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A Novel Approach to the Treatment of Le Fort Fractures Using Internal Fixation to Achieve Mandibulomaxillary Fixation

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ABSTRACT

Background: We aimed to determine the minimum effective period of mandibulomaxillary fixation after the inadequate internal fixation of Le Fort I or Le Fort II fracture. **Objective:** The aim of this study was to investigate the stability of the skeleton after the treatment of Le Fort I or Le Fort II fractures by measuring bite forces and to determine the minimum time required for effective mandibulomaxillary fixation following treatment with internal fixation and mandibulomaxillary fixation. **Method:** A prospective study was performed to examine the treatment of Le Fort I or Le Fort II fracture in the Department of Maxillofacial Surgery at the National Hospital of Odonto-Stomatology in Ho Chi Minh City, Vietnam. A total of 31 patients were included, with up to 1 month of follow-up after discharge from the hospital. Midface bone stability and the mandibulomaxillary fixation time were evaluated using bite force criteria after 1, 2, and 4 weeks. **Results:** Midface bone stability values 1, 2, and 4 weeks after treatment were 87.1%, 100%, and 100%, respectively. After 1 week, 87.1% of patients achieved intermaxillary fixation, and 96.3% of these patients were treated with at least three rigid plates. The remaining 12.9% of patients achieved fixation after 2 weeks, and all of these patients were fixed only at zygomaticomaxillary sutures ($p < 0.05$). Bite forces increased significantly at 2 weeks compared with 1 week and at 4 weeks compared with 2 weeks ($p < 0.05$). **Conclusion:** When treated using only rigid fixation, through the placement of plates and screws at zygomaticomaxillary buttresses, patients with Le Fort I and Le Fort II fractures can achieve mandibulomaxillary fixation after 2 weeks. For Le Fort I fractures, rigid fixation using plates and screws at zygomaticomaxillary buttresses and canine buttress at three positions can achieve mandibulomaxillary fixation after only 1 week ($p = 0.0001$).

Keywords: Le Fort, internal fixation, mandibulomaxillary fixation, mandibulomaxillary fixation time, zygomaticomaxillary sutures, nasomaxillary sutures.

1. BACKGROUND

Phillips et al.'s study on 6989 Le Fort fractures showed that there were 1132 cases (16%) with diagnosis of Le Fort I fractured and 1305 (19%) with Le Fort II fractures (1), respectively. The increasing complexity of traffic accidents has resulted in an increase in the numbers of Le Fort I and Le Fort II fractures cases, in addition to an increase in the number of total maxillary fracture cases. Midfacial fractures are associated with complicated clinical characteristics, causing severe deformations after the injury, resulting in sequelae that include malocclusion, convex facial structure, displaced eyeballs, or nerve injuries (2). Therefore, the clinical characteristics of these fractures must be properly and accurately evaluated to determine the optimal treatment strategy.

Open reduction and internal fixation using plates and screws can enhance the stability and correction of anatomic structures, improving the recovery of bite forces and bite function. However, in some cases, such as in severely comminuted fractures, mandibulomaxillary fixation may improve maxillary immobilization, particularly in cases in which internal plates achieve inadequate fixation (3).

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2. OBJECTIVE

The specific aims of the present study were to investigate the stability of the skeleton after the treatment of Le Fort I or Le Fort II fractures by measuring bite forces and to determine the minimum time required for effective mandibulomaxillary fixation following treatment with internal fixation and mandibulomaxillary fixation

3. MATERIAL AND METHODS

This study was performed on 31 patients diagnosed with Le Fort I or Le Fort II fracture at the Department of Maxillofacial Surgery, National Hospital of Odonto-Stomatology in Ho Chi Minh City, Vietnam, from August 2019 to June 2020. Patients with collapsed bones, fractures with large defective areas, unidentifiable intercuspation position due to excessive teeth loss, or previous treatment for Le Fort I or Le Fort II fracture or mandibular fracture at the other healthcare facilities were excluded from this study. Informed written consent was obtained from all patients. This study was approved by the Ethics Committee of Biomedicine Study of University of Medicine and Pharmacy at Ho Chi Minh City (No. 19389 – ĐHYD).

