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Effect of Delay of Care for Patients with Craniomaxillofacial Trauma in Rwanda

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Abstract

Objectives. Craniomaxillofacial (CMF) trauma represents a significant proportion of global surgical disease burden, disproportionally affecting low- and middle-income countries where care is often delayed. We investigated risk factors for delays to care for patients with CMF trauma presenting to the highest-volume trauma hospital in Rwanda and the impact on complication rates.

Study Design. This prospective cohort study comprised all patients with CMF trauma presenting to the University Teaching Hospital of Kigali, Rwanda, between June 1 and October 1, 2020.

Setting. Urban referral center in resource-limited setting.

Methods. Epidemiologic data were collected, and logistic regression analysis was undertaken to explore risk factors for delays in care and complications.

Results. Fifty-four patients (94.4% men) met criteria for inclusion. The mean age was 30 years. A majority of patients presented from a rural setting (n = 34, 63%); the most common cause of trauma was motor vehicle accident (n = 18, 33%); and the most common injury was mandibular fracture (n = 28, 35%). An overall 78% of patients had delayed treatment of the fracture after arrival to the hospital, and 81% of these patients experienced a complication (n = 34, P = .03). Delay in treatment was associated with 4-times greater likelihood of complication (odds ratio, 4.25 [95% CI, 1.08-16.70]; P = .038).

Conclusion. Delay in treatment of CMF traumatic injuries correlates with higher rates of complications. Delays most commonly resulted from a lack of surgeon and/or operating room availability or were related to transfers from rural districts. Expansion of the CMF trauma surgical workforce, increased operative capacity, and coordinated transfer care efforts may improve trauma care.

Keywords

facial trauma, craniomaxillofacial trauma, facial reconstruction, mandible fracture, global health, health equity

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Trauma is a leading cause of morbidity and mortality worldwide, causing more deaths than HIV/AIDS, tuberculosis, and malaria combined.[1,2] Congested traffic, prevalence of motorcycle use, underdeveloped safety infrastructure, and high rates of alcohol abuse all contribute to the high incidence of traumatic injury.[3] Craniomaxillofacial (CMF) trauma disproportionally affects low- and middle-income countries (LMICs), resulting in approximately 5 million death per year.[4,5] CMF trauma more commonly affects young people (ages, 21-30 years), which has a significant impact on the health and workforce of many LMICs.[6-8] The high rates of morbidity, such as permanent mental and physical disabilities, can have a vast socioeconomic impact on communities.[3,7,9-11]

Proper CMF fracture care requires a trained CMF surgical workforce, diagnostic and treatment facilities, and materials for rigid internal fixation. Deficiencies in any of these may result in delays in care, defined as no treatment for at least 3 days following the inciting event.[12] Delays increase the risk of complications such as infection, nonunion, malunion, trismus, pain, and malocclusion.[6] Elucidating reasons for delays in CMF care is critical to improving care in LMICs.

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Rwanda is an East African nation of 13 million people described by the World Bank as a low-income country.[13] CMF trauma care is primarily performed at 3 tertiary referral centers in Rwanda, of which the University Teaching Hospital of Kigali (CHUK) sees the highest volume and is most representative of the greater population. We aim to characterize the risk factors for delay in management of patients with CMF trauma at CHUK and how this may affect complication rates.

Methods

This is a prospective cohort study of all patients with a diagnosis of CMF trauma who presented to the emergency department of CHUK between June 1 and October 1, 2020. Exclusion criteria were patients who would not consent for the study, although this did not pertain to any participants. Approval was granted by the Rwandan College of Medicine and Health Sciences Institutional Review Board (134/CMHS IRB/2020), and all data were collected by full-time otolaryngologists of CHUK. Demographic data, including patient origin, alcohol consumption prior to injury, and type of injury, were collected upon intake with a predetermined survey instrument. Data on patients' socioeconomic class were defined with the Rwandan governmental scale for socioeconomic class based on income (grades 1-4, with grade 1 representing lower income and grade 4 representing higher income). Patients were then followed for a minimum of 6 months to assess outcomes.

Delay in care was defined as $\geq$3 days between documented injury and arrival to CHUK. Delay in treatment was defined as $\geq$3 days between arrival to CHUK and definitive management. Reasons for delay to the hospital and reasons for delay once hospitalized were documented by the treating team. Complications were assessed over the follow-up period and included vision change, tooth loss, facial deformity, documented infection, malocclusion, malunion, paresthesia, and presence or absence of trismus. Trismus was defined by self-reported presence of limited mouth opening.

