7.7% of the 26.5 percent of young adults with TMDs were aware of the symptoms and signs of the illness. 69% of Turkish citizens were unaware that they had a TMJ disorder, according to Nekora et al. [9]. In the current research, the explanation for why large numbers of TMD patients are asymptomatic could be due to the absence of serious TMJ dysfunction. As most of the mild cases are often self-limiting, patients will not get medical treatment.

In the 6-month follow-up, among the trauma patients, a low level of response has been commonly observed, which reflects the fact that the patients are negligent towards their health [10]. There is a higher probability that patients with problems are more likely to participate in the research as opposed to their counterparts; hence, the result will be an overestimate in such cases.

The finding that TMJ dysfunction is prevalent after facial fractures is to be noted, but in our patients, severe dysfunction was relatively uncommon, and subjective symptoms outperformed asymptomatic clinical findings as treatment predictors. Nine patients had severe symptoms, but none had severe clinical dysfunction of the TMJ.

A similar study conducted by Rajantie H et al. [1] concluded that most of their patients had mild clinical findings 6 months postoperatively, which is almost similar to our study. In contrast to our study, they did not discover any meaningful association between the subjective symptoms and the clinical outcomes.

A study by Al-Hashmi et al. [4] supports the view that most injuries to the mandible are completely reversible. Here we want to highlight the point that surgeons are cognizant of the possibility of TMJ dysfunction after mandibular fractures, but equal importance to TMJ evaluation after ZMC fractures should be given.

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In a study by Ribeiro et al. [2], postoperatively, mouth opening returned to normal after a period of 1 month, and after the second month, standard bite force and EMG activity were achieved. The disadvantage was that the sample size was small compared to our study; they treated minimally displaced fractures with only intraoral plating, which was different in our scenario as our cases ranged from mild to severe degrees of trauma, and the treatment plan varied according to each case.

In the past, it was thought that occlusal factors were crucial to the genesis of TMD. Manfredini et al. [11] did discover a greater frequency of occlusal disturbances in TMD patients, indicating that some occlusal factors arbitrate TMD by loading the joint-muscle complex. Hence, the occlusal disturbance can be considered a risk factor, and a proper evaluation should be carried out. Though in other studies reported by Manfredini et al. [12], there was a negative association between dental occlusion and TMJ dysfunction. However, in our study, some of the patients had TMJ tenderness due to mild occlusal interferences, and once those factors were removed, the patient's condition improved.

Previously, it was believed that women in the age group of 25–45 years were more affected than the male population, but recently, a lot of studies have been conducted in the US and Europe that show that TMDs are more prevalent in the age group of 45–60 years. In a review by Yadav S et al. [13], it was concluded that most older adults are affected by TMD, and in accordance with gender predilection, TMD is more frequent in females as compared to males. Also, it was observed that most of the patients had mild symptoms, which were usually self-limiting. In our study, we treated patients of all age groups, so it can be said that some of our patients had TMD due to the age-related changes of the TMJ.

A few of the parameters of a similar study by Mridula et al. in 2022 [14] on the severity of TMJ dysfunction in post-surgical treatment of unilateral ZMC fractures were similar to our study. These parameters involved clicking of the joint, pain on opening or closing, biting in the preauricular region, or any deviation of the mandible during mouth opening. However, the Friedman test and post-hoc analysis were applied to 29 patients, whereas our study implemented an independent t-test and Pearson's chi-squared test on 60 patients (a larger sample size). Also, we have used all 3 indices of the Helkimo index (anamnestic index, dysfunctional index, and occlusal index), which is different from the above-mentioned study.

Because of its simplicity, the Helkimo index has been used in our research [7], despite the fact that it has not been thoroughly validated and does not offer a diagnostic classification for TMDs. The fact that this index does not differentiate between TMD related to the joints and muscles is another drawback. Some features, such as joint sounds, are now considered innocuous but have been included in the index. The new evidence-based recommended diagnostic criteria for TMD (DC/TMD) are appropriate for use in clinical settings; however, not many studies have been conducted based on these criteria [15].

Although severe dysfunction was relatively uncommon in our patients, it is noteworthy that dysfunction of the TMJ is common following facial fractures and that subjective manifestations were a better predictor of treatment outcomes than asymptomatic clinical findings. Nine patients had severe symptoms, but none had severe clinical dysfunction of the TMJ. One of the limitations of this study is the short follow-up period following surgery, which is known to cause significant variations in the patients' symptoms over time. Henceforth, more similar studies with a longer follow-up period and a larger pool of patients are recommended in the future to yield more conclusive data.

5. SUMMARY AND CONCLUSION: Surgery of the zygomaticomaxillary complex fractures continues to play a small but nonetheless important role in the evaluation of TMD. The ZMC fracture being the most prevalent fracture of the midface skeleton, trauma to this region leads to indirect injury to the TMJ, leading to its dysfunction that generally goes unnoticeable. Our study assessed the incidence and characteristics of TMD in ZMC fracture patients who were treated surgically and completed the 6-month follow-up period. The dysfunction of the TMJ was evaluated by the Helkimo index.

Based on statistical analysis, the majority of the patients had no subjective symptoms (50/60), but on clinical evaluation, around 44 patients had mild to moderate dysfunction of the TMJ, whereas no patients had severe clinical signs. There was a moderately positive correlation between the three indices of the Helkimo index. No significant association was found between the demographic variables and the clinical findings of TMD. To conclude, mild TMJ dysfunction is usually present after a fracture of the ZMC, so medical professionals should exercise greater caution, evaluate TMJ function during the follow-up phase, and refer patients for TMJ dysfunction treatment if needed.

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