

Classification of Midfacial Fractures on Computed Tomography Following Head Injury in a Nigerian Population

Yvonne U Osuagwu, Abiodun O Adeyinka, Atinuke M Agunloye, Vicky N Okoje¹

Departments of Radiology and ¹Oral and Maxillofacial Surgery, University College Hospital/College of Medicine, University of Ibadan, Oyo State, Nigeria

Correspondence: Dr. Atinuke M Agunloye, Department of Radiology, University College Hospital, Ibadan, Oyo State, Nigeria.
E-mail: tinuagunloye@yahoo.com

ABSTRACT

Background: Head injury is a global epidemic which results in fractures of the craniofacial 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 midfacial fractures and to characterize and classify the observed fracture patterns and associated findings on CT. **Patients and Methods:** Between 2006 and 2008, 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, and associated intracranial and soft tissue injuries. **Results:** The modal age group of the patients was the 30 to 39 year age group while the mean age was 32.78 years $\pm$ 18.51 standard deviation (SD) 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 midfacial fractures. The midfacial fractures were grouped according to the proposed classification. Most of the fractures involved the sinonasal complex (SNC; 47.3%), while the remainder was almost equally distributed in the zygomatico-maxillary complex (ZGMC; 24.4%) and orbital complex (OC; 28.3%). Subgroups were assigned depending on the associated CT findings including soft tissue swelling, cranial fractures, and intracranial abnormalities. **Conclusion:** Road traffic accidents (RTA) continue to be a major cause of head injury and midfacial fractures followed by falls and assault. We have described the CT findings in midfacial fractures following head injury in the study area and suggest a classification system for categorizing these fractures and associated findings.

Key words: Computed tomography; head injury; midfacial fractures

Introduction

Head injury has become a global epidemic and its radiological evaluation has evolved from conventional radiography to modern cross-sectional imaging techniques like computed 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, and 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

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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] Hence, most surgeons prefer computed tomography (CT) for preoperative evaluation of facial fractures.^[23] The introduction of 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 (3D) reconstruction.^[24,25]

CT 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 3D CT imaging modalities has resulted in improved ability to recognize various facial fracture types.^[5,27-29] The CT bone window 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]

CT 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 the 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; thus highlighting the importance of developing a universally accepted classification system for CT detected craniofacial fractures. 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] Any proposed classification should take into consideration the fracture patterns common to the subregion. This study focuses on fractures involving the

orbits, zygomatico-maxillary, and sinonasal 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 study area and to attempt at a classification system for such midfacial fractures based on the fracture sites and associated soft tissue and intracranial findings.

Patients 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 eligible patients who presented at the Radiology Department within the study period (January 2006-June 2008) were evaluated. The patients presented with head injury and had CT scan within 7 days of injury.

Informed consent to participate in the study was obtained from all conscious adult patients. In unconscious patients or minors (less than 18 years) 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 noncontrast images were acquired in all patients. Coronal images were taken in the prone position in cases of suspected blow out fractures or to better demonstrate a Le Fort fracture.

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 (3 mm) contiguous slices were taken through the base of skull and 7 mm slices up to the vertex. CT parameters were 120 kV, 100 mAs minimum tube current using a 512 × 512 matrix. Scan duration was about 5-10 min in all cases.

Data collection

Patient demographics

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

Image review

All CT images were 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 midfacial bones were recorded in the data sheet, after which facial fractures in each patient were then broadly divided into – zygomatico-maxillary, sinonasal, 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.

Proposed classification system for midfacial fractures detected on CT in this study

The proposed classification system divides the midface into three units namely, the zygomatico-maxillary complex (ZGMC), sinonasal complex (SNC), and orbital complex (OC). Subgroups were then included to document associated injuries.

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

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.

SNC fractures

This classification refers to fractures involving the frontal, sphenoidal, and maxillary sinuses; the nasal bones; ethmoidal air cells bilaterally; and the body of the sphenoid bone and its greater and lesser wings.