To explore the relationship between delays in diagnosis or treatment and outcomes, univariate and multivariable logistic regression modeling was performed to calculate crude and adjusted odds ratios (ORs) with 95% CIs. Covariates for multivariable models were based on clinical relevance and data availability and included age, sex, education level, alcohol intake, and distance from the hospital when relevant. An alpha of 0.05 was selected as the cutoff for statistical significance. Participants were excluded from the regression modeling if they had missing data; however, no patients had any missing data and thus a complete case analysis was undertaken. Statistical analyses were carried out in Stata version 16.1 (StataCorp). A map of the geographic distribution of patients with trauma was created by calculating the direct distance from the center of the patient's home district to CHUK with Google Maps version 9.135.0.3.

The majority of CMF injuries were mandible fractures. Therefore, a subanalysis was performed to explore the impact of arrival and treatment delays on mandible fracture outcomes. As part of the subanalysis, patients who were treated for mandible fractures and had reported early trismus in their clinic visit were then queried by phone at the 6-month mark to determine the status of trismus to better understand this complication.

Results

A total of 54 patients met criteria for inclusion in the study; 51 (94.4%) were men. The mean age was 30 years (range, 4-65). The majority of patients presented from a rural setting (63%, n = 34) and traveled a mean 33 km (SD, 28; range, 4-102) to the hospital (**Figure 1**). The majority of patients were of socioeconomic class 3 (51.9%). All patients had full health insurance coverage through Rwanda's national health insurance program (**Table 1**). The median follow-up was 238 days (range, 180-345).

Motorcycle accidents were the most common cause of trauma (n = 18, 33%), followed by assault (n = 16, 29.6%). An overall 18.5% of patients reported use of alcohol at the time of injury. The most common injury was mandible fracture (n = 28), followed by zygomatic fracture, frontal bone fracture, or soft tissue injury (n = 8 for each; **Table 2**). Of those with mandible fractures, 14 had an isolated mandible fractures, while 14 had associated injuries, the most common of which was LeFort III (n = 3).

The majority of patients presented to the hospital within 1 day of injury. Nine patients (16.7%) had delayed presentation to the hospital, defined as $\geq$3 days after injury. Of the 9 patients who had delayed presentation to the hospital, 3 came by self-transport while the remaining 6 came by ambulance. All 9 patients were transferred from a local district hospital.

An overall 78% of patients had delayed treatment of the fracture after arrival to the hospital, defined as $\geq$3 days between arrival and treatment (n = 42). The majority of patients (52%) were treated within 4 to 7 days, but 26% had treatment delays for $>$7 days. The most common cause of delay was material not being available (n = 23, 54.8%), followed by lack of surgeon or operating room availability (n = 15, 35.7%; **Table 3**). Of note, 8 of the 9 patients who experienced delay on presentation to the hospital also experienced delay in treatment after arrival to the hospital.

Overall, 81% of patients with delayed treatment experienced a complication (n = 34), as compared with the 19% complication rate in those without treatment delay (chi-square, P = .031). On regression analysis, patients were 4.25 times more likely to have a complication if treatment was delayed $\geq$3 days after arrival to the hospital (OR, 4.25 [95% CI, 1.08-16.70]; P = .038). There was no statistically significant increase in complication rate for patients who arrived to the hospital $\geq$3 days after injury (OR, 1.5 [95% CI, 0.27-8.09]; P = .64).

Though not statistically significant, patients were 5.8 times more likely to have delayed arrival to the hospital if originating from a rural setting (OR, 5.85 [95% CI, 0.67-50]; P = .10). Similarly, for every 1-km increase in distance from the hospital, patients were 1.03 times more likely to have a delayed arrival. For example, for a patient with a 10-km distance from the hospital, the odds were 10.3 times greater that they would

