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Covid-19 and maxillo-facial fractures: A comprehensive retrospective cohort study on the analysis of costs in COVID-19 era

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Ethics Committee Approval
The research protocol of this study was approved by the Ege University local clinical research ethics committee (EgeTAEK) on 10/31/2020 and with approval number 20-11T/23.
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

Background/Aim: Maxillofacial trauma management has also undergone a change starting from December 2019 due to the emergence of a new viral infection, later called COVID-19, and then a pandemic mandating new medical protocols. This retrospective cohort study aimed to explain the changes in medical costs and underlying causes of cases with maxillofacial bone fractures during the COVID-19 period, based on the lack of focus on cost analyses on this subject in previous studies.
Methods: Patients who were operated on for maxillofacial trauma in our clinic before and during the COVID-19 outbreak were retrospectively analyzed in terms of sex, age, etiology, personal protective equipment (PPE) usage, treatment methods, and total costs. Statistical analyses were carried out for any significant changes.
Results: A total of 78 patients of which 38 were operated on before whereas 40 were operated on during the COVID-19 outbreak, were included in this study. Accordingly, 24 patients of the pre-COVID-19 group and 37 patients of the post-COVID-19 group were admitted from Emergency Department (ED), which included all the first wave patients (n=21). In the pre-COVID-19 group, a total of 220 screws and 58 plates were used for 22 IRFs. The total LoH of the patients was 180 days. In the post-COVID-19 group, 274 screws and 70 plates were used for 24 IRFs. The total LoH of the patients was 185 days. A total of 156 PPE including N95 masks and extra operation shirts were used. The pre-COVID-19 group's treatment costs were calculated as USD 320.3 per patient. Post-COVID-19 group's treatment costs were calculated as USD 496.68 per patient.
Conclusion: The statistical evaluations revealed that the COVID-19 pandemic resulted in differences due to the introduction of PCR tests applied for each patient and the PPE used for the precautions taken for the COVID-19 infections. On the other hand, there were no changes in the number of the use of plates, screws, and in the length of hospitalization. It can be argued that this outcome has led to no necessary changes in the treatment protocols in terms of costs.

Keywords: Maxillo-Facial fractures, COVID-19, Closed fractures, Medical costs, Multiple fractures, Cost analysis

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Introduction

In December 2019, a novel pneumonia epidemic hit Wuhan and then became a pandemic in only 3 months [1]. Daily life and the burden of daily stresses changed to lockdown and pandemic stress that caused different morbidities [2]. In this era, traumatic patients with maxillofacial (MF) fractures were expected to have operated in facilities with adequate manpower and COVID-19-segregated services [3]. Some of the departments in our hospital which were organized to serve in several buildings in a complex, like the burn center allocated under service of infectious disease, pulmonology, and anesthesiology departments to isolate and treat COVID-19-patients. Inherently, as clinicians of a tertiary hospital, we are obliged to treat emergency patients such as traumatic maxillofacial fractures and tumor patients with bone/soft tissue defects, too, as usual. However, we observed alterations in types of admissions and clinical features of patients with maxillofacial area problems in our center.

Before the COVID-19 pandemic hit the world, only surgical masks, caps, shirts, and gloves were used for most of the operations. Literature had argued and settled most of the issues about postoperative complications, costs, and hospitalization lengths. Conversely, we were introduced to a novel status with alterations which cannot be foreseen. Precautions were taken and changed by governments, as recent data accumulated. Like many countries that halted the routine normal life, Turkey had curfew periods during the pandemic term, similarly, to limit the spread of the disease. Therefore, in the past year, medical professionals encountered many different situations.

Medical practice costs a lot according to the amounts mentioned in the literature. However, costs and prices of medical supplies and services per country may change. In this study, we aim to find out if characteristic features like etiology, admission rates, or costs of maxillofacial patients changed in a tertiary trauma center during the pandemic.