All patients were subjected to clinical examination, photographic assessment, and radiological examinations (computed tomography imaging with three-dimensional views). All 31 patients who fulfilled the selection criteria underwent internal fixation, using at least zygomaticomaxillary buttresses with some cases that could not be bone grafting, such as severely comminuted fractures at the nasomaxillary buttress or nasofrontal buttresses. After the osteosynthesis, they underwent mandibulomaxillary fixation.

This study was performed prospectively, with three postoperative appointments, as follows. Firstly, second re-examination were conducted one week, two weeks after discharge, during which bone stability and bite force were evaluated. If the midface skeleton was stable, the mandibulomaxillary fixation could be removed. If the midface skeleton was unstable, the mandibulomaxillary fixation would be maintained to enhance stability. The third re-examination was conducted 1 month after discharge, and the all patients' arch bars were removed from both jaws, and they were evaluated using the same examinations used at the first and second re-examination (Figure 1).

Bone stability was assessed by using a constant amount of force, that is equivalent to the bite force for the same place through force meter (FG-5100, MRC Ltd)

Evaluation of bite force: Patients were seated with a straight head and back posture and asked not to lean back against the wall. Patients were asked to bite the sensor of a bite force measurement device at the central incisor region and at the first molar region, holding the bit for 3–4 seconds with the occlusal plane parallel to the floor (4). This procedure was repeated three times, the

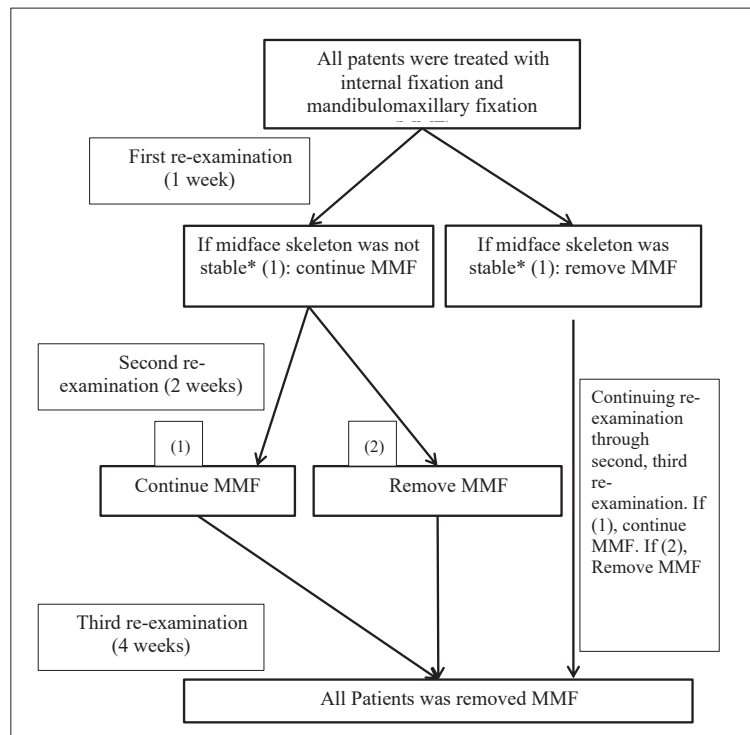


Figure 1. Three examination time points were evaluated after discharge

values were recorded, and a mean value was calculated (5).

Evaluation of midface skeleton stability: Patients were seated with a straight head and back posture and asked not to lean back against the wall so that the occlusal plane remained parallel to the floor. The midface skeleton was pulled downward at the incisor region and the second molar region using a constant amount of force, that is equivalent to the bite force for the same place by force meter (FG-5100, MRC Ltd). During the application of downward force, patients were instructed to bite at the intercuspation position, and the degree of occlusion was evaluated. Proper occlusion was an indicator that the skeleton was secure. This evaluation was performed three times during each re-examination. The skeleton was deemed secure if the results of all three evaluations were evaluated as secure.