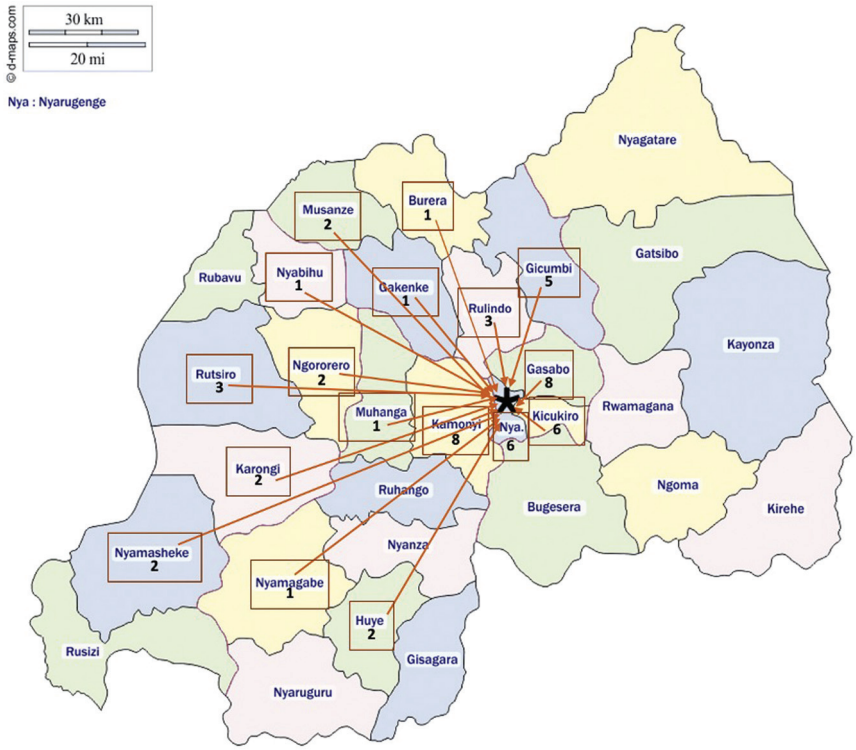

Figure 1. District map of Rwanda. Number of patients traveling from each district to University Teaching Hospital of Kigali, Kigali, Rwanda. The mean distance traveled to the hospital was 33 km (SD, 28; range, 4-102).

Table 1. Participant Characteristics.

	No.	%
Sex: male	51	94.4
Age, y, mean (range)	30 (4-65)	
Origin		
City	20	37.0
Rural	34	63.0
Socioeconomic category		
1	4	7.4
2	21	38.9
3	28	51.9
4	1	1.9
Cause of trauma		
Assault	16	29.6
Bicycle	14	25.9
Fall	1	1.9
Motorcycle	18	33.3
Mining	1	1.9
Motor vehicle	4	7.41
Alcohol detected on arrival: yes	10	18.5
Mode of transportation to the hospital		
Ambulance	47	87.0
Police	1	1.9
Self	6	11.1

have a delayed presentation (OR, 1.03 [95% CI, 1.005-1.06]; $P = .018$).

Patients who reported alcohol intake at the time of injury were 5 times more likely to have delayed presentation to the hospital (OR, 5.2 [95% CI, 1.08-25.01]; $P = .04$). After controlling for distance, this association became slightly less significant (OR, 5.4 [95% CI, 0.95-31.20]; $P = .058$). However, there was no increased risk of complications in patients who had alcohol exposure (OR, 3.78 [95% CI, 0.43-32]; $P = .23$).

Given that mandible fractures were the most common injury, a subanalysis was undertaken to explore this population. It found that treatment of mandibular fractures varied, though we do not have data on specific type of mandible fracture. Eight patients were treated with conservative management (eg, soft diet and physical therapy), 10 with closed reduction/maxillomandibular fixation (MMF), and 10 with open reduction/internal fixation (ORIF). The most common complication in mandibular fracture treatment was residual trismus, which was self-reported in 14 patients immediately posttreatment, 9 of whom were treated with MMF. Of the 14 patients with posttreatment trismus, 9 were able to be reached by phone at 6 months after treatment. Of these 9 patients, 7 had residual trismus, all of which had been treated with closed reduction/MMF. Of the 10 patients treated with ORIF, 8 had no postoperative trismus; 1 had trismus that resolved by the follow-up phone call; and the final patient had immediate postoperative trismus but could not be reached for follow-up.

Table 2. Injury Characteristics.

	No.	%[a]
Eye injury	3	3.7
Fracture		
LeFort I	3	3.7
LeFort II	7	8.6
LeFort III	4	4.9
Mandible	28	34.6
Maxillary	2	2.5
Nasal bone	4	4.9
Zygomatic	8	9.9
Orbital	4	4.9
Frontal bone	8	9.9
Soft tissue injury	8	9.9
Dental injury	2	2.5

[a]Percentage of total injuries, not patients.

Table 3. Delay of Care.