Materials and methods

This study was designed as a single-center, retrospective study in Ege University Hospital, Plastic Surgery, and Emergency Medicine Clinics. The research unit is a tertiary reference health center, and about 190,000 patients were cared for annually before the COVID-19 era. The research protocol of this study was approved by the Ege University local clinical research ethics committee (EgeTAEK) on 10/31/2020 and with approval number 20-11T/23. After the approval of the committee, adult patients with Maxillofacial Fractures (MF FX) of which the International Statistical Classification of Diseases and Related Health Problems (ICD) code is S02, who were operated in our clinic between 07/21/2019 and10/31/2020 were retrospectively evaluated. This date range was determined by the beginning of lockdowns and hospital arrangements for the COVID-19 pandemic in our center (03/11/2020, named as "COVID-19 -deadline"). Prior to this date, patients who were treated with routine algorithms formed the pre-COVID-19 group, whereas the patients who were operated on after this date with necessary COVID-19 precautions formed the post-COVID-19 group. Exactly 234 days were set for both pre-and post-event to build the control and study groups. Additionally, the COVID-19 group was further divided into three groups, including the first lockdown period (11.02.2020 – 01.07.2020), the summer period without lockdowns (01.07.2020 – 15.09.2020) and the second lockdown period (15.09.2020 - 31.10.2020). A retrospective search was conducted to obtain data about epidemiology, admission methods (Emergency Department (ED) or Plastic Surgery outpatient clinic), etiologies, operations, lengths of hospitalization (LoH), precautions are taken per operatively, and treatment costs were recorded. Etiologies were further divided for traffic accidents (TA), falls; assaults, home (or sport) accidents, and gun wound (or crush) injuries. Costs of the treatments were calculated as the total of multiple admissions and screening tests for COVID and PPEs that had been used were included. All costs were calculated as US dollars (USD) per exchange rate of Turkish Lira (TL) as of January 2021 (7.35TL/USD).

Statistical analysis

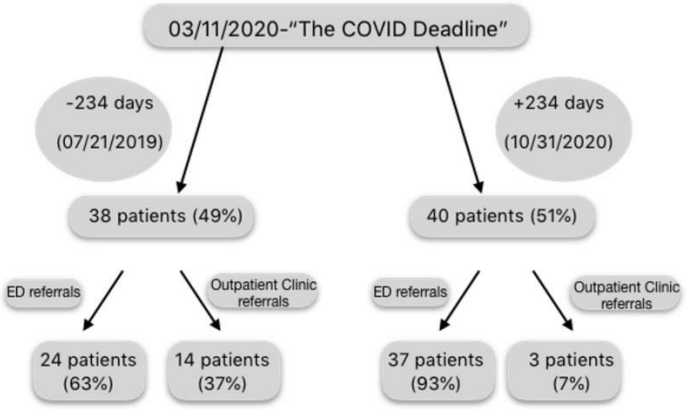
Statistical analysis was done to reveal any significant changes between pre-and post- COVID-19 groups. As the first step of the statistical evaluations, to validate the sample size, the G*Power computer software was utilized for Power Analysis, with medium effect size (d=0.66), 80% power, and 5% type I error level, for the Independent Sample T-test to be performed within the framework of the above-mentioned purposes [4, 5]. Accordingly, a minimum of 38 participants were required in each group.

The IBM SPSS 25.0 software was used for the statistical evaluations. Descriptive statistics in the analyses were presented as frequency (n), mean, standard deviation (SD), minimum (Min), and maximum (Max) values. The independent sample t-test was used to compare the two-group comparisons of costs, the number of plates, screws, and the length of hospitalization before and during the COVID-19 pandemic. The level of significance was set as $P<0.05$.

Results

A total of 78 patients were operated on in our clinic for fractures during this timeline. Of these patients, 38 were operated on before, and 40 were operated on after the COVID-19 -deadline. Also, 22 of the patients were females while 56 were male. Of the patients, 39 of the patients were aged 20 or lower whereas the remaining 39 were aged 30 or higher. A group of 24 patients of the pre- COVID-19 group was admitted from ED, while 37 patients of the post- COVID-19 group were referred from ED. The ED referrals in the post-COVID-19 group comprised all the first wave patients (n=21), 6 of the summer patients (n=8), and 8 of the second wave patients (n=10) (Figure 1). Three patients from the pre-Covid-19 group and five patients from and the post-COVID-19 group had two admittances to the PS ward, due to intermaxillary fixation (IMF) extraction or postoperative follow-ups, respectively.

