Classification of Mid-facial fractures on Computed Tomography following head injury in a Nigerian population

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ABSTRACT

Background: Head injury is a global epidemic, which results in fractures of the cranio-facial region. Computed Tomography (CT) is the gold standard in evaluating the head injured patient. The aim of this study was to assess the causes of head injury resulting in mid-facial fractures and to characterize and classify the observed fracture patterns and associated findings on CT.

Patients and Methods: Between 2006 and 2008, three hundred (300) consecutive patients with acute head injury were evaluated with a helical General Electric (GE CT/e) CT scan machine. Data reviewed included cause of injury, age and gender distribution, types of facial fractures sustained, associated intracranial and soft tissue injuries. The Mid-facial fractures were grouped according to the proposed classification. Sub-groups were assigned depending on the associated CT findings including soft tissue swelling, cranial fractures and intracranial abnormalities.

Results: The range of patient age was between 30 to 39 years (mean= 32.78years ± 18.51SD) with a male: female ratio of 8:3. Abnormal CT scans were seen in 244 (81.4%) of the 300 patients studied. Of the 244 abnormal cases, 79 (32.4%) patients had mid-facial fractures. Most of the fractures involved the sino-nasal complex (47.3%) while the remainder was almost equally distributed in the zygomatico-maxillary complex (24.4%) and orbital complex (28.3%).

Conclusion: Road traffic accidents (RTA) continue to be a major cause of head injury and mid- facial fractures followed by falls and assault. We have described the CT findings in mid-facial fractures following head injury in the Nigerian population and suggest a classification system for categorizing these fractures and associated findings.

INTRODUCTION

Head injury has become a global epidemic and its radiological evaluation has evolved from conventional radiography to modern cross-sectional imaging techniques like computerized tomography (CT) scans and magnetic resonance imaging (MRI). Conventional radiographs relied mostly on skull views and special projections to demonstrate the orbits, paranasal sinuses, temporal bones and base of the skull.

Road traffic accidents (RTAs) are the most common cause of facial fractures globally and in Nigeria[1-11]. Falls are common at the extremes of age, in the very young and those above 50 years of age [12-16]. In both adults and children, males are predominantly affected [1,8,10, 12, 14, 16-19]. Patients over 50 years are the only age group with a female preponderance[12].

The facial skeleton comprises the bones of the maxilla, zygoma, and the bony walls of the nasal cavity, paranasal sinuses, the orbit, and the mandible. It is one of the most complex arrangements of curving bony structures in the body and it is commonly involved in head injury [12, 20-22] Fractures involving the midface are common sequelae of motor vehicle accidents, falls, assault and other blunt trauma[17].

Facial fracture patterns in adults and children are influenced by socioeconomic factors; in addition, the anatomical characteristics of the pediatric facial skeleton also influence the fracture patterns seen in childhood[17].

Although plain radiographs are useful in detecting facial fractures, they will miss at least 65% of such fractures[13]. As a result, most surgeons prefer Computed Tomography (CT) for pre-operative evaluation of facial fractures[23].The introduction of Computed Tomography (CT) in 1972 transformed diagnostic capabilities in the demonstration of facial fractures and the advent of Spiral CT has reduced scan time and produced thinner sections with the capability of three-dimensional reconstruction [24, 25]. Computed

Tomography is now regarded as the gold standard for diagnostic imaging of head injury in children and adults[5-8, 13, 26]. The introduction of two dimensional (2D), multi-detector and three dimensional (3D) CT imaging modalities has resulted in improved ability to recognize various facial fracture types[5, 27-29]. The CT bone window reconstruction algorithm is an additional advantage in the detailed delineation of these fractures[5, 30]. Recently, cone-beam CT has also proven to be a reasonable alternative to imaging facial fractures and it has the advantage of reducing radiation dose and improving image quality[31].

Computed Tomography is indicated in the assessment of the unconscious head injured patient as it also demonstrates associated intracranial injuries[5-7, 26]. CT is also essential in further evaluation of patients with suspected facial fractures where conventional radiographs appear normal[26].

In 1901, Rene Le Fort classified fractures of the facial skeleton as seen on plain radiography. This classification was based on major lines of injury and disruption of the structural framework of the face[32]. However, 2D and 3D imaging sometimes demonstrates fracture types which do not fit into the Le Fort classification. Hence using the Le Fort classification may underestimate the complexity of facial fractures limiting the description of overall fracture patterns involving the face[27, 28]. Aside from the Le Fort classification, many authors have devised their own systems of classification to reflect patterns of craniofacial fractures now detectable on CT[27, 33, 34]. These newer classification systems were developed to accommodate fractures that do not fall into the Le Fort classification[27, 28]. Some of these classification systems also attempt to reflect surgical relevance of fractures and indices of injury severity[35, 36]. Adebayo *et al*[37] noted inconsistent terminology in the classification of maxillofacial fractures across centers. It is particularly relevant to categorize common fracture patterns and their etiology because patterns of facial fractures vary from country to country and within countries[1, 13,21,22,38]. So, any proposed classification should take into consideration the fracture patterns common to the sub-region. This study focuses on fractures involving the orbits, zygomatico-maxillary and sino-nasal complexes, as well as associated soft tissue and intracranial injuries.