	No.	%
Delayed presentation to the hospital		
No	45	83.3
Yes	9	16.7
If yes: reason for delay of arrival		
Delayed diagnosis	2	22.2
Delayed referral	3	33.3
Delayed transfer	1	11.1
Economic difficult	3	33.3
Time between injury and arrival, d		
<1	39	72.2
1-3	6	11.1
4-7	6	11.1
>7	3	5.6
Delayed treatment, after presentation		
No	12	22.2
Yes	42	77.8
If yes: reason for delay of treatment		
Admission to intensive care unit	2	4.8
Associated injury	1	2.4
Material unavailability	23	54.8
Neglected	1	2.4
Surgeon unavailable	15	35.7
Time between arrival to hospital and treatment, d		
<1	3	5.6
1-3	9	16.7
4-7	28	51.9
>7	14	26.0

Discussion

This is the first prospective study of patients with CMF trauma treated at Rwanda's largest referral center. It shows an increased complication rate of 81% for those patients treated ≥3 days after arrival to the hospital, a statistically significant difference in comparison with patients who did not experience delay in treatment. Factors leading to delays in treatment of patients with CMF trauma must be understood to improve care. While 9 patients experienced delays in arrival to the hospital, 42 of 54 patients experienced delay in treatment after arrival to the hospital. The most significant risk factors for delay in our setting were availability of surgeon, operating room time, and materials. The lack of a proper global CMF surgical workforce and associated materials contributes to delayed CMF trauma care and corroborates data from prior studies indicating that delays in care lead to worse outcomes for patients.[6,12,14,15] While the complication rates in our study are higher, they are in line with prior studies showing rates ranging from 13.6% to 35.5%[12,14,15] in patients who experienced delayed treatment in other LMICs. Barriers to care in our study were similar to those in studies in South Africa and Nigeria.[3,6,15,16] These include transfer of care from a rural setting, availability of surgical workforce and equipment, and systemic barriers such as socioeconomic status and, in most other countries, health insurance coverage.

Location matters. In our study, delays in presentation were more common in patients coming from rural settings; in fact, all patients with delay came from a district hospital. This is similar to studies for non-CMF trauma where transfer of patients from secondary care centers unequipped to handle trauma can introduce a bottleneck in care.[17] The process of hospital transfer relies on diagnostic imaging and ambulance transport, both of which may be sources of delay. Implementation of integrated trauma care systems has been shown to lower morbidity and mortality.[17] Similarly, expansion of CMF trauma treatment capabilities at regional referral hospitals could mitigate transfers entirely. This requires investment in radiology facilities and an expansion of the CMF surgical workforce. At the time of the study, 3 CMF trauma surgeons service 13 million people in Rwanda, which is inadequate. A long-standing commitment to CMF trauma education programs is a wise investment in this regard. Curricula tailored for CMF trauma in low-resource settings have been developed[5]; however, there is no substitution for CMF trauma skills development within existing training programs.

Delays in treatment after arrival to the hospital were associated with a significantly higher risk of complications. In our study, patients were 4 times more likely to experience a complication if treatment was delayed ≥3 days. This corroborates prior studies showing that treatment within 3 days of injury has low infection rates,[18] while treatment after 3 and 5 days is associated with higher complication rates.[12,14,15]

Understanding reasons for delay is critical to addressing gaps in care. Lack of surgeon and operating room availability was the largest contributing factor in delay of care. The existing surgical workforce crisis[19] is known to have significant

implications on patient outcomes. For patients to have operative care for traumatic injuries, there must be adequate numbers of surgical and anesthesiology personnel and operating theaters. Prior studies by the Lancet Commission for Global Surgery, have shown that with increasing density of surgeons and anesthetists, surgical morbidity and mortality decrease.[20] Rwanda is similar to many other LMICs in its need for expansion of the CMF surgical workforce.

A lack of reconstruction materials (eg, plates and screws, implants) was another source of delay. While ORIF is the gold standard treatment for many mandibular fractures, MMF alone was performed in an equal number of patients in this study population. To account for the lack of operating room or surgeon availability, patients sometimes undergo MMF under local anesthesia, which occurs more commonly in resource-limited settings.[3,21,22] While this study is limited by surgeon preference, prior studies have shown lower quality-of-life metrics and higher rates of postoperative pain and trismus in patients treated with MMF vs ORIF.[23,24] This was borne out in our study as the majority of patients treated with MMF had residual trismus at the 6-month follow-up phone call.