Figure 1: Flowchart of building the patient population



Treated bone fractures were 20 mandible fractures, including four cases of other concomitant MF FXs, 15 zygomatic fractures (ten tripods and five isolated arches), one nasal fracture, four blow-out fractures, and three Le Fort III fractures that two tripod zygomatic and one mandible fractures were associated with. Seven mandible fractures were treated with IMF only, while 13 were treated with IRF with or without IMF. All tripod fractures were treated with IRF, as all zygomatic arch fractures were treated with Gillies Operation. All the blow-out fractures were treated with cartilage grafting. In total, 220 screws and 58 plates were used for 22 IRFs (avg. 10 screws/patient and 2.63 plates/patient). The total LoH of the patients was 180 days (avg. 4.74 days/patient) (Table 1).

Table 1: Cases of pre- and post-COVID groups

	Pre-COVID	Post-COVID
Mandible FX	26	38
Zygomatic FX	17	7
Frontal FX		3
Blow-out	4	3
Nasal FX	1	
LeFort II		1
LeFort III	3	
IRF	26	27
Plate	60	75
Screw	226	291
PPE	0	192
LoH*	4.33	4

LoH: Length of hospitalization, *: Is given as average days per patient.

All the patients were tested for COVID-19, and negative results were obtained for all patients. Treated bone fractures were 31 mandible fractures, of which three were with other MF FXs concomitantly, seven zygomatic fractures (five tripods and two isolated arches), two frontal bone fractures, one inferior orbital rim fracture, one blow-out fracture, and one Le Fort II fracture. 12 mandible fractures were treated with IMF only, while 19 mandible fractures were treated with IRF. Two zygomatic arch fractures and one of the zygomatic tripod fractures were treated with Gillies operation. Four tripods, two frontal bone fractures, and the blow-out fracture were treated with IRF. In total, 274 screws and 70 plates were used for 24 IRFs (avg. 11.42 screws/patient and 2.92 plates/patient). The total LoH of the patients was 185 days (avg. 5 days per patient). A total of 156 PPE including disposable gowns and sheets were used (3.9/patient).

The etiology of pre-COVID-19 group comprised 16 TAs (42%), three home accident injuries (8%), nine falls (24%), nine assault-related injuries (24%), and one gun wound injury (2%). The post-COVID-19 group comprised 16 assault injuries (40%), 10 fall injuries (25%), 10 TA (25%), three home accidents (8%), and one crush injury (2%) due to the Izmir earthquake in October 2020. Eight patients (20%) were operated on during the first wave whereas 22 (55%) were operated on during summer and ten patients (25%) during the second wave.

The treatment costs of the pre-COVID-19 group were calculated as USD 12,171.78 in total. The Average cost per patient was USD 320.31 (min. USD 10.42-max. USD 1.208,40). The lowest cost of USD 10.42 was for a nasal fracture patient, which was treated with only closed reduction. The treatment costs of the post-COVID-19 group were calculated as USD 18,712.40 in total. The average cost per patient was USD 496.68 (min. USD 20.00, max. USD 2515.30) (Table 2) (Figure 2, 3).

