RESEARCH

Violence-related facial trauma: analysis of multidetector computed tomography findings of 727 patients

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Objectives: The multidetector CT (MDCT) findings of facial trauma in victims of interpersonal violence were assessed.

Methods: All MDCT requests for suspected facial injury during a 62 month period were retrieved; 727 cases met the inclusion criteria. Images were interpreted by two researchers by consensus.

Results: Of the 727 patients (aged 15–86 years old, mean 37), 583 (80.2%) were male and 144 (19.8%) female. Of all the patients, 74% had a fracture, and of these 44% had multiple non-contiguous fractures.

Conclusions: Violence is a very common cause of facial injury. Nasal and orbital fractures predominate. Males are more often involved; they are younger, sustain fractures more often and significantly more often present with high-energy fracture patterns. LeFort fractures are often unilateral or asymmetrical, and are frequently accompanied by other, clinically significant fractures. Up to 25% of patients with fractures do not have paranasal sinus effusions.

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Introduction

Violence can result in various injuries, the head and neck are regions often the most affected.¹ Trauma to these regions also accounts for the largest proportion of admissions to hospital.¹ Facial trauma may lead to life-threatening conditions, such as airway compromise and profuse blood loss.² Physical examination of facial injuries can be difficult because of soft tissue swelling, lacerations and pain.^{3,4} Early detection of visual damage is important so that adequate interventions can be instituted;⁵ furthermore, for optimal results, the surgical team needs to have an accurate understanding of the facial injuries pre-operatively.⁶ CT, a non-invasive method, is gaining increasingly more acceptance in the evaluation of facial trauma,^{6,7} as it can often visualize complex injuries with a precision unattainable by conventional radiography or clinical examination. Further, multidetector CT (MDCT) is

faster than conventional helical CT and has decreased image noise. MDCT allows high-quality multiplanar reformation (MPR) and isotropic viewing,⁸ all of which improve the diagnostic power of this imaging modality, thus benefiting the trauma patients.

As facial trauma, as a result of violence, is common and the fracture morphology is often complex, the radiologist should be familiar with the imaging findings. The purpose of this study was, therefore, to assess the MDCT findings of facial trauma in victims of interpersonal violence in a large series of consecutive patients in one institution.

Materials and methods

The study took place at Töölö Trauma Centre, Helsinki University Hospital, Finland, a trauma centre serving a population of 1.3 million. The study protocol was approved by the hospital's ethics board. The study period was 62 months, beginning from the time of the installation of the MDCT scanner (Lightspeed QX/i;

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GE Medical Systems, Milwaukee, WI) in August 2000 until September 2005.

All 2413 MDCT scans requested for suspected facial injury were retrieved using a picture-archiving and communications system (PACS). Patients without acute trauma or traumatic aetiology, as well as paediatric patients aged under 15 years, were excluded. In this retrospective study, 727 cases met the inclusion criteria of suspected facial injury due to interpersonal violence. Victims of gunshots were excluded, as were patients where the violence resulted from a fall from a height, because of the different mechanism of injury.

All patients were scanned by a four-section multi-slice CT scan with 4×1.25 mm collimation, pitch 3, table feed 3.75 mm/s, rotation time 1.0 s, tube current 40 mA, voltage 140 kV, and an approximate total exposure time of 45 s. In addition to the 1.25 mm axial images reconstructed with a 0.8 mm increment, routine 1.3 mm coronal plane MPR images were reconstructed with a 1.3 mm increment. Whenever considered clinically necessary by the attending on-call radiologist or surgeon, additional sagittal plane MPRs (24%) and three-dimensional (3D) volume-rendering images (19%) were obtained (post processing on a GE Advantage Workstation 4.3, GE Medical Systems, Milwaukee, WI). Imaging was performed, on average, 2.6 days after the trauma (range 0–61, data on the exact time was missing in 42%).

The MDCT scans were interpreted using clinical workstations (Agfa DS3000 Impax v. 4.5, Agfa-Gaevert, Mortsel, Belgium) by two researchers (EMS, MPK) by consensus. Both interpreted all of the images by themselves and any differences were resolved in a consensus read-out. The injuries were categorized into 12 groups: nasal fractures, naso-orbito-ethmoid (NOE) fractures, orbital fractures, LeFort I, LeFort II and LeFort III fractures, frontal bone fractures, zygomatic arch fractures, zygomatic complex (ZMC) fractures, maxillary fractures, mandibular fractures and skull

base fractures. In addition, effusions of the paranasal sinuses (maxillary, frontal, ethmoid and sphenoid) were recorded. Frontal bone injuries were subsequently classified according to Manolidis⁹ into five subtypes: type 1 (anterior wall fracture, minimal comminution), type 2 (anterior wall fracture, comminution), type 3 (anterior and posterior wall fracture, posterior wall fractures without significant displacement or dural injury), type 4 (anterior and posterior wall fracture, dural injury and cerebrospinal fluid leak) and type 5 (as type 4 with additional soft tissue or bone loss or severe disruption of the anterior cranial fossa).