Statistical analysis

Collected data were analyzed using SPSS for Windows (version 20.0). Descriptive analyses (mean and standard deviation) were calculated for all variables. Comparative analyses were conducted using paired T-tests, Chi square test. All analyses were performed with a reliability of 95%, and significance was established at $p \leq 0.05$.

4. RESULTS

During the study time frame, 31 patients were recruited. The average age was 32.77 years, with 74.2% of patients in the range of 18–39 years. Men had a significantly higher incidence of Le Fort fractures than women (87.1% men vs. 12.9% women, Table 1). All fractures were the result of motorcycle accidents. The average length of hospital stay was 12 days (range: 4–31 days).

Midface bone stability

Age	n	Male	Female
18–39	23 (74.2%)	23 (74.2%)	0
40–59	7 (22.6%)	3 (9.7%)	4 (12.9%)
60	1 (3.2%)	1 (3.2%)	0
Total	31 (100%)	27 (87.1%)	4 (12.9%)

Table 1. Distribution of LeFort fractures according to age and sex

Number of plates	Time to mandibulomaxillary fixation			p
	1 week	2 weeks	(%)	
2	1	4	16.1	0.0001
3	7	0	22.6	
4	18	0	58.1	
6	1	0	3.2	
(%)	87.1	12.9	100	

Table 2. Correlation between the number of plates and mandibulomaxillary fixation time p = 0.0001. 2 test

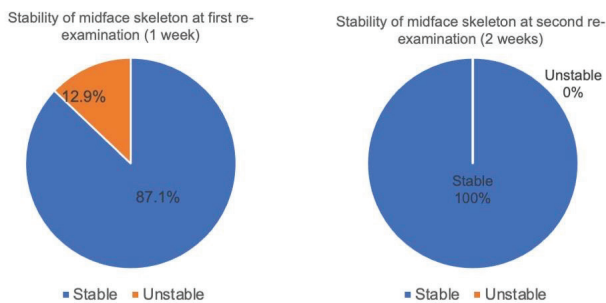


Figure 2. Assessment of midface stability upon re-examination after 1 week and 2 weeks.

Of the 31 patients, 27 had midface bone stability after 1 week, and 100% of patients demonstrated midface bone stability after 2 weeks and after 4 weeks (Figure 2).

Correlation between number of plates and mandibulomaxillary fixation time

Of 31 patients, 27 presented with midface bone stability after one week of mandibulomaxillary fixation, and 96.3% of these patients were treated using 3 or 4 plates placed at zygomaticomaxillary sutures and nasomaxillary sutures. The remaining 4 patients experienced midface bone stability after two weeks of mandibulomaxillary fixation, and all of these patients were treated using 2 plates placed at zygomaticomaxillary sutures (Table 2).

5. DISCUSSION

All of the cases included in the current studies were injured due to traffic accidents. In a similar study by Oliveira-Campos, traffic accidents accounted for 56% of the midfacial fracture cases (6), including 32% of cases injured due to motorcycle accidents. Venugopal reported that traffic accidents were the cause of 87% of cases in their study (7). However, in the study reported by Tent, traffic accidents only accounted for 15.3% of total cases, whereas 44.85% of cases were due to violent interactions (8).

The causes of Le Fort fractures can vary depending on factors associated with the local economy and society.

Traffic accidents often occur in developing countries, such as Vietnam, where motorcycles represent the most common vehicle type. The difference in the occurrence of Le Fort fractures between men and women reflects differences in work characteristics and social activities (9). In the current study, men (87.1%) accounted for the majority of patients compared with women (12.9%), and adults aged 18–39 represented 74.2% of the current study population. Oliveira-Campos reported that the men accounted for 90% of their population with midfacial fractures, with the largest age group (38%) being those 21–30 years (6). Zaleckas reported that men represented 81.5% of their study population (10). In the study by Tent, 50.9% consisted of people aged 20–39 years (9).