Table 2: The values and changes in parameters before and after the COVID-19 pandemic

Variables	Group	f	min	max	$\bar{X}$	SD	*t*	*P*-value
Total Costs including PCR tests (in the post-COVID-19 group)	Pre-COVID-19 Group	38	10.42	1208.40	320.31	244.46	-2.131	0.036
	Post-COVID-19 group	40	20.00	2515.30	496.68	450.97		
Plate	Pre-COVID-19 Group	38	0	7	1.53	1.62	-0.546	0.578
	Post-COVID-19 group	40	0	9	1.75	1.97		
Screw	Pre-COVID-19 Group	38	0	30	5.79	6.69	-0.689	0.493
	Post-COVID-19 group	40	0	25	6.85	6.89		
Length of Hospitilization	Pre-COVID-19 Group	38	1	17	4.74	4.76	0.115	0.908
	Post-COVID-19 group	40	1	16	4.63	3.77		

Figure 2: Distributions (left) histogram and (right) plot charts of logarithmic derivatives of the costs.

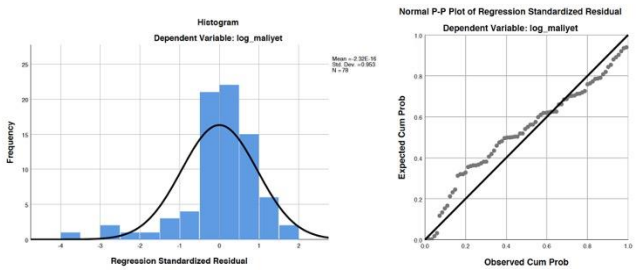
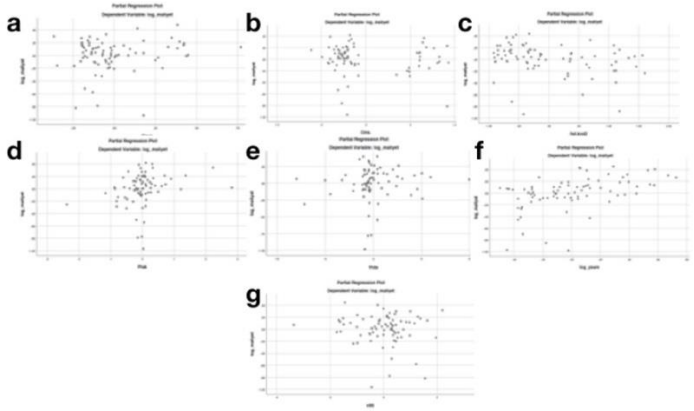


Figure 3: Plot charts of the variables and logarithmic derivative of the costs. Variables: a>Group, b>Sex, c>Fractured bone, d>Plate count, e>Screw count, f>hospitalization length, g>PPE



Discussion

When the COVID-19 pandemic hit, the threshold for interventions was raised to assure fewer transfections of COV-SARS-2 virus between hospital environments and patients [2].

Early suggestions for elective MF surgery were to be deferred as orthognathic surgery [6]. This was logical and strictly followed, like lockdowns. However, besides social and psychological ones, there was also an economic impact of the pandemic. From macro - to micro -, all the parts of the economic systems of the world adapted to a "new normal", which necessitates a different income-expenditure balance, assuring older entries of expenditures to change [7]. For this instance, as we examine in this study, patient-care costs for trauma surgery in maxillofacial area have changed.

After the COVID-19 outbreak, most of the people got scared and obeyed the restrictions. As a result of their fear of the disease, they got out of their homes only for mandatory needs. We expected to see the same effect in our patients. Our patient profile which showed a relative rise in ED admissions in the post-COVID-19 era satisfied this expectation, indicating a higher tendency of the patients to refer to the ED only in the case of unbearable discomfort. We believe that this can be interpreted as a social expression of the human behavior of which life is at stake under the COVID-19 threat.

The etiology of MF bone fractures has been extensively studied in previous studies. It was thought that the changes in the circumstances due to the COVID-19 outbreak might have caused the etiological distribution and ranking of the cases. For example, trauma due to firearm injuries or domestic violence was shown to increase in the USA [5]. In our study, we conversely found less assault and even no firearm injuries. Surprisingly, MF traumas were more frequently encountered than the same length of time before the COVID-19 -deadline. Most of the patients were encountered during summer. This can be accounted to loosened lockdown restrictions, allowing the population to interact more. Nevertheless, we encountered no gunshot wounds or sports injuries during this whole term. This may be caused by the reason that; team sports were restricted during this time interval. Moreover, maxillofacial gunshot injuries probably caused a higher and faster mortality rate, making them less encountered by us.