Our main objective is to reiterate the incidence of these fractures following head injury in the Nigerian population and to attempt at a classification system for such mid-facial fractures based on the fracture sites and associated soft tissue and intracranial findings.

MATERIALS AND METHODS

This was a prospective study describing the Computed Tomographic patterns of fractures involving the facial bones following head injury. The associated soft tissue and intracranial findings were also noted. It was conducted in the Radiology department of the University College Hospital, (UCH) Ibadan.

Patient Selection

Three hundred (300) eligible patients who presented at the Radiology department within the study period (January 2006 to June 2008) were evaluated.

Inclusion Criteria:

Head injured patients who had CT scan within 7 days of injury.

Exclusion Criteria:

Head injured patients who had CT scan after 7 days of injury.

Restless patients in whom sedation was contraindicated

Informed consent to participate in the study was obtained from all conscious adult patients. In unconscious patients or minors (less than 18years) consent was obtained from parents or guardians.

Approval for the study was obtained from the University of Ibadan/University College Hospital ethics review committee.

Image Acquisition and Cranial Helical CT Protocol

All patients were positioned supine on the CT table, with head immobilization achieved with adhesive straps. Image acquisition was tailored to specific clinical indications. Axial non-contrast images were acquired in all patients. Coronal images were taken in the prone position in cases of suspected blow out fractures or a Le Fort fracture mechanism is suspected. Unconscious patients and patients with associated cervical spine injuries could not have direct coronal CT imaging.

All CT studies were performed using a Helical General Electric (GE CT/e) single detector scanner (General Electric medical systems). The acquisition volume for the axial images was angled parallel to the superior orbitomeatal line to avoid excessive irradiation of the orbits. Scans were taken from the level of the posterior margin of the first cervical vertebral body up to the vertex. Three (3mm) contiguous slices were acquired from the skull base in 7mm slices up to the vertex. CT parameters were 120KV and 100 mAs minimum tube for adults using a 512x512 matrix. Manufacturer pre-set pediatric protocols for CT brain were used for children to minimize radiation. Scan duration was about 5-10minutes in all cases.

Data Collection

A) Patient demographics

Comprehensive personal data regarding age, sex, and type of injury were obtained from patient's clinical records and personal interviews where possible.

B) Image Review

All CT images were initially reviewed by a senior trainee radiologist and then independently by a consultant radiologist. All images were reviewed using bone and brain windows. Fractures of individual mid- facial bones were recorded in the data sheet , after which facial fractures in each patient were then broadly divided into zygomatico-maxillary, Sino-nasal, orbital and mixed groups ,on the basis of the proposed classification system. Cranial fractures, soft tissue injuries and other intracranial findings relevant to patient care were also documented.

Statistical Analysis

The data obtained was analysed using the statistical package for social sciences (SPSS 15.0 Inc.Chicago Illinois). Correlations were obtained with chi-squared tests with 95% confidence interval. Mean values, distribution of variables are represented on tables, pie charts, histograms and bar charts where appropriate.

Proposed Classification System for mid-facial fractures detected on CT in this study-

The proposed classification system divides the mid-face into three units namely, the Zygomatico-maxillary complex (ZGMC), Sino-nasal complex (SNC) and orbital complex (OC). Sub-groups were then included to document associated injuries.

For the purpose of this study the following definitions were used:

Zygomatico-maxillary complex (ZGMC) Fractures: fractures involving the zygomatic or maxillary bones; zygomatic arch, all processes of the zygomatic bones as well as the zygomatic processes of the maxillary and frontal bones were grouped under the term ZGMC.

Sino-nasal complex (SNC) Fractures: This classification refers to fractures involving the bones of the frontal, sphenoidal and maxillary sinuses; the nasal bones; ethmoidal air cells bilaterally; the body of the sphenoid bone and its greater and lesser wings.

Orbital Complex (OC) Fractures

Any fracture involving the medial or lateral walls of the orbit, the orbital roof and the orbital floor/roof of the maxillary sinus.

Mixed Mid-Facial (MMF) Fractures

When there is a combination of at least two of the aforementioned facial fracture groups, it is classified as a mixed mid-facial fracture.