The preoperative time in this study was 12 ± 6.25 days. Other studies reported similar preoperative time, such as Venugopal, who reported an average preoperative time of 7 days (7). William suggested that surgery should not be performed immediately following an accident to allow for edema reduction, providing exposure to more optimal surgical sites. However, opportunities for wound infections increase if the preoperative time is too long, which can complicate recovery. Therefore, the authors recommended an average preoperative time of 1–2 weeks for maxillofacial injuries (11).

In our study, we evaluated outcomes 1 week after discharge. In 27 cases, accounting for 87.1% of the study population, skeletal stability was achieved by the first re-examination. by the second re-examination, 2 weeks after discharge, 100% of the study population had achieved skeletal stability. Midfacial skeletal stability at the first re-examination was observed in the 83.9% of total cases treated with at least three plates. The stable osteosynthesis of three buttresses, including the two zygomaticomaxillary buttresses and one canine buttress, likely enhanced the initial skeletal stability. The 4 cases with unstable midface skeletal structures at the time of the first re-examination were continuing mandibulomaxillary fixation. At the second re-examination, 100% of the study cases were stable, and the arch bars were released. The evaluation of midfacial skeletal stability represents the most important and valuable finding of the present study. Skeletal stability depends on various elements, including the number of plates inserted onto the midfacial buttresses, the wound recovery process, and bite force. However, the bite forces measured among individual patients varied widely across different time points. Stable osteosynthesis contributes to midfacial skeletal stability, and mandibulomaxillary fixation contributed to occlusion stability. In cases of unstable osteosynthesis, mandibulomaxillary fixation was able to support skeletal stability, preventing the generation of excessive levels of bite force that might cause the displacement of the structural skeleton. Jagodzinski and Krettek suggested that the mobilization of bones during cartilage calcification could be beneficial for secondary fracture healing; however, the degree of mobilization and the defective areas between the bone heads must remain small (12). Bite force is a contributing factor to

the displacement of the midface skeleton after surgery, which can destabilize the midface skeleton. Thus, to evaluate skeletal stability, our study utilized a technique to exert a counteracting force on the midface skeleton in three regions, using a force equivalent to the maximum bite force measured before the surgery and mimicking the direction of an impacted bite force. The stability of the skeleton was then measured according to the intercuspatation of the occlusion, which contributed to the determination of midface skeletal stability. The midface anterior bones in the canine buttress region can be mobilized using a single screw placed at the zygomaticomaxillary buttresses on both sides when performing osteosynthesis. Moreover, according to Marsell, cartilage calcification can require up to 2–3 weeks (13).

In our study, all cases of midfacial Le Fort fractures were treated using an osteosynthesis technique involving zygomaticomaxillary buttresses placed on both sides, as the fracture line observed in Le Fort I and Le Fort II fractures cross the zygomaticomaxillary buttresses. The zygomaticomaxillary buttresses can withstand and transfer large amounts of force from the molar regions of the midface (14). In a Le Fort I fracture, osteosynthesis at the canine buttresses on both sides contributes to the reconstruction of anatomic characteristics and prevents midface pulling, reducing pseudarthrosis occurrence and contributing to the stability of the midface and zygomaticomaxillary buttresses. For Le Fort II fractures, the reconstruction of zygomaticomaxillary buttresses on both sides should be performed first during osteosynthesis. Additional osteosynthesis steps performed at the infraorbital furrow and frontonasomaxillary buttress can contribute to the stability of the midface skeleton. However, in some cases, such as in cases with severely comminuted fractures at the nasomaxillary buttress or nasofrontal buttresses, mandibulomaxillary fixation may contribute to midface immobilization following inadequate internal fixation. During osteosynthesis of Le Fort I and Le Fort II fractures, osteosynthesis is recommended at the zygomaticomaxillary buttresses on both sides. Canine buttresses (for Le Fort I fracture) and the infraorbital rim and nasofrontal buttresses (for Le Fort II fractures) represent additional positions that can support the stabilization of the midfacial skeleton.

