ORIGINAL ARTICLE

Evaluation of pterygoid plate fractures unrelated to Le Fort fractures using maxillofacial computed tomography

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ABSTRACT

BACKGROUND: This study aims to describe the major pterygoid plate fractures (PPFs) patterns unrelated to Le Fort fractures (LFFs) using maxillofacial computed tomography (CT).

METHODS: After obtaining our hospital ethics committee approval (37-05), data for PPF were acquired from the medical records of all the trauma patients who were diagnosed using CT at our hospital from April 2014 to April 2017.

RESULTS: Of the 178 patients, 135 (male/female = 86/49; mean age = 37.2 years) had LFF and 43 (male/female = 35/8; mean age = 38.6 years) had PPF without associated LFF. PPF patterns unrelated to LFF included temporal bone (11.6%), sphenotemporal buttress (25.5%), zygomaticomaxillary complex (30.2%), displaced mandible (23.3%), nasal (4.7%), and isolated fractures (4.7%). The etiologies of facial fractures were not significantly different between both sexes (p=0.576). No significant difference between Le Fort and non-Le Fort groups was found for age (p=0.603) and the causes of trauma (p=0.183).

CONCLUSION: PPF is most commonly seen with LFF, but it may also be seen alone or with other non-LFF indicating that all PPF are not related to LFF. Axial reformatted CT images can easily display PPF and the degree of displacement of the fragments, and they can be used to guide surgical reduction of the fractures.

Keywords: Computed tomography; Le Fort fractures; pterygoid plate.

INTRODUCTION

Facial injuries are common presentations to the emergency department, and various fractures concerning the calvarial, skull base, and facial structures after the craniofacial trauma can be observed. The clinical and radiological evaluation of facial fractures is important for the accurate diagnosis and treatment of patients. Therefore, the most commonly used imaging method in the detection of facial fractures is computed tomography (CT). The pterygoid plate fracture (PPF) was originally described and classified by Rene Le Fort[1] and the findings of PPF don't refer to only the Le Fort fractures (LFF). This study aimed to focus on the PPF patterns using maxillofacial CT scans and to describe the major PPF patterns unrelated to LFF.

MATERIALS AND METHODS

Study Population

Data for PPF were retrospectively collected from the medical records of all the trauma patients who were diagnosed using maxillofacial CT scan at our hospital from 1 April 2014 to 1 April 2017. After obtaining our hospital ethics committee approval (37-05), clinical information including the patient's age, sex, and etiology of injury were extracted from the medical records. Patients with inadequate medical records or inadequate CT scan due to motion or breathing artifacts were excluded.

CT Technique and Image Analysis

Imaging was performed using a 128-slice CT scanner (Op-

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tima CT 660, GE Healthcare System, Milwaukee, USA), (120 kV; 150 mAs; collimation = 64 × 0