The three units: the Zygomatico-maxillary complex (ZGMC), Sino-nasal complex (SNC) and orbital complex (OC) are assigned numbers 1 to 3 respectively. The number 4 is assigned to the **Mixed Mid-Facial (MMF) fractures, i.e:**

Fractured mid-facial groups-

ZGMC =1
SNC =2
Orbital =3
Mixed =4

Sub-groups are then assigned depending on the associated CT findings as follows:

- Sub-category (a) is assigned when there is associated soft tissue swelling,
- sub-category (b) when there is associated cranial bone fracture
- sub-category (c) imply coexistent intracranial bleed/hematoma or cerebral oedema, and
- Sub-category (d) is assigned when there are intracranial foreign bodies- gun

pellets, air pockets or unclassified.

- Category (e) is for any combination of the associated findings.

The classification system was applied to all mid-facial fracture patterns seen on CT scans in this study.

RESULTS

Three hundred (300) eligible patients with head injury were evaluated. The sex and age distribution of the patients are shown in figure 1. Two hundred and eighteen (218) of the 300 patients (72.7%) were males while 82 (27.3%) were females, with an approximate male: female ratio of 8:3. The mean age was 32.78years ± 18.51 (SD); specifically 33.77 ± 17.30 for males and 30.12 ± 21.28 (SD) for females. The age difference was statically significant p=0.028 (<0.05).

Table 1 shows the incidence of the various causes of head injury by age group and sex. The modal age group for head injury was the 30-39 year old group (22.3%). It was also the most common age group for males with head injury. The most frequent female age group for head injury was 0-9 years.

Road traffic accident (RTA) was the most common cause of head injury seen in 236 (78.6%) patients, followed by falls in 35(11.7%) patients. Gun shot injury (GSI) was the least common cause 11(3.7%) recorded in the series. For all the analysed causes of head injury, males were more affected than the females.

Computed Tomographic (CT) Findings:

Of the 300 patients studied 56(18.6%) had normal imaging findings and 244(81.4%) had abnormal findings giving an approximate abnormal to normal ratio of 4:1.

Of the 244 patients with abnormal CT findings, only 79 (32.4%) patients had mid-facial fractures. Figure 2 is a pie chart of the frequency distribution of the mid-facial fractures in the head injured patients according to the proposed classification. The most prevalent mid-facial fracture was the mixed type- MMF, involving a combination of two or more groups and was seen in 37 (46.8%) of the 79 patients followed by fractures of the sino-nasal complex seen in 25 (31.6%) of 79 patients.

Table 2 is the distribution pattern in the three proposed categories of mid-facial fracture by aetiology of injury. A total of 131 mid-facial fractures were recorded in the 79 patients with mid-facial fractures (single or multiple and unilateral or bilateral fractures in any particular bone of the mid-face in a patient is recorded as one occurrence). Sixty two (47.3%) fractures involved the sino-nasal complex while 37 (28.2%) and 32 (24.4%) fractures were recorded for the orbital and ZGMC complexes respectively.

Tables 3, 4 and 5 show the total number of fractures in all bones of the mid-face.

Road traffic accident (RTA) was responsible for the highest number of fractures in all the three categories of mid-facial fractures (Table 2).

Mid- Facial Fracture Sites:

Zygomatico-maxillary complex (ZGMC) Fractures-

Table 3 shows the total number of fracture sites in the ZGMC. Slightly more fractures were recorded on the left (52.8%) than on the right. The zygomatic arch (52.8%) was the most commonly fractured part of the ZGMC.

Orbital Complex (OC) Fractures- (figs 3 and 4)

Table 4 shows the distribution of the total number of fractures in the orbital complex. More fractures were recorded on the right (59.1%) than on the left. The orbital fractures most frequently involve the lateral (37.9%) and medial (36.4%) walls of the orbit. Fractures of the orbital floor were recorded in 8 (12.1%) cases and half of these were blow-out fractures.

Sino-nasal Complex (SNC) Fractures- (fig 5)

Table 5 is the distribution of the total number of sino-nasal complex fractures. Fractures on the right side were more frequent, seen in 52.3% of the SNC fractures. The maxillary sinus (51.1%) was the most frequently involved constituent of the SNC. The SNC was a component of all the 37 cases of mixed mid-facial fractures shown in fig 2.

Mixed Mid-Facial (MMF) Fractures- (figs 6 and 7)

When there is a combination of at least two of the aforementioned facial fracture groups, it is classified as a mixed mid-facial fracture.

Apart from mid-facial fractures, other abnormal CT findings recorded in this cohort of patients included cranial fractures, intracranial haematoma, cerebral oedema, soft tissue swelling and intracranial foreign bodies like gun pellets and air pockets.