In our study, only one case required osteosynthesis at the nasofrontal buttresses, representing 3.2% of the study population. Among Le Fort II fractures, 5 cases required osteosynthesis at the zygomaticomaxillary buttresses, accounting for 16.1% of the study population. In this study, we performed osteosynthesis in all cases at the zygomaticomaxillary buttresses on both sides (100%). At the canine buttresses, collapsed bones were often observed because bones in this region are fragile. Therefore, 7 cases (22.6%) underwent osteosynthesis at one canine buttress, whereas the majority of cases (18 cases, 58.1%) underwent osteosynthesis at the canine buttresses on both sides. Mandibulomaxillary fixation represents a supportive technique that can be performed after osteosynthesis if the skeleton has not been fixed by a sufficient number of plates and screws (15).

Mandibulomaxillary fixation helps maintain occlusion during the fracture healing process while simultaneously reducing midface skeletal displacement caused by muscle movements. In our study, mandibulomaxillary fixation was performed in all cases (100%) after surgery. In the majority of cases, 87.1%, fixation was achieved within 1 week, whereas in 12.9% of cases, fixation was achieved within 2 weeks. The time necessary to achieve mandibulomaxillary fixation depended on the stability of the midfacial skeleton after the osteosynthesis (16). Arch bars can be retained to fix the jaws for 1–3 weeks, depending on the stability of the skeleton (16).

Most patients (87.1%) who achieved mandibulomaxillary fixation 1 week after discharge were treated in at least 3 positions, including the zygomaticomaxillary buttresses and the canine buttress. In the 4 cases (12.9%) for which mandibulomaxillary fixation was not achieved until 2 weeks after discharge, only 2 positions were treated at the zygomaticomaxillary buttresses. The internal fixation at the right buttresses of the midface contributed to reducing the time necessary to achieve mandibulomaxillary fixation among patients with Le Fort I or Le Fort II fractures. Zygomaticomaxillary buttresses are the first positions that require osteosynthesis, whereas the canine buttresses helped stabilize the midfacial skeleton at the central incisor region (17). Thus, the combination of internal and mandibulomaxillary fixations contributed to midfacial skeletal stability within 1–2 weeks after discharge. In some cases, such as severely comminuted fractures at the nasomaxillary buttress or nasofrontal buttresses, mandibulomaxillary fixation may also contribute to midface immobilization following inadequate internal fixation.

The limitation of our study was that this prospective study used only a short follow-up duration, which was unable to adequately assess the long-term outcomes for patients. In addition, the number of samples included in the study population was relatively small. Further studies should be performed in larger samples sizes with long-term follow-up to validate our findings.

6. CONCLUSION

In conclusion, when treating Le Fort I and Le Fort II fractures, the use of only rigid fixation using plates and screws at zygomaticomaxillary buttresses may achieve mandibulomaxillary fixation within 2 weeks. For Le Fort I fractures, the use of rigid fixation using plates and screws at the zygomaticomaxillary buttresses and the canine buttress, at a minimum of three positions, may achieve mandibulomaxillary fixation within 1 week.

Ethical approval and Declaration of patient consent: This study was approved by the Ethics Committee of Biomedicine Study of University of Medicine and Pharmacy at Ho Chi Minh City (No. 19389 – ĐHYD). All participants provided written informed consent prior to enrolment in the study. Privacy and confidentiality of the patient records were adhered to, in managing the clinical information in the conduct of this research.

- **Author's contribution:** Le Hoai Phuc, Cao Huu Tien, and Doan-Van Ngoc contributed equally to this article as co-first authors. Le Hoai Phuc, Cao Huu Tien, and Doan-Van Ngoc gave a substantial contribution to the acquisition, analysis, and data interpretation. Le Hoai Phuc and Nguyen Minh Duc had a part in preparing the article for drafting and revising it critically for important intellectual content. Each author gave final approval of the version to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
- **Conflicts of interest:** There are no conflicts of interest to declare.
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