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Comparative Study between Open and Closed Reduction in Management of Subcondylar and Ramus Mandibular Fractures

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Abstract

Background: **Condylar fracture management is often a matter of discussion and controversy among maxillofacial topics and constitutes 11-16% of all facial fractures and 30-40% of mandibular fractures.** ***objective:*** **To improve the outcome after subcondylar and ramus fractures management.** ***Patients and Methods:*** **This study was carried out as a randomized controlled trial. Patients are older than 12 years with subcondylar fractures and exclusion criteria of the previous history of temporo mandibular joint dysfunction, mandibular condylar head, and intracapsular fractures and delay presentation of the fracture after 3 weeks. The study was demonstrated as two groups: Group A =open reduction and internal fixation and group b =closed reduction. Post-intervention assessment was done.** ***Results:*** **We found that there was a statistically significant higher mean maximum interincisal opening among the open reduction group than closed reduction after 2 months of treatment (34.12 SD and 30.22) and 6 months (35.09 and 32.18). Also, there was statistically significantly lower mean lateral excursion among the closed reduction group than open reduction after 2 months of treatment (8.57 & 10.27) and similarly after 6 months (8.91 & 11.5).** ***Conclusion:*** **open reduction is superior to closed reduction in the management of cases of displaced and foreshortened subcondylar fractures.**

***Keywords*:** Open Reduction, Closed Reduction, Subcondylar, Ramus Mandibular Fractures

Introduction

The subcondylar area anatomically is the distal part of the condylar process, this area is superiorly confined to the line passing through the sigmoid notch and anteriorly to the line obliquely connecting the sigmoid notch to the masseter tuberosity. This area has important components such as the facial nerve and temporomandibular joint (TMJ) which gives it great clinical value. Both are prone to functional disability due to either the fracture itself, or the surgical intervention. Different stages of dislocation, displacement, comminution, and fracture line are dependent on the force magnitude, point of application and transmission, and the patient's mandibular position and occlusion, during the trauma[1]. Fractures of the subcondylar region constitute 11-16% of all facial fractures and 30-40% of mandibular fractures[2]. The

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vulnerability of the nearby temporomandibular joint (TMJ), difficult surgical access, and limited bone stock for osteosynthesis has made fractures of this region challenging to treat[3]. Proper treatment of the subcondylar fracture is essential for the maintenance of speech, eating, swallowing, and masticatory function[4]. There are various guidelines regarding the management of condylar fractures of the mandible by open or closed treatment of this type of fractures[5]. The selection of a treatment modality for subcondylar fracture depends on the displacement severity, fracture area, and other factors such as the patient's age and the coexistence of other fractures. The Closed Reduction approach consisted of Maxillomandibular Fixation with elastics for a period of 7 to 35 days (mean, 20 days). After this period of maxilla mandibular fixation (MMF), guiding elastics were used for a variable period in most cases, to maintain proper occlusion and to enable mouth opening at the same time[6]. Closed Reduction is considered a safe treatment as it does not damage the nerves and blood vessels and causes no postoperative complications or residual scars but the patient stay for a long time in Maxillomandibular Fixation affects tempro mandibular joint function and quality of life[7]. Open Reduction is performed through various surgical methods depending on the fracture site and several bone fragments. In open treatment, standardized surgical treatment grade uses retromandibular, anteroparotid approach for surgical access. The fractures are fixed with 2 mm titanium miniplates. maxillomandibular fixation with light elastics was kept for 3 to 5 days postoperatively[8]. This study is to determine which is better for patients with Fractures of the subcondylar region, the Open or the Closed Reduction of their Fractures by showing the clinical and radiological outcomes differences between closed reduction (CR) and open reduction and internal fixation (ORIF) in the management of subcondylar fractures for better outcomes for these patients especially as after open reduction the patient may suffer from visible scar, facial nerve affection and may need long operative time. The study aim is to improve the outcome after subcondylar and ramus fractures management.

Patients and Methods

This Randomized clinical trial was carried out on patients presenting to the Plastic Surgery unit (Suez Canal University Hospital) with unilateral mandibular subcondylar and ramus fractures through random selection. This study was conducted in Suez Canal University Hospital, Plastic Surgery unit for three years from 2018 to 2020. The study included patients older <12 years (as younger age growth plates can be affected) with subcondylar fractures (may be combined with other fractures). Patients with a previous history of temporomandibular joint dysfunction, Mandibular condylar head and intracapsular fractures, or delay presentation of the fracture after 3 weeks were excluded.