Results

Of the 727 participants (aged 15–86 years, mean 37), 583 (80.2%) were male (15–74 years, mean 36) and 144 (19.8%) were female (16–86 years, mean 41). Of these, 538 (74.0%) had a fracture; of the 583 males and 144 females, 454 (77.9%) and 84 (58.3%), respectively, had a fracture.

The 538 patients with a fracture were aged on average 38 years (range 15–82): the 454 males, 37 years-old (range 15–74) and the 84 females, 42 years-old (range 16–82) (Figure 1). Altogether, these 538 patients had 926 different types of fractures (Table 1). Multiple non-contiguous fractures were sustained by 235 patients.

Isolated nasal fractures were detected in 256 patients: 42 unilateral and 185 bilateral nasal bone fractures, 113 unilateral and 42 bilateral fractures of the nasal process of maxilla and 79 nasal septal fractures. Isolated zygomatic arch fractures were detected in 24 patients. Maxillary fractures were present in 91 patients, 6 of whom had a bilateral fracture. All 14 NOE fractures were unilateral, and a nasolacrimal canal fracture was associated in all but 1 case (93%). Of the 131 patients with ZMC fractures, only 1 had a bilateral fracture.

Figure 1 Age distribution of all 727 victims of violence and the 538 with fractures

Table 1 Findings in 727 victims of violence

	<i>Number of patients with fractures (males/females)</i>	<i>Percentage of all patients</i>	<i>Age (years), mean, range</i>	<i>Sinus effusions (%)</i>
Nasal	256 (223/33)	35	39 (15–82)	70
Orbital	192 (152/40)	26	38 (16–73)	85
ZMC	131 (116/15)	18	37 (16–74)	98
Maxilla	91 (78/13)	13	38 (15–59)	87
Mandible	68 (58/10)	9	38 (16–65)	62
LeFort I	43 (41/2)	6	44 (22–74)	100
LeFort II	34 (33/1)	5	44 (22–72)	100
Skull base	31 (30/1)	4	40 (18–64)	97
Zygomatic arch	24 (22/2)	3	37 (18–60)	58
LeFort III	19 (19/0)	3	42 (18–58)	100
Frontal bone	18 (18/0)	2	40 (29–65)	94
NOE	14 (13/1)	2	35 (17–52)	100
Other fractures	5 (5/0)	1	41 (24–54)	60
Total	926 (808/118)*	–	37 (15–86)†	63*
No fracture	189 (129/60)	26	37 (15–86)	27

*Patients with multiple fractures occur more than once

†Mean age and range in 727 patients

**Sinus effusions in 727 patients (%)

NOE, naso-orbito-ethmoid; ZMC, zygomatic complex

Altogether 192 patients had 242 isolated orbital fractures: 115 floor, 107 medial, 14 roof and 6 lateral wall fractures. Of these, 103, 99, 13 and 3, respectively, had an intact orbital rim and were thus classified as blow-out or blow-in fractures (Figure 2a,b). A total of 68 patients had 106 mandibular fractures: 10 condylar, 29 subcondylar, 11 coronoid, 2 ramus, 20 angular, 4 body, 19 parasymphysis, 8 symphysis and 3 isolated alveolar. Altogether 46 patients had a type of fracture involving the alveolar ridges.

Of the 18 isolated frontal fractures, 4 were type 1, 4 were type 2, 5 were type 3, 3 were type 4 and 2 were type 5. Skull base fractures were detected in 31 patients. Furthermore, five cases were found with an isolated pterygoid plate fracture without a LeFort fracture. Four of these five patients had, among other fractures, a subcondylar fracture of the mandible (Figure 3). LeFort fractures were detected in 48 patients (46 male, 2 female; mean age 44 years). The LeFort I, II and III fractures were classified as symmetric (same kind of fracture on both the left and right side of the face) and asymmetric (unilateral fracture or a different kind of LeFort fracture on the right or left side). Of the 48 patients, 22 had symmetric, 10 asymmetric and 16 both symmetric and asymmetric fractures. Co-existing types of LeFort fractures were also frequent (Table 2, Figure 4).