Table 6 is the distribution pattern of the CT detected mid facial fractures according to the classification system proposed based on the fracture sites and associated findings.

For all the associated findings, the highest frequencies of occurrence were in the mixed mid-facial (MMF) fracture group. Intracranial hematomas or cerebral oedema are more likely to be associated with fractures of the MMF (60%) and SNC (40%) groups There were three cases of intracerebral hematomas and two cases of cerebral oedema.

Table 1: Aetiology and incidence of Head Injury by Age group and Sex

Age group (years)	RTA n=236		GSI n=11		Assault n=18		Fall n=35		Total n=300		Total N=300 (%)
	M	F	M	F	M	F	M	F	M	F	
0-9	9	6	0	0	2	1	8	10	19	17	**36 (12%)**
10-19	16	9	1	0	2	2	3	1	22	12	**34 (11.3%)**
20-29	40	13	2	1	6	1	0	0	48	15	**63 (21%)**
30-39	51	8	5	1	0	1	1	0	57	10	**67 (22.3%)**
40-49	27	13	1	0	1	1	3	0	32	14	**46 (15.3%)**
50-59	15	3	0	0	0	0	1	0	16	3	**19 (6.3%)**
60-69	13	6	0	0	0	1	3	0	16	7	**23 (7.7%)**
70+	3	4	0	0	0	0	5	0	8	4	**12 (4%)**
Total	**174**	**62**	**9**	**2**	**11**	**7**	**24**	**11**	**218**	**82**	
%	**73.7%**	**26.3%**	**81.8%**	**18.2%**	**61.1%**	**38.9%**	**68.6%**	**31.4%**	**72.7%**	**27.3%**	**300 (100%)**
	236 (100%)		**11(100%)**		**18(100%)**		**35(100%)**		**300 (100%)**		

RTA = Road Traffic Accident; GSI= Gun Shot InjuryM= Male; F=female

Figure 1: Age group and Sex Distribution of Patients Studied

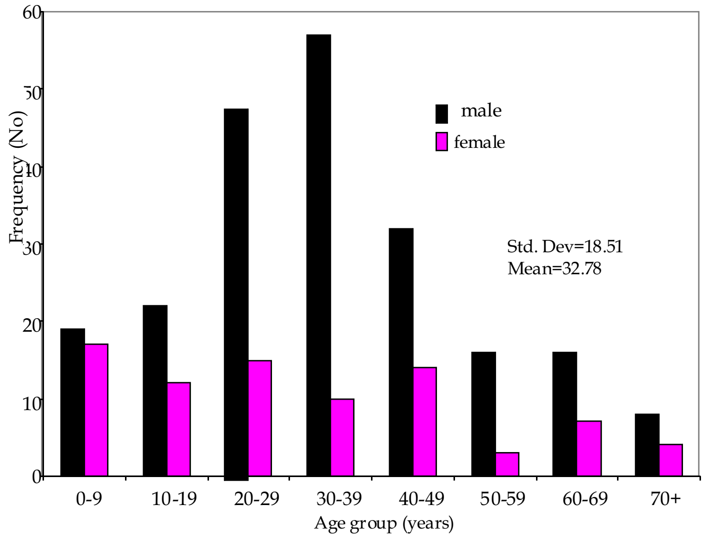


Table 2: Distribution pattern of sites of mid-facial fractures in 79 patients according to aetiology of injury

Fracture site	RTA	GSI	Assault	Fall	Total
ZGMC fractures	31	0	0	1	**32 (24.43%)**
SNC fractures	58	1	1	2	**62(47.33%)**
Orbital Complex fractures	35	1	0	1	**37(28.24%)**
Total	**124(94.7%)**	**2 (1.5%)**	**1(0.8%)**	**4(3%)**	**131(100%)***

ZGMC= Zygomaticomaxillary Complex, SNC= Sinonasal Complex
RTA = Road Traffic Accident, GSI= Gun Shot Injury
* Some patients had multiple fractures.

Figure 2: Incidence of mid-facial fractures in 79 head injured patients according to the proposed classification groups.