Study procedure

History taking and general examination

History of chronic illness e.g., diabetes, hypertension. And careful local examination combined with radiological assessment (evaluation of the following parameters: site of the fracture, degree of fracture displacement, occlusion, mouth opening, and shortening of ramus height detected by CT scan). Based on Towne's and panoramic raradiographs, the fractures are categorized into 3 classes: 1) Class 1 (minimally displaced)-fracture with ramal height shortening; 2 mm and/or degree of fracture dis-

placement; 10°. 2) Class 2 (moderately displaced)-fracture with ramal height shortening; 2 to 15 mm and/or degree of fracture displacement; 10 to 35°. 3) Class 3 (severely displaced)-fracture with ramal height shortening; 15 mm and/or degree of fracture displacement; 35°).

Pre-operative Preparations:
1) Routine laboratory investigations, 2) Panorama: the presence of fractures, 3) 3D CT. in combined fractures

Operative techniques
Closed reduction approach Intermaxillary fixation was performed using the arch bar and wire for 4 to 6 weeks. After stabilization of the fracture site, intermaxillary fixation was removed and normal occlusion is maintained using rubber bands and a soft diet for 2 weeks. when need functional therapy was performed simultaneously to restore the previous state of mandibular movement. The arch bar and wire were applied to adjust occlusion and were removed after 1 week. Other fractures like parasymphesis fractures were fixed first.

Post-operative care
Follow-up examinations through 6 months and measurement data recorded at 2 and 6 months. Results of the clinical and radiological examinations were recorded on a specific form.

Clinical parameters assessment

1. Range of motion of the injured joint with the contralateral joint as given by the mouth opening (maximum interincisal distance) and by the extent of lateral excursion and of protrusion.
2. Assessment of pain with a visual analog scale with values from 0 (no pain) to 100 (strongest pain or discomfort).
3. Occlusion: a. Identical to pretraumatic. b. Slight difference. c. Functional malocclusion. d. Requirement of occlusal adjustment. e. Gross malocclusions.
4. Motor nerve function *(House–Brackmann grading system)*: a. No deficit. b. Mild weakness. c. Moderate weakness. d. Severe weakness. e. Absence of function.
5. Sensory perception: a. Full sensation. b. Can distinguish cotton/wood/pin. c. Not full but not distracting. d. Can discern pressure. e. Profoundly numb.
6. Mandibular protrusion measurement.
7. Lateral excursion.
8. *Radiological Assessment*
9. Quantification of Degree of Displacement,
10. Quantification of Ramus Height Shortening and, Degree of healing
11. *Documentation*
12. Pre-operative & Post-operative photos of the fracture

Data analysis

Data were managed using Statistical Package of Social Sciences (SPSS) version 20.

Results

The present study was a randomized clinical trial carried out on patients with unilateral mandibular subcondylar and ramus fractures from the Plastic Surgery unit at Suez Canal University Hospital to compare the treatment results of Open Reduction and Rigid Internal Fixation (ORIF) versus CR and Maxillomandibular Fixation (CRMMF) for Subcondylar Fractures. Table (1) showed no statistically significant difference between studied groups regarding their socio-demographic characteristics with a mean age at injury for group with closed reduction was 33.18 vs. 31.27 years for open reduction. Among the studied groups, 72.7% and 81.8% of the group with closed and open reduction groups were males.