OC fractures

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

Mixed Midfacial Fractures

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

The three units: ZGMC, SNC, and OC are assigned numbers 1 to 3, respectively. The number 4 is assigned to the MMF;

Fractured midfacial groups

ZGMC = 1.

SNC = 2.

Orbital = 3.

Mixed = 4.

Subgroups are then assigned depending on the associated CT findings as follows:

- Subcategory (a) is assigned when there is associated soft tissue swelling,

- Subcategory (b) when there is associated cranial bone fracture,
- Subcategory (c) imply coexistent intracranial bleed/hematoma or cerebral edema, and
- Subcategory (d) is assigned when there are intracranial foreign bodies, that is, gun pellets, air pockets, or unclassified.
- Category (e) is for any combination of the associated findings.

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

Results

Three hundred eligible patients with head injury were evaluated. The sex and age distribution of the patients are shown in Figure 1. Two hundred and eighteen 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 32.78 years $\pm$ 18.51 (standard deviation (SD)); specifically 33.77 $\pm$ 17.30 for males and 30.12 $\pm$ 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 years (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.

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

Computed tomographic findings

Of the 300 patients studied; 56 (18.6%) had normal imaging

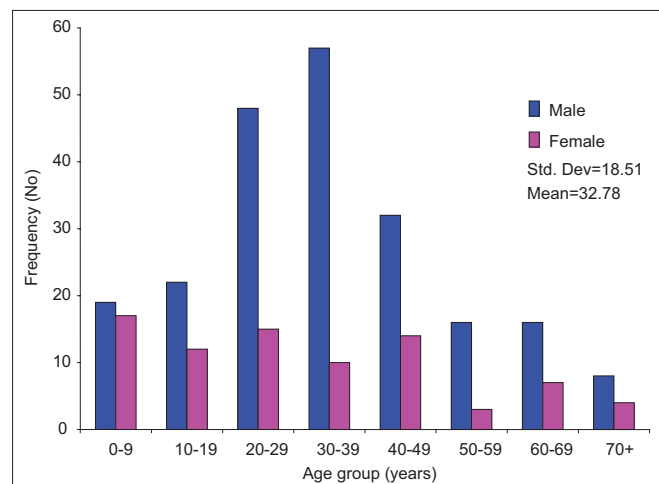


Figure 1: Age group and sex distribution of patients studied

Table 1: Etiology 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	
(%)	236 (100)		11 (100)		18 (100)		35 (100)		300 (100)		300 (100)

RTA – Road traffic accident; GSI – Gunshot injury; M – Male; F – Female

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 midfacial fractures. Figure 2 is a pie chart of the frequency distribution of the midfacial fractures in the head injured patients according to the proposed classification. The most prevalent midfacial 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 SNC seen in 25 (31.6%) of 79 patients.

Table 2 is the distribution pattern in the three proposed categories of midfacial fracture by etiology of injury. A total of 131 midfacial fractures were recorded in the 79 patients with midfacial fractures (single or multiple and unilateral or bilateral fractures in any particular bone of the midface in a patient is recorded as one occurrence). Sixty-two (47.3%) fractures involved the SNC, while 37 (28.2%) and 32 (24.4%) fractures were recorded for the orbital and ZGMCs, respectively.

Tables 3-5 however show the total number of fractures in all bones of the midface.

RTA was responsible for the highest number of fractures in all the three categories of midfacial fractures [Table 2].

Midfacial fracture sites

Zygomatico-maxillary complex 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 fractures

Table 4 shows the distribution of the total number of fractures in the OC [Figures 3 and 4]. 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 eight (12.1%) cases and half of these were blow-out fractures.

Sino-nasal complex fractures

Table 5 is the distribution of the total number of SNC fractures. Fractures on the right side were more frequent, seen in 52.3% of the SNC fractures [Figure 5]. 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 MMF fractures shown in Figure 2.

Mixed mid-facial fractures

When there is a combination of at least two of the aforementioned facial fracture groups, it is classified as a MMF fracture [Figures 6 and 7].