Substance abuse is often correlated with increased risk of trauma and delayed presentation to care.[25] In our patient population, there was a 5-times greater risk of delayed presentation in patients who had been consuming alcohol; however, there was ultimately no increased risk of complication correlated with alcohol intoxication. Coordinated efforts to intervene in substance abuse in LMICs have been supported by the World Health Organization,[26] which would in turn decrease trauma related to the use.

While many LMIC health care limitations are due to a lack of patients' ability to pay for treatment, Rwanda is unique in its national insurance program. It is an income-based health coverage plan named Mutuelle de Santé, and 100% of patients who sustained facial fractures were covered under this program. This does not necessarily mean that all of their care was free, as under national health coverage, patients are still required to pay a small income-based percentage, which can be challenging for families in groups of lower socioeconomic status. Yet, this likely improved patients' ability to access care, making these data less generalizable to LMICs where no such program exists. However, Rwanda demonstrates how a nationalized system of insurance can potentially improve health outcomes and increase access to care, especially in patients of lower socioeconomic class.

Motorcycles are the primary mode of transport in Rwanda and, as with many other African countries, have been a large source of traumatic injury.[27] However, Rwanda is unique in its universal helmet law for all motorcycle drivers and passengers. This may explain the increased prevalence of mandible fractures in our study, as the most commonly used helmets do not provide lower face defense. This injury trend among helmet wearers has been studied in other contexts, as seen in the higher rates of mandible fractures in bicyclists whose helmets similarly do not protect the lower face.[28] While Rwanda's universal helmet law and its strict enforcement form a crucial public health policy, further interventions may include more protective helmets. Similarly, this study likely underestimates the true CMF injury rates for LMICs where helmets are not enforced.

This study has limitations, such as its small sample size. Similarly, patients who were referred to CHUK may present a referral bias; with very few CMF surgeons practicing in Rwanda, results may vary by individual surgeons. Additionally, malocclusion as a complication may be associated with concomitant injuries, such as LeFort fractures and not mandible fractures alone, though this would more likely lead to a type I error and underestimate the significance. The same could be said for the period of the data collection, during the COVID-19 lockdowns in Rwanda, when motor vehicle collisions would be potentially reduced, therefore underestimating the true rates of CMF trauma. Similarly, the data collected on distance traveled to reach the hospital were calculated with coordinates to determine a straight-line distance, which would not accurately reflect the actual distance traveled. While this is a limitation, it is a standard method of presenting GIS data (geographic information system), and it certainly underestimates the true impact of distance on patient travel. Thus, our finding of increased complications related to distance traveled is likely an underestimate of the true impact of distance, which correlates with many other studies on access to health care for rural populations. Finally, we acknowledge that 8 patients experienced delays both prior to arriving to the hospital and prior to treatment after arrival. This limits our ability to distinguish the specific cause of delay, although it suggests the trend that delays in treatment after arrival to the hospital are the most common source of delay and should be addressed by systemic intervention. Nonetheless, this is the first study to examine reasons for delay of CMF trauma care in Rwanda, which is a critical step in addressing the CMF trauma burden of disease.

Conclusion

Delays in treatment for CMF trauma $\geq$3 days are associated with an increased risk of complications. Delays in care were most commonly caused by transfers from a district hospital to the tertiary care center and by lack of surgeon and/or operating facility availability. Coordinated efforts to widen access to CMF trauma care outside the tertiary care setting, strengthen the surgical workforce and supplies, and expand public health programs to decrease substance abuse and increase use of personal protective equipment such as motorcycle helmets may help ease the burden of morbidity due to these injuries.

Author Contributions

Gaelen B. Stanford-Moore, data analysis, data interpretation, manuscript composition and editing, study design, agree to be accountable; **Gilbert Niyigaba**, data collection, study design, data analysis, data interpretation, manuscript composition and editing, agree to be accountable; **Gratien Tuyishimire**, study design, data analysis, data interpretation, manuscript composition; **Jenny Yau**, data analysis, data interpretation, manuscript editing, agree to be accountable; **Amol Kulkrani**, study design, data interpretation, manuscript composition, agree to be accountable; **Victor**

Nyabyenda, study design, data interpretation, manuscript composition, agree to be accountable; **Isaie Ncogoza**, study design, data interpretation, manuscript composition, agree to be accountable; **David A. Shaye**, study design, data analysis, data interpretation, manuscript composition and editing, agree to be accountable.

Disclosures

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Level of Evidence

Level 3, prospective nonrandom follow-up study.

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