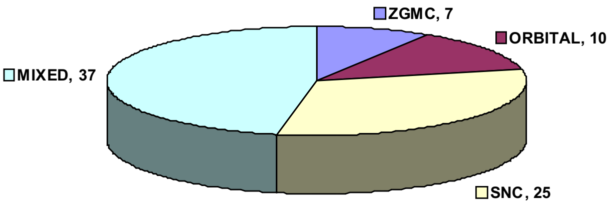


Table 4: Distribution of fracture sites in the Orbital Complex (OC) group

Fractured Orbital Complex Constituents	Right	Left	Total
Medial wall	15	9	**24 (36.4%)**
Orbital roof fracture	6	2	**8 (12.1%)**
Lateral wall	11	14	**25 (37.9%)**
Orbital floor	6	2	**8 (12.1%)**
Orbital apex	1	0	**1 (1.5%)**
Total	**39 (59.1%)**	**27 (40.9%)**	**66* (100%)**

* Some patients had multiple and/or bilateral fractures

Table 6: Frequency distribution pattern of 79 patients with Mid-Facial Fracture According to Proposed Classification System

Associated Findings/ Sub-groups	Major Group Classification				
	ZGMC= 1	SNC=2	Orbital=3	Mixed=4	Total
None	1 (7.7%)	5 (38.5%)	1 (7 .7%)	6 (46.1%)	**13 (100%)**
a	1 (8.33%)	4 (33.33%)	3 (25%)	4 (33.33%)	**12 (100%)**
b	1 (16.66%)	1 (16.66%)	1 (16.66%)	3 (50%)	**6 (100%)**
c	0 (0%)	2 (40%)	0 (0%)	3 (60%)	**5 (100%)**
d	0 (0%)	0 (0%)	2 (50%)	2 (50%)	**4 (100%)**
e	4 (10.3%)	13 (33.3%)	3 (7.7%)	19 (48.7%)	**39 (100%)**
Total	**7**	**25**	**10**	**37**	

Where:

a	=	Associated soft tissue swelling
b	=	Associated cranial bone fractures
c	=	Associated Intracranial haematoma or cerebral oedema
d	=	Associated intracranial foreign body
e	=	Any combination of a-d
ZGMC	=	Zygomatico-maxillary Complex, SNC= Sino-nasal Complex

Table 3: Distribution of fracture sites in the Zygomatico-maxillary Complex (ZGMC) group

Fractured ZGMC constituents	Right	Left	Total
Frontal process of zygoma	6	5	**11 (20.8%)**
Zygomatic arch	13	15	**28 (52.8%)**
Pterygopalatine process of maxilla	0	1	**1 (1.9%)**
Alveolar process of maxilla	0	0	**0 (0%)**
Orbital process of maxilla	0	0	**0 (0%)**
Zygomatic process of maxilla	3	2	**5 (9.4%)**
Body of Zygoma	3	5	**8 (15.1%)**
Total	**25 (47.2%)**	**28 (52.8%)**	**53* (100%)**

* Some patients had multiple and/or bilateral fractures

Table 5: Distribution of Sino-nasal complex fractures

Fractured Sino-nasal constituents	Right	Left	Total
Maxillary sinus	19	26	**45 (51.13%)**
Frontal sinus	10	4	**14 (15.91%)**
Ethmoidal sinus	6	3	**9 (10.23%)**
Sphenoidal sinus	5	3	**8 (9.09%)**
Body of sphenoid	3	3	**6 (6.82%)**
Greater wing	2	2	**4 (4.54%)**
Lesser wing	1	0	**1 (1.14%)**
Nasal Bone	-	1	**1 (1.14%)**
Total	**46 (52.3%)**	**42 (47.7%)**	**88*(100%)**

* Some patients had multiple and/or bilateral fractures

Figure 3: Axial CT image (bone window) showing bilateral orbital fractures affecting the medial wall and roof of orbit on the right and left respectively (arrows) - *orbital complex fracture.*

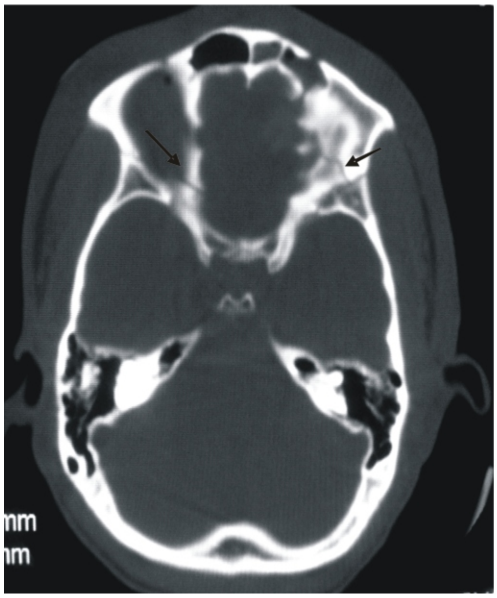


Figure 4: Coronal CT image showing a blow-out fracture of the left orbit with associated soft tissue herniation into the right maxillary sinus and sinus haematoma (white and blue arrows respectively) - ***orbital complex fracture.***