In different studies, zygomatic fractures were shown to be the most injured bone in MF trauma, while some others indicate the mandible. Also, literature mentions a male predominance in MF fractures [8,11]. When the most common etiologies were taken into account (TA and assaults), male predominance is not sound overwhelming as the cause [11]. However, during the COVID-19 pandemic, due to lockdowns around the globe, this etiological ranking might have changed, also affecting sexual predominance. Yet, in our study, male predominance continues, while rankings of etiologies changed only during the first wave.

COVID-19 also changed protocols for the patient approach. For instance, it is known when an asymptomatic patient is encountered, a high risk of COVID-19 transfection is possible in the MF-area surgeries, due to close interaction of the operative team with the oro-nasal area [8]. Therefore, in our algorithm, we prefer preoperative PCR tests to minimize the risk of operating a COVID-19 (+) patient, which has a higher risk of postoperative pulmonary complications. This algorithm also minimizes the surgical team's exposure risk, while adding to total costs [2]. On the other hand, unlike our previous algorithm, patients sometimes wait in the ward, occupying a room isolated until the PCR test result is obtained, adding extra time to LoH. Nevertheless, as LoH values were shown to differ statistically insignificant in this rise, the PCR tests seem to be a major reason. In the future, the development of cheap testing kits may reduce the costs, maybe even to a level that may not give statistically significant differences in costs.

Costs for maxillofacial fracture treatments have been examined many times in previous studies. A Turkish study by Altıparmak et al. [8] has reported a median of USD 114 in their MF FX cost-analysis study. In a US-based study, treatment costs for mandible and zygomaticomaxillary fractures were given as high as between USD 5.620,61 and USD 9.051,94 [9]. As the study by Altıparmak et al. was also conducted in Turkey, it grants a more accurate estimation of the pre-COVID-19 period. However, our results revealed higher costs than those reported by Altıparmak et al., showing a 2.5- COVID-19 increase in costs of such patients of the pre- COVID-19 era. Furthermore, our statistics showed that COVID-19 has added an extra 1-fold of increase to the average values of costs when compared with Altiparmak et al.'s study. Their study compared different hole counts referring screw counts in IRF, but without taking the plate counts into account [8]. However, although our costs were found to be strongly correlated with plate usage, LoH, and fractured bone types (but not screw usage), none of these parameters were found to be statistically significant between pre-and post-COVID-19 groups. Therefore, it would not be wrong to say that we did not change our treatment protocols, but COVID-19 precautions increased the costs by addition of some expenses. The increase in the total costs was directly related to the use of PCR tests for the detection of the disease and the PPE used for the precautions taken for the COVID-19 infections. On the other hand, there were no changes in the number of the use of plates, screws, and also in the length of hospitalization.

With this study, we aimed to reveal if COVID-19 pandemic conditions affect the etiology of MF fractures, treatments, and costs of MF traumas. Eventually, our population's characteristics were found to be similar in the COVID-19 era, with higher costs of total treatments.

The small size of the patient population can be regarded as one of the limitations of the present study. However, the power analysis carried out prior to the Sample t-test to analyze the significance of the differences between the groups yielded that sample size is adequate to carry on with the current data. Also, our comparison does not focus on different bone fractures' treatment costs. To overwhelm these problems, larger populations, even enough counts of patients that may allow specific bone fracture comparisons, can be used in future studies.

Conclusion

The present study revealed that the circumstances that emerged with the onset of the COVID-19 outbreak yield differences in terms of the total costs of treatment of MF fracture surgeries. Accordingly, the onset of the use of PCR tests for the detection of the disease and the PPE used for the precautions taken for the COVID-19 infections. On the other hand, there were no changes in the number of the use of plates, screws, and in the length of hospitalization. It can be argued that this outcome has led to no necessary changes in the treatment

protocols in terms of costs and the procedures were carried out in their normal routine.

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