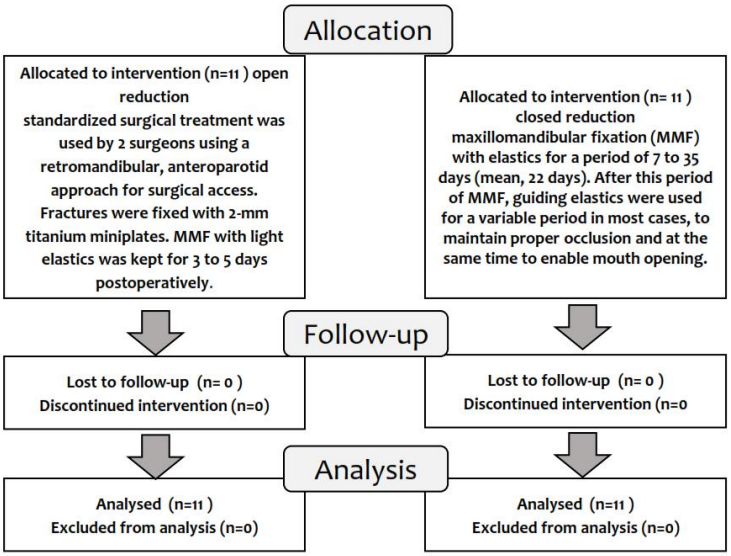

Figure 1: CONSORT flow chart showing study design among studied cases

Table 1: Sociodemographic characteristics of the studied groups

	Closed reduction n=11	Open reduction n=11	Test of Significance
Age at injury (yr)			t=0.86
Mean ± SD	33.18 ± 4.40	31.27 ± 5.90	p=0.40
Gender			
Male	8 (72.7)	9 (81.8)	FET
Female	3 (27.3)	2 (18.2)	P=1.0
Smoking			
Non-smoker	7 (63.6)	4 (36.4)	FET
Smoker	4 (36.4)	7 (63.6)	P=0.395
Chronic illness			
-ve	8 (72.7)	6 (54.5)	χ^2=0.786
+ve	3 (27.3)	5 (45.5)	p=0.375

Data are presented as no. (%), t: Student t-test, FET: Fischer exact test, χ^2=Chi-Square test

Among the groups treated with closed reduction; 36.4% were smokers, 27.3% had chronic disease and among groups treated with open reduction; 63.6% were smokers and 45.5% had chronic illness. Table (2) illustrates a statistically significantly higher average period of MMF among group with open reduction than group with closed reduction (22 versus 4.2 days). Among the groups with open reduction; 54.6% right sided , 81.8% class 1 fracture , 36.4 % of the fractures were due to motor vehicle and 27.3% class 2. Table (3) demonstrates a statistically significant higher mean maximum interincisal opening among open reduction group than closed reduction after 2 months of treatment (34.12 & 30.22) and similarly after 6 months (35.09 & 32.18). There was statistically significant lower mean intentional Lateral excursion among open reduction group than closed reduction after 2 months of treatment (8.57 & 10.27) and similarly after 6 months (8.91 & 11.5) (Table 3). Also, there was a statistically significant higher mean intentional protrusive movement among the closed reduction group than open reduction after 2 months of treatment (5.14 & 3.95) and similarly after 6 months (5.08 & 3.24), respectively.

Table 2: Characteristics of mandibular fracture among studied groups

	Closed reduction n=11 No. (%)	Open reduction n=11 No. (%)	test of significance
Average period of MMF (days), mean±SD	4.2±0.58	22±9.8	t=7.15 p<0.001*
Diagnosis			
Right	7(63.6)	6(54.6)	χ^2=0.188
Left	4(36.4)	5(45.4)	p=0.66
Class of fracture			
Class 1	0	9(81.8)	
Class 2	3(27.3)	2(18.2)	p<0.001*
Class 3	8(72.7)	0	
Cause			
Motor vehicle	5(45.5)	4(36.4)	MC p=0.25
Assault	2(18.2)	3(27.3)	
Others	4(36.4)	4(36.4)	

*MC: Monte Carlo test χ^2=Chi-Square test t: Student t test *statistically significant if p<0.05. Multivariate analysis was done for confounding factors and this factor was nonsignificant.*

Comparing after 2- & 6-months' values, there is statistically significant increase of lateral excursion (Table 3). Table (3) also illustrates that there was statistically significant higher mean deviation on opening among closed reduction group than open reduction after 2 months of treatment (0.18 & 1.19) and similarly after 6 months (0.29 & 1.25) on both unilateral and bilateral fractures. There was no statistically significant difference with lower mean pain score assessed by Visual analogue scale among closed reduction group than open reduction after 2 months of treatment (0.89 & 1.25) while there is statistically significant difference between both groups after 6 months (1.22 & 4.21), respectively. Comparing after 2- & 6-months' values, there is statistically significant increase of pain score (Table 3). Table (4) illustrates that there was no statistically significant difference of motor and sensory nerve function between studied groups, all studied cases restore full motor and sensory functions after 6 months' post-treatment. Table (5) illustrates that there was statistically significant difference of average shortening pre-treatment among studied groups. After 2 & 6 months there is no statistically significant difference between studied groups. Comparing pre-treatment and post-treatment results shows statistically significant difference for all readings (after 2 and 6 months). Table (6) shows a statistically significant difference in subcondylar angulation of average angulation pre-treatment among studied groups. After 2 & 6 months there is no significant difference between the studied groups. Comparing pre-treatment and post-treatment results shows statistically significant differences for all readings (after 2 and 6 months). Table (7) illustrates no statistically significant difference in displacement frequency pre- and post-treatment among studied groups. For the group with closed reduction, there is no statistically significant difference between pre and 2 months post-treatment and between after 2& 6 months, while there is a statistically significant difference between pre-treatment and after 6 months post-treatment.