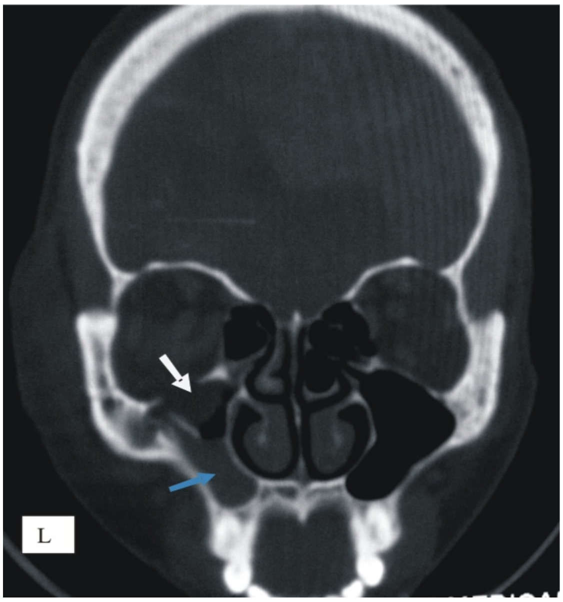


Figure 5: Axial CT image (bone window) showing communited fractures of medial and lateral walls of the right maxillary sinus (arrows). The nasal septum and medial wall of the left maxillary sinus are also fractured. Note right maxillary sinus haematoma (*Sino-nasal complex fracture*).

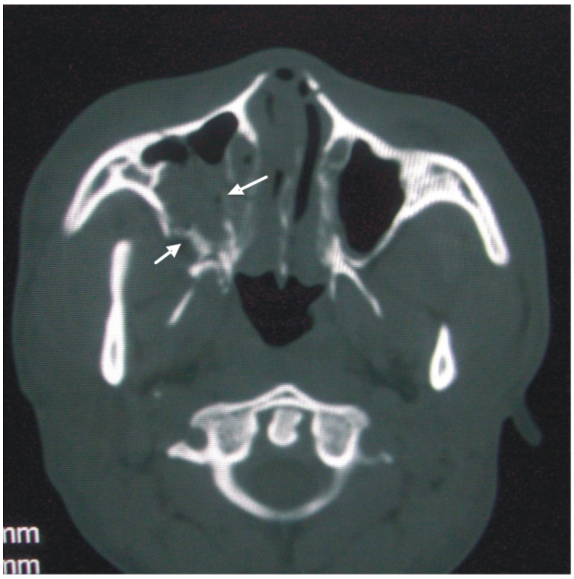


Figure 6: Axial CT image (bone window) showing a communited fracture of the left zygomatic arch (white arrow) and lateral wall of the left orbit (black arrow) with overlying soft tissue swelling- a *mixed mid-facial fracture* (ZGMC/OC combination)

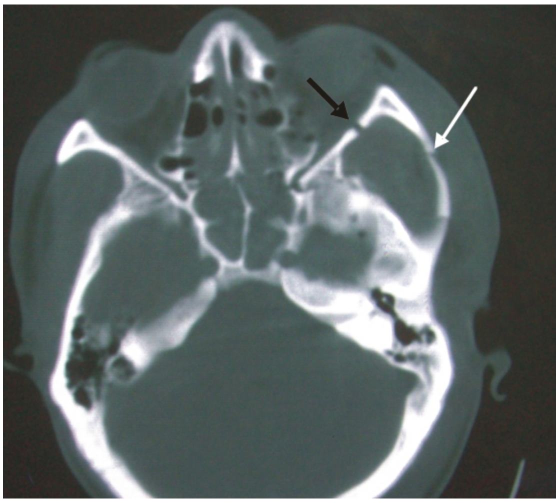
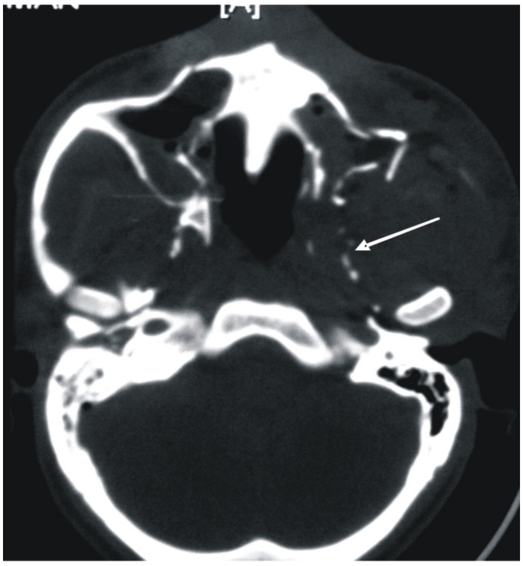


Figure 7: Axial CT image (bone window) showing communited bilateral sino-nasal complex fractures. Note bilateral hematomas in the maxillary sinuses. The associated fracture of the left pterygoid process of the maxilla (arrow) makes this a *mixed mid-facial fracture* (ZGMC/SNC combination).