In the group of 538 patients with a fracture, 134 (25%) had a clear sinus sign (CSS) and an absence of paranasal sinus effusions,¹⁰ whereas, among the 189 non-fractured patients, 138 (73%) had clear sinuses (Figure 1). Thickened paranasal sinus mucosa of a chronic nature was not considered as free fluid.¹⁰ In the further analysis of CSS, cases with clear sinus and a fracture were excluded because imaging was performed over a week after the trauma. Also not included were fractures non-adjacent to sinus walls (nasal, mandibular, zygomatic arch, lateral and superior walls of the orbit, maxillary alveolar and skull base not involving the sinuses). The remaining 25 patients, presenting a

false positive CSS, had 12 orbital floor and 9 medial wall fractures, 3 maxillary sinus anterior, 1 posterior and 1 medial wall fracture, 1 frontal bone fracture and 1 ZMC fracture. Further, the CSS was viewed in cases with isolated nasal, isolated zygomatic arch and isolated mandibular fractures. Effusions in the sinuses were detected in 45%, 33% and 14%, respectively.

Skull base fractures were frequently associated with facial fractures; of the 31 patients with a skull base fracture, 20 had multiple facial fractures, and only in 1 case was no facial fracture detected.

Discussion

Violence is a major problem worldwide. Cultural and social factors may result in varying injury patterns between victims in different nations and communities.¹¹

In this study, violence was involved in 30% of all suspected facial trauma, which is less than previously reported in urban trauma centres: Laski *et al*¹² reported that the majority (75%) of facial trauma cases are the result of violence.

The epidemiology and demographics of trauma-related facial injury are relatively well known and, in comparing the results with earlier reports, global. At the authors' institution, an average of 11.7 patients per month (108/1 000 000 annual incidence) are imaged with MDCT because of suspected violence-related facial trauma. Of these, 8.7 patients per month (80/1 000 000 annual incidence) have a facial or skull base fracture. These numbers may be an underestimation of the actual incidence because victims of minor facial trauma are not always transferred to the trauma centre. Furthermore, some patients, particularly young women, suffering violence may falsely report a falling accident.^{13–15}

Similar to other studies,^{1,11,16,17} this report had a male predominance, 4:1. This was even more evident in

a

b

Figure 2 (a,b) A 31-year-old male sustained a medial blow-out fracture (arrows) of the right orbit after a kick to the right side of the face. An air-fluid level interface is present (arrowhead)

those patients with a fracture, 6.4 males, to 1 female. According to Downing *et al*,¹ victims of violence are more often males in all age groups, except in those over 75. This study showed similar findings; there were more male patients in all age groups, except in those over 70 (Figure 1). Only 7 patients were over 70, the mean age of all patients was 37. Of those with a fracture, the mean age was 38, which is slightly higher than the mean age of 33, reported by Eggensperger *et al*.¹⁶ In our study, male victims were younger: 36 years compared with 41 years in females. The highest age peak was in 35- to 40-year-olds in males and in 45- to 50-year-olds in females (Figure 1). Patients with high-energy fractures (skull base, frontal, and, LeFort I, II and III) were older than patients with other types of fractures.

Overall, violence-related trauma seems to predominantly affect the young and middle-aged. Whether injury type, location and mechanism also differ between

Figure 3 A 24-year-old male who sustained subcondylar (arrow), pterygoid plate (arrowhead) and nasal fractures as a result of hitting and kicking

genders is controversial.^{11,18} In our study, however, males had significantly more high-energy fractures; females had no frontal bone or LeFort III fractures. In addition, females had no isolated pterygoid plate fractures. Furthermore, skull base, LeFort I and LeFort II fractures were detected almost exclusively in males. Typical for both genders is that violence often results in injuries of the head, neck or face.^{1,11} Among domestic abuse victims, significantly more are females, whereas males are more likely to be involved in altercations.¹⁸ The most common form of interpersonal violence is a hit with a fist, but high-energy means, such as use of brass knuckles or kicking, are increasing.¹⁴ Abuse of alcohol and drugs contributes markedly to the rising incidence of violent trauma,¹⁶ and males are significantly more likely to be intoxicated at the time of trauma.¹⁸ Violence takes place mostly on the weekends and during holiday seasons.^{17,19} Victims of violence often suffer from additional problems, such as drug abuse and poverty, in contrast to patients with different injury aetiology, such as sport or motor vehicle accidents.¹⁸ These factors can lead to treatment complications and suboptimal clinical outcomes despite improved surgical techniques.¹⁸

In Eggensperger *et al*,¹⁶ the mandible was fractured in 24% of patients with maxillofacial fractures, and 76% of fractures were in the middle and upper facial skeleton; there was a predominance of 2:1 for the left side in all fractures, except the mandible, with orbital