Table 3: Post-operative assessment of clinical parameters distribution among studied groups				
	Closed reduction n=11	Open reduction n=11	Test of significance (t-test)	
Maximum interincisal opening (mm)				
After 2 months	30.22± 1.98	34.12 ± 2.10	t=4.48	P=0.0002*
After 6 months	32.18 ± 2.11	35.09 ± 1.58	t=3.66	P=0.001*
Paired t-test	p=0.01*	p=0.02*		
Lateral excursion (sum of both sides, mm)				
After 2 months	10.27±1.10	8.57 ± 1.42	t=3.14	p=0.005*
After 6 months	11.50±1.22	8.91 ± 1.55	t=4.35	p=0.0003*
Paired t-test	p=0.02*	p=0.04*		
Protrusive movement (mm)				
After 2 months	5.08±1.2	3.24±0.71	t=4.38	p=0.0003*
After 6 months	5.14±0.95	3.95±0.89	t=3.03	p=0.0006*
Paired t-test	p=0.02*	p=0.01*		
Deviation on opening (mm)				
After 2 months	0.18±0.14	1.19±0.45	t=3.21	p=0.001*
After 6 months	0.29±0.15	1.25±0.98	t=3.21	p=0.004*
Paired t-test	p<0.001*	p<0.001*		
Pain (visual analogue scale, VAS)				
After 2 months	0.89±0.42	1.25±0.87	t=1.24	0.23
After 6 months	1.22±0.98	4.21±1.54	t=5.43	P<0.001*
Paired t-test	p=0.02*	p<0.001*		

*Parameters described as mean ±SD *Statistically significant if p<0.05*

Table 4: Post-operative motor and sensory nerve function distribution among groups				
		Closed reduction n=11	Open reduction n=11	Test of significance (Student t test)
Motor nerve function **No deficit** **Mild weakness** **Moderate weakness**	After 2 months	9(81.8) 1(9.1) 1(9.1)	10(90.9) 1(9.1) 0(0.0)	MC P=0.59
Motor nerve function **No deficit**	After 6 months	11(100)	11(100)	P=1.0
SM		P=0.33	P=0.59	
Sensory perception: **Full sensation.** **Can distinguish cotton/wood/pin.**	After 2 months	10(90.9) 1(9.1)	11(100.0) 0(0.0)	FET P=1.0
Sensory perception: **Full sensation.**	After 6 months	11(100)	11(100)	P=1.0
SM		P=0.305	P=1.0	

SM: Stuart Maxwell test FET: Fischer exact test

The same was detected for the group with open reduction except that there is a statistically significant difference between re-treatment and 2 months after treatment.

Table (8) demonstrates that there was no statistically significant difference between the studied groups regarding the frequency of complications and external

wound complications. A higher frequency of complications was presented among groups with closed reduction than open reduction.

Table 5: Mean shortening distribution among studied groups.				
Radiographic results		Closed reduction n=11	Open reduction n=11	Test of significance (Student t-test)
The average shortening/mm	Pre-treatment	2.58±0.85	6.74 ±2.55	t=5.13 p=0.0001*
	After 2 months	1.85±0.71	2.10±0.98	t=0.685 p=0.50
	After 6 months	1.15±0.89	1.20±0.94	t=0.128 p=0.899
Paired t-test		P1<0.001* P2<0.001* P3=0.04*	P1<0.001* P2<0.001* P3=0.02*	

*Parameters described as mean ±SD *Statistically significant if p<0.05.*
p1: difference between pre-operative and after 2 months post-operative
p2: difference between pre-operative and after 6 months post-operative
p3: difference between 2 months & 6 months post-operative

Table 6: Mean angulation distribution among studied groups				
Radiographic results		Closed reduction n=11	Open reduction n=11	Test of significance (Student t test)
Angulation °	Pre-treatment	3.45± 2.15	8.92±4.19	t=3.85 p=0.001*
	After 2 months	2.19±1.58	1.96±0.93	t=0.416 p=0.68
	after 6 months	1.85±0.93	1.74±0.78	t=0.300 p=0.767
Paired t test		P1=0.001* P2=0.002* P3=0.01*	P1<0.001* P2<0.001* P3=0.03*	