DISCUSSION

Globally, the most common cause of facial fractures is road traffic accidents (RTAs) [1-4, 13, 19 21, 22] although in some regions, assault is a more common cause [18, 38, 39-45]. These differences may be accounted for by known variations in etiology between and within countries[21]. When facial fractures result from RTAs, the pattern, incidence and severity also varies according to the vehicle or mode of transportation prevalent in the region [13,17,18,46,47].

The pattern of craniofacial injuries is known to vary within and between countries depending on the socioeconomic and cultural factors prevailing at the time of study, thus necessitating a periodic verification of changing trends in the aetiology of such injuries[21].

The demographic profile of the cohort in this study was consistent with the previous reports in literature. Head injury is more common in males [2, 3, 12, 17-19, 21,22,37,48] and the modal age group of 30-39 years seen in this study, is also within the broad age range of 21-40 years recorded by previous authors [6,11,21,49]. The highest incidence in those studies was however in a slightly lower age group of 18-25 years and early exposure to driving in those areas with higher socioeconomic status is a potential factor.

The high incidence of head injury in the youth has been attributed to reckless driving and predominance of violence in that age group[21]. Road traffic accident was by far the most common cause of head injury in both males and females in this study.

Falls and assault respectively were second to RTAs as the most common aetiology in this study. This tallies with previous work done in this environment [9, 21, 22.] Hussain *et al* [12], however, found assault to be a less common cause in females. Similar to our study, Guven[50], Kaban[51] and Tanaka *et al* [52] found falls to be the second most prevalent cause of head injury. Falls are generally common at the extremes of age as noted by Reuben *et al* [23], Hussain *et al* [12] and Obajimi *et al* [6]. The low incidence of gunshot injuries (4%) in this study is in consonance with the work of Obajimi *et al* [30]. No case of industrial injury was seen in this study despite the increased incidence of industrial head injury recorded by Adeyemo *et al*[21].

In Nigeria, assault appears to be the most common cause of facial fractures in the North Eastern part of the country[38]. Generally, assault-related facial injuries show a rising trend in Nigeria and this is believed to be due to the poor socioeconomic conditions which have resulted in increased unemployment, difficult living conditions and stress with resultant propensity to crime [21, 22 and 38.]

Gunshot facial injuries have also shown a steady increase amongst the civilian population in Nigeria.[30, 63-66]. This is a direct sequela of the incessant armed robbery attacks, ethnic conflicts, as well as campus cult activities[29, 53-56]. Sports injuries, industrial accidents and falls also contribute to the various etiologies of facial injury [12,17,21,22, 48].

The role of CT scan as the imaging technique of choice in the evaluation of craniofacial injury is undisputed, even in children [13, 5-8, 26, 57]. Computed Tomography is able to obtain detailed information of bone fractures and other intracranial abnormalities associated with head injury as well as displays this information using appropriate window settings for clarity[5, 30]. Coronal imaging proved useful in the delineation of blow-out fractures and fractures involving the zygomatic arch but could not be utilized in all patients in this study due to states of consciousness and associated cervical spine injuries. Ideally, CT evaluation of facial fractures should be in multiple planes and 3D volume rendered images facilitate better understanding of potential cosmetic and functional complications [58]. High resolution ultrasonography has also proven to be useful in the evaluation of nasal fractures in children[59].

Le Fort [32] focused attention on facial fractures with the concept of the face as a unit and developed a specific system of classifying facial fractures using plain radiographs. However, CT is now the gold standard in the evaluation of patients with facial fractures[24] and the Le Fort system of classification has been found to be insufficient for accurate description of all the fracture sites that can now be seen with CT [28]. Only 45% of fracture types recorded by Buitrago-Tellez *et al* [27] could be adequately classified using the Le Fort system, while only 28.7% of patients reviewed by Donat *et al*[28] met the criteria of the Le Fort classification. Many authors have subsequently devised their own systems of classification to accommodate the perceived lapses in the Le Fort system[27, 33-35, 60-62]. Fractures of the facial skeleton have been widely studied as a composite unit [1, 12,13,27,49] or with emphasis on particular subdivisions [35, 62, 63-66]. Previous studies have shown that fractures of the Zygomatico-orbital complex and the zygomatic arch are probably the most commonly fractured bones of the facial skeleton [18,21,67]. The high incidence of involvement of these bones seems related to the prominence of these bones within the facial skeleton. Conversely, the most commonly fractured facial bones recorded in this study were those of the sino-nasal region. Sino-nasal complex (SNC) fractures most frequently involved bones of the maxillary sinus and this is presumably due to the anterior location of this sinus in the face. The frontal sinus, being protected by thick cortical bone is more resistant to fracture than any other facial bone[68]. Consequently, frontal sinus fractures usually result from high velocity impacts such as motor vehicle collisions, assaults, industrial accidents and sports injuries[68].