Table 2 Distribution of LeFort I, II and III fractures in 48 patients

Type of LeFort fracture	Number of patients
LF I (unilat.)	4
LF I (bilat.)	8
LF II (unilat.)	1
LF II (bilat.)	0
LF III (unilat.)	1
LF III (bilat.)	1
LF I (unilat.) + LF II (bilat.)	2
LF I (bilat.) + LF II (unilat.)	7
LF I (bilat.) + LF II (bilat.)	7
LF II (unilat.) + LF III (unilat.)	1
LF II (bilat.) + LF III (unilat.)	1
LF I (unilat.) + LF II (unilat.) + LF III (unilat.)	3
LF I (unilat.) + LF II (bilat.) + LF III (bilat.)	2
LF I (bilat.) + LF II (unilat.) + LF III (unilat.)	2
LF I (bilat.) + LF II (bilat.) + LF III (unilat.)	2
LF I (bilat.) + LF II (bilat.) + LF III (bilat.)	6

LF, LeFort; unilat., unilateral; bilat. bilateral

and zygomatic bone fractures constituting 50%. Of the 926 fractures, 827 (92%) were in the middle or upper facial skeleton but only 68 (8%) were in the mandible (31 skull base fractures not included). The nasal bone and the orbit were the areas most often involved; of the

538 patients with a fracture, 48% had nasal and 36% had orbital fractures. The nasolacrimal canal was fractured in 93% of the NOE cases. Often, the facial trauma was complicated; of the 538 patients with a fracture, 235 (44%) had multiple non-contiguous fractures. Unlike fall-from-height accidents²⁰ with “sentinel fractures”, that is, low-energy fractures strongly correlating with underlying high-energy fractures, violence-inflicted traumas can occur as low-energy patterns only. Therefore, it is more difficult to establish a threshold beyond which the likelihood of underlying high-energy fractures rises. All patients with a frontal bone, LeFort I, II or III, or an isolated pterygoid plate fracture had at least one other separate fracture type. This was also the case with all but one skull base fracture patient. The results, therefore, suggest that, in patients sustaining such a high-energy fracture pattern, extra care should be taken to find additional low-energy fractures and, correspondingly, low-energy fractures may obscure an underlying high-energy fracture. Interestingly, only 19% of 48 patients with a LeFort fracture presented as typical symmetrical, single fractures (Table 2).

Figure 4 (a) Right side; (b) left side. 3D images of a 46-year-old male. Violence resulted in bilateral LeFort I (black arrows) and II (black arrowheads) fractures, a unilateral LeFort III fracture on the left side (asterisks) and a fractured nasal bone (white arrow). (c) Axial image of the same patient, fractures indicated with white arrowheads

An orbital or maxillary fracture can be suspected when an air–fluid level is present in the paranasal sinuses;^{10,21} injury to the lining of the sinuses results in this free fluid.^{10,21} However, 25 patients were found with clear sinuses despite suffering a fracture of a bone adjacent to the sinus wall. Most of these fractures were medial and inferior fractures of the orbit. In addition, 337 patients (46%) had fractures in bones not adjacent to sinuses. Even though these fractures have previously been considered as not showing the CSS,¹⁰ sinus effusions were found in 45% of patients with an isolated nasal fracture. The aetiology of these effusions remains unexplored.

CT is used routinely to detect skeletal and visceral injuries in multiple injury patients.²² CT is the modality of choice to provide exact information on the amount of comminution and extensions of multiple fracture lines.²³ On CT, facial fractures may not always be observed elaborately; even major fracture patterns, such as ZMC or LeFort fractures, can be quite subtle.¹⁰ However, minimally displaced subtle fractures (that is, fractures of the orbital floor) are important to detect.¹⁰ Thin-section CT scans have a very good contrast for the differentiation of normal and deformed bony and soft

tissue structures.⁵ Spiral MDCT rapidly provides high-resolution images and 3D reformation capability with little patient co-operation.⁵ The 3D reconstructions are a valuable aid in assessing complex injury patterns.²⁴

In conclusion, violence is a very common cause of facial injury. Males are more often involved; they are younger, sustain fractures more often and present high-energy fracture patterns significantly more often. Of the 727 patients examined for suspected facial injury, 74% had a fracture and, of these, 44% had multiple non-contiguous fractures. Nasal and orbital fractures were most common, presenting with low-energy trauma. However, all fracture patterns occur in violence-related trauma and, more importantly, up to 14% of patients with a fracture present with high-energy fracture patterns. The radiologist interpreting these findings should be aware that up to 25% of patients with fractures do not have paranasal sinus effusions, that high-energy LeFort fractures often present as unilateral or asymmetrical fractures and that they are frequently accompanied by other, clinically significant fractures as well. In the authors' experience, MDCT provides the best means for accurate diagnosis of these injuries.

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