Apart from midfacial fractures, other abnormal CT findings recorded in this cohort of patients included cranial fractures, intracranial hematoma, cerebral edema, soft tissue swelling, and intracranial foreign bodies like gun pellets and air pockets.

Table 6 is the distribution pattern of the CT detected midfacial 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 MMF fracture group. Intracranial hematomas or cerebral edema are more likely to be associated with fractures of the MMF (60%) and SNC (40%) groups.

Discussion

Globally, the most common cause of facial fractures is RTAs,^[1-4,13,19,21,22] although in some regions, assault is a more common cause.^[18,38-45] 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

Table 2: Distribution pattern of sites of midfacial fractures in 79 patients according to etiology 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 – Zygomatico-maxillary complex; SNC – Sinonasal complex; RTA – Road traffic accident; GSI – Gunshot injury; *Some patients had multiple fractures

Table 3: Distribution of fracture sites in the 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, ZGMC – Zygomatico-maxillary complex

Table 4: Distribution of fracture sites in the orbital complex group

Fractured OC 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, OC - Orbital complex

Table 5: Distribution of sinonasal complex fractures

Fractured sinonasal 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

and between countries depending on the socioeconomic and cultural factors prevailing at the time of study, thus

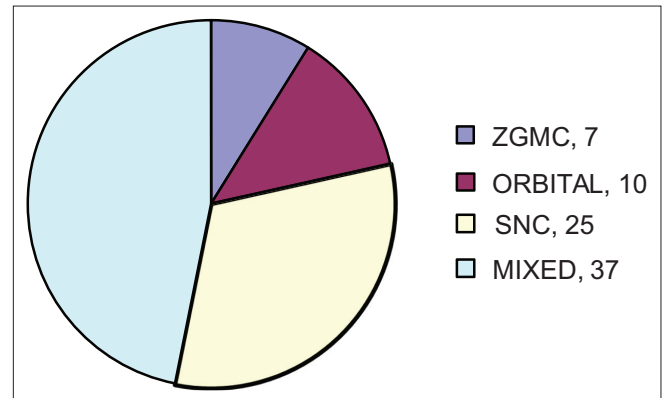


Figure 2: Incidence of midfacial fractures in 79 head injured patients according to the proposed classification groups

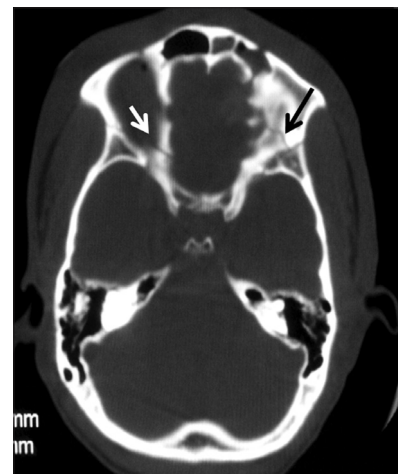


Figure 3: Axial computed tomography image (bone window) showing bilateral orbital fractures affecting the medial wall and roof of orbit on the right and left, respectively (arrows); orbital complex fracture

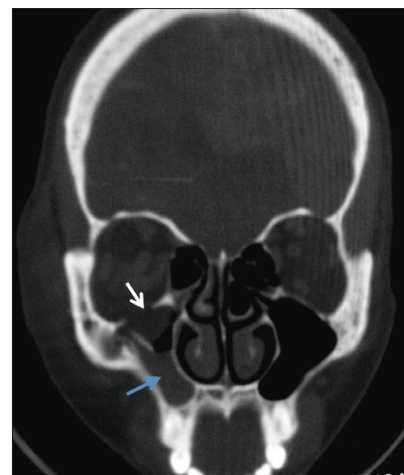


Figure 4: Coronal CT image showing a blow-out fracture of the left orbit with associated soft tissue herniation into the right maxillary sinus and sinus hematoma (white and blue arrows, respectively); orbital complex fracture