In this study, the zygomatic arch was the most frequently fractured bone of the ZGMC. This contrast with the studies by Adeyemo *et al*[21] and Obuekwe[11] who recorded more fractures of the body of the zygoma rather than the arch.

Orbital fractures in this study most commonly involved the medial walls due to the thin fragile bone of the lamina papyracea compared with other bones of the orbit. The lateral was also equally involved. Fractures of the medial orbital wall may be associated with herniation of orbital fat and medial rectus muscle into the ethmoid sinus while orbital floor fractures may cause herniation of extraconal soft tissue or even the inferior rectus muscle into the maxillary sinus, the so called "blow-out fractures" [26,63]. Computed tomography with 3D imaging can measure pre- and post operative orbital volumes, as well as assess post operative reduction of the displaced orbital soft tissue mass to ensure better surgical outcomes[69]. Orbital apex fractures were rare in this study as also recorded by Hopper *et al* [63]. The rarity of orbital apex fractures may arise from the fact that it is located deep in the cranium. Orbital roof fractures may be associated with injury to the dura, adjacent frontal lobe or extra ocular muscles and may rarely extend into the optic canal with resultant injury to the optic nerve[26]. Cribriform plate fractures also often involve the dura and arachnoid[26].

The need for a universally accepted and easily understood classification system for craniofacial injury is supported by the fact that the Le Fort classification could only be applied to one case in this study, a finding which has also been noted by other authors[27, 28, 33, and 60]. In view of this, a proposed classification system from this study provides a simple, convenient and reproducible method of classifying mid-facial fractures. It should provide a meaningful common terminology to communicate fracture details from radiologist to surgeon. It is similar to the system devised by Buitrago-Tellez *et al*[27], but does not denote displaced and non displaced fractures as separate sub-groups. It also does not take into consideration the amount of energy required to cause injury as described by Manson [33] and Gruss[60]. Catapano *et al*[70] have also recently developed a comprehensive classification system which includes a severity scale An advantage of our classification system is that it takes into consideration soft tissue injuries which are believed to compromise patient outcome by affecting healing and outcome of reconstructive surgery[71]. Soft tissue swelling was common in all the fracture groups but was least seen in association with ZGMC (7.7%) fractures.

A limitation of this study is that the data may not precisely reflect all possible mid-facial fracture types seen in head injury because the data analysed came from only those patients who were able to afford the CT scan. In our institution, CT scan is not always available or affordable to all victims of RTA. An average CT study in Ibadan costs 35,000 Naira which is approximately 275 US dollars. This is unaffordable for most patients in a country where 70.2% of the population live on less than $1.00 per day[72]and patients usually have to pay out of pocket since health insurance is not yet widely available.

Another limitation of our study was the use of a single slice CT scanner, as the ideal protocol suggested by Buitrago-Tellez[27] utilizes 1mm cuts with 2mm intervals and this requires a multi-slice CT. However, the single slice scanner may be the only one available in centres in the developing world and this study has shown that it is still useful in evaluating mid-facial fractures.

CONCLUSION

Fractures of the midface are common in head injured patients and computed tomography is invaluable in their assessment. A single slice CT scanner available in our centre was able to demonstrate these fractures. Road traffic accidents are the most common cause of head injury and result in a variety of fractures involving the mid-face and cranium.

A classification system which accommodates the various fracture types common to a particular environment and which describes the associated findings that may affect patient outcome is invaluable. The Le Fort system is clinically relevant; however it fails to classify all fractures types seen on CT.
A proposed classification system for this environment is presented based on CT findings from this study.

The benefits of a standard classification are improved intra and interdisciplinary agreement and will allow for the development of standard treatment protocols for the various fracture types encountered thereby improving patient care.

RECOMMENDATIONS

This study recommends the following:

1. The incidence of mid-facial trauma secondary to RTA can be reduced by enactment of appropriate legislation directed at the widespread installation of air bags into all motor vehicles and helmet use by cyclists and enforcement of traffic rules to minimize road traffic accidents.
2. Provision of Computed Tomography scanners in health care centres and subsidization of the prohibitive cost of CT to make it affordable to most head injured patients.
3. A collaborative effort between radiological centres in the country in order to develop an acceptable and sensitive classification system which can be utilized in CT assessment of patients with cranio-facial injuries.

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