*Parameters described as mean ±SD *Statistically significant if p<0.05*
p1: difference between pre-operative and after 2 months post-operative
p2: difference between pre-operative and after 6 months post-operative
p3: difference between 2 months & 6 months post-operative

Discussion

The present study was randomized clinical trial carried out on 22 patients with unilateral mandibular subcondylar and ramus fractures through random selection from Plastic Surgery unit (Suez Canal University hospital) to compare the long-term treatment results of Open Reduction and Rigid Internal Fixation (ORIF) versus Closed Reduction and Maxillomandibular Fixation (CRMMF) for Subcondylar Fractures. with a mean age at injury for a group with closed reduction was 33.18 versus 31.27 years for open reduction. Among the studied groups, 72.7% and 81.8% of the group with closed and open reduction groups were males.

Table 7: Mean displacement of fractured fragment distribution among studied groups						
Displacement of the fractured fragment		Closed reduction n=11		Open reduction n=11		Test of significance
		N	%	n	%	
Pre-Operative	Medial overlap type	2	18.2	1	9.1	MC p=0.663
	Lateral overlap type	6	54.5	8	72.7	
	Non-displaced	3	27.3	2	18.2	
After 2 months	Lateral overlap type	3	27.3	1	9.1	FET P=0.58
	Non-displaced	8	72.7	10	90.9	
After 6 months	Lateral overlap type	1	9.1	0	0.0	FET P=1.0
	Non-displaced	10	90.9	11	100.0	
Stuart Maxwell test		P1=0.07 P2=0.009* P3=0.26		P1=0.002* P2=0.194 P3=0.305		

FET: Fischer exact test
p1: difference between pre-operative and after 2 months post-operative
p2: difference between pre-operative and after 6 months post-operative
p3: difference between 2 months & 6 months post-operative

Table 8: Distribution of complications among studied groups			
	Closed reduction n=11(%)	Open reduction n=11(%)	Test of significance
Complications	3(27.3%)	1(9.1%)	FET, P=0.58
External wound complication	1(9.1%)	2(18.2%)	FET, P=1.0

FET: Fischer exact test

Among the groups treated with closed reduction; 36.4% were smokers, 27.3% had chronic disease and among the group treated with open reduction; 63.6% were smokers and 45.5% had chronic illness. Our study showed that there is a statistically significant higher mean maximum interincisal opening among the open reduction group than closed reduction after 2 months of treatment (34.12 & 30.22) and similarly after 6 months (35.09 & 32.18). Balouch et al. [9] showed no differences in the maximum interincisal opening, deviation on opening, and occlusion between closed and open management groups after treatment. Likewise, found no clinical differences, such as occlusion or interincisal mouth opening, between the CR and ORIF groups. And in our study, there is a statistically significantly lower mean Lateral excursion among the open reduction group than closed reduction after 2 months of treatment (8.57 & 10.27) and similarly after 6 months (8.91 & 11.50). Our study shows that there is statistically significantly higher mean Protrusive movement among closed reduction group than open reduction after 2 months of treatment (5.14 & 3.95) and similarly after 6 months (5.08 & 3.24). Our study also showed that there is statistically significant higher mean deviation on opening among closed reduction group than open reduction after 2 months of treatment (0.18 & 1.19) and sim-

ilarly after 6 months (0.29 & 1.25). And our study shows that there is a statistically significant difference of average angulation re-treatment among studied groups. After 2 & 6 months there is no statistically significant difference between the studied groups. Comparing pre-treatment and post-treatment results shows statistically significant differences for all readings (after 2 and 6 months). In Kim et al.[10]. Performed forty-eight patients presenting with subcondylar fracture showing in the CR group, 2 condylar fragments were displaced medially, 7 laterally, and 6 were non-displaced. In the ORIF group, 2 condylar fragments were displaced medially, 24 laterally, and 7 were non-displaced. The average period of MMF was 5.47 days in the CR group and 6.33 days in the ORIF group. Associated mandibular fractures occurred in 68.75% of cases, especially symphysis fractures (64.58%). Twelve patients (11 symphysis, 1 body) from the CR group and 21 patients (20 symphysis, 1 body) from the ORIF group had concomitant mandibular fractures. All concomitant fractures were treated with ORIF. The clinical parameters were observed three months after treatment. Neither group had any patients with post-treatment malocclusion or permanent nerve injury. The mouth opening of all patients was greater than 40 mm. However, 6 of 15 patients (40%) in the CR group showed deviation on mouth opening. Similarly, 11 of 33 patients (33%) in the ORIF group showed deviation on mouth opening. And in the CR group, the difference between the first visit and the three-month follow-up was 1.25±1.61 mm in loss of ramus height and 0.32°±1.56° in tangential angulation and in the ORIF group the difference between the first visit and three-month follow-up was 2.60±2.02 mm in loss of ramus height and 6.92°±4.86° in tangential angulation. There was a statistically significant difference between the groups in the loss of ramus height (P=0.008) and tangential angulation (P=0.000). There was also a statistically significant difference between the groups in preoperative tangential angulation (P=0.002). Our study illustrates that there is statistically significant difference of average shortening pre-treatment among studied groups. After 2 &6 months there is no statistically significant difference between studied groups. Comparing pre-treatment and post-treatment results shows statistically significant difference for all readings (after 2 and 6 months). In Singh et al. [11] showed that in CR two (20%) patients reported with functional malocclusion (range: 1–3) and in OR no patient reported with functional malocclusion (range: 1–2). And found statistically significant difference in pain, mouth opening, and lateral excursion movement between the two groups. Open treatment provides better clinical and radiological outcomes for the displaced subcondylar fractures. No significant complications existed in the open group (10% facial nerves paresis). No significant scarring was evident in any of the operated patients. Elsayed et al.[12] argued that surgical access to the mandibular condyle, would increase the risk of trauma to the facial nerve and leave unpleasant scarring (27, 32-34). Hypertrophic scarring in 7.5% of cases are said to be quite tangible and significant. Our study illustrates that there is no statistically significant difference in displacement frequency pre- and post-treatment among the studied groups. For the group with closed reduction, there is no statistically significant difference between pre and 2 months post-treatment and between after 2& 6 months, while there is a statistically significant difference between pre-treatment and after 6 months post-treatment. The same was detected for group with open reduction except that there is statistically significant difference between pre-

treatment and after 2 months after treatment. In Kuntamukkula et al. [13] found that the dynamic stability of the TMJ showed residual imbalances at least at the 6-month postoperative mark, thus speaking against the idea that ORIF provides better correction than that achieved by closed reduction. And our study is showing that there is no statistically significant difference with lower mean pain score assessed by Visual analogue scale among closed reduction group than open reduction after 2 months of treatment (0.89 & 1.25) while there is statistically significant difference between both groups after 6 months (1.22 & 4.21). Comparing after 2- & 6-months' values, there is statistically significant increase of pain score. A second paper in 2018, by Naik k., et al, stated that although there may be some early differences, after the 2-month postoperative mark, there are no significant differences in pain between patients treated with closed reduction and those who undergo ORIF. The report also found no significant long-term differences between the two procedures regarding masticatory function and mandibular range of motion. A study Ho SY et al., [14] which included 20 open-reduction and 18 closed-reduction patients, found that postoperative chewing functions, malocclusion rates, TMJ pain, and radiographic outcomes were better in the open-reduction group. And we showed that there is no statistically significant difference between studied groups regarding frequency of complications and external wound complications. Higher frequency of complications was presented among group with closed reduction than open reduction. In Hackenberg et al [1] declaring that the superior anatomic reduction and better functional results, induce ORIF as the treatment of choice in patients with complex conditions. Another advantage would be the immediate capability of the patient to move the injured area, reducing the MMF required time and thus lowering the risk of ankylosis. We showed that that there is no statistically significant difference of motor and sensory nerve function between studied groups, all studied cases restore full motor and sensory functions after 6 months' post-treatment. In contrast to our results, Eckelt[15] illustrated that some problems exist in ORIF method including difficulty in accessing the fracture site and insufficient or failed reduction of the fracture. When reduction of the condylar fragment is unsatisfactory and the condyle is more rigidly fixed in a non-physiologic position, the risk of postoperative remodeling and degenerative change is too high because of the increased functional loading. The risk of facial nerve injury is a problem that needs to be overcome.

Conclusion

The results of the study favor the open treatment for the management of in cases of displaced and foreshortened subcondylar fractures.

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