Table 6: Frequency distribution pattern of 79 patients with midfacial fracture according to proposed classification system

Associated findings/subgroups	Major group classification				Total (%)
	ZGMC=1	SNC=2	Orbital=3	Mixed=4	
None	1 (7.7%)	5 (38.5%)	1 (7 0.7%)	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	

a – Associated soft tissue swelling; b – Associated cranial bone fractures; c – Associated intracranial hematoma or cerebral edema; d – Associated intracranial foreign body; e – Any combination of a-d; ZGMC – Zygomatico-maxillary complex; SNC – Sinonasal complex

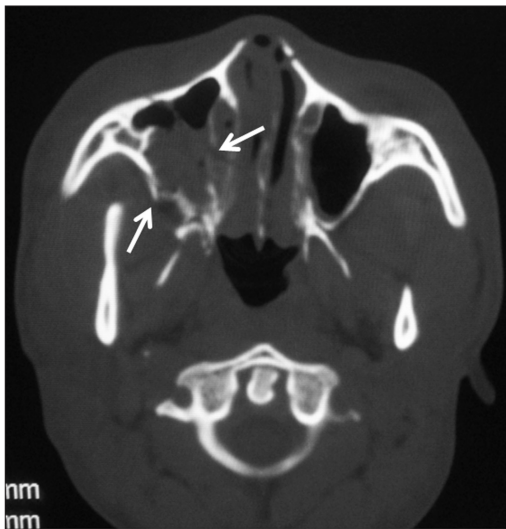


Figure 5: Axial CT image (bone window) showing comminuted fractures of medial and lateral walls of the right maxillary sinus (arrows). The nasal septum and medial wall of the left maxillary sinus are also fractured. Note right maxillary sinus hematoma (sinonasal complex fracture)

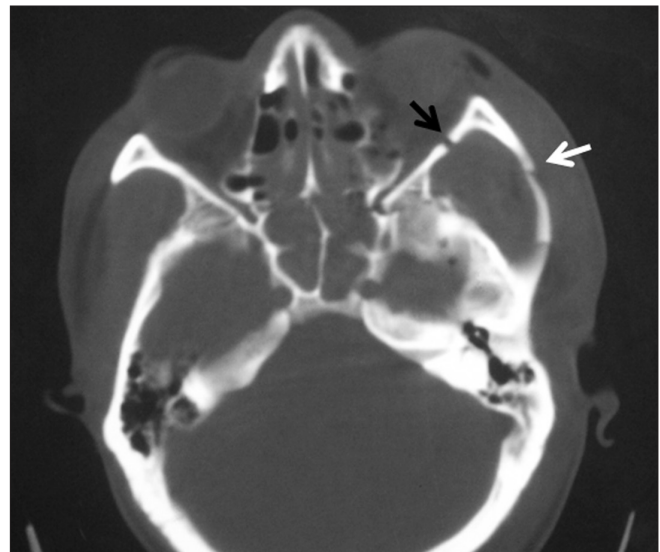


Figure 6: Axial CT image (bone window) showing fractured left zygomatic arch (white arrow) and lateral wall of the left orbit (black arrow) with overlying soft tissue swelling; a mixed midfacial fracture (ZGMC/OC combination)

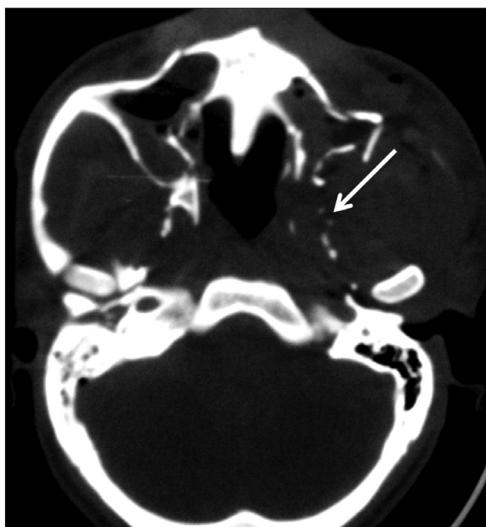


Figure 7: Axial CT image (bone window) showing bilateral sinonasal complex fractures. Note bilateral hematomas in the maxillary sinuses. The associated fracture of the left pterygoid process of the maxilla (arrow) makes this a mixed midfacial fracture (ZGMC/SNC combination)

necessitating a periodic verification of changing trends in the etiology 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 may be a factor.

The high incidence of head injury in youths has been attributed to reckless driving and increased violence in that age group.^[21] RTA was by far the commonest cause of head injury in both sexes in this study.

After RTA, falls and assault respectively were the next most common etiology in this study. This tallies with previous work done in this environment.^[9,21,22] Hussain *et al.*,^[12] however

noted assault to be a less common cause in females. In children, Guven,^[50] Kaban,^[51] and Tanaka *et al.*,^[52] also noted that falls were 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.^[21,22,38]

Gunshot facial injuries have also shown a steady increase amongst the civilian population in Nigeria.^[30,53-56] This is sequel to the incessant armed robbery attacks, ethnic conflicts, as well as campus cult activities.^[29,57-60] 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.^[13,5-8,26,61] CT 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 images facilitate better understanding of potential cosmetic and functional complications.^[62] High resolution ultrasonography has also proven to be useful in the evaluation of nasal fractures in children.^[63]

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 diagnosis of patients with facial fractures^[24] and the Le Fort system of classification is no longer sufficient to describe 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.^[27,33-35,64-66]

Fractures of the facial skeleton have been widely studied as a composite unit^[1,12,13,27,49] or with emphasis on particular subdivisions.^[35,53-56,66] 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 sinonasal region. 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 contrasts with the studies by Adeyemo *et al.*,^[21] and Obiekwe *et al.*,^[11] who recorded more fractures of the zygoma.

Orbital fractures in this study most commonly involved the medial and lateral walls probably due to the thin fragile bone of the lamina papyracea compared with other bones of the orbit. 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 herniate into the maxillary sinus, the so called "blow-out fractures".^[26,53] CT with 3D imaging can measure pre- and postoperative orbital volumes, as well as assess postoperative 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.*^[53] 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 dura and arachnoid.^[26]

The need for a universally accepted and easily understood classification system for craniofacial injury is buttressed 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.^[27,28,33,64] In view of this, a proposed classification system from this study provides a simple, convenient, and reproducible method of classifying midfacial 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 nondisplaced fractures as separate subgroups. It also does not take into consideration the amount of energy required to cause injury as described

by Manson *et al.*,^[33] and Gruss and MacKinnon.^[64] However, an advantage of this 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.^[70] 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 classification system is that individual fractured bones are not separately identified as only the particular facial group is noted. Catapano *et al.*,^[71] have recently developed a comprehensive classification system which includes a severity scale.

A limitation of this study is that the data may not precisely reflect all possible midfacial fracture types seen in head injury because the data analyzed 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 lives 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 was the use of a single slice CT scanner, as the ideal protocol suggested by Buitrago-Tellez *et al.*,^[27] utilizes 1 mm cuts with 2 mm intervals and this requires a multi-slice CT. However, the single slice scanner may be the only one available in centers in the developing world and this study has shown that it is still useful in evaluating midfacial fractures.

Conclusions

Fractures of the midface are common in head injured patients and CT is invaluable in their assessment. A single slice CT scanner available in our center was able to demonstrate these fractures. RTAs are the most common cause of head injury and result in a variety of fractures involving the midface 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 fracture 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 midfacial 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 RTAs.
2. Provision of CT scanners in health care centers and subsidization of the prohibitive cost of CT to make it affordable to most head injured patients.
3. A collaborative effort between radiological centers in the country in order to develop an acceptable and sensitive classification system which can be utilized in CT assessment of patients with craniofacial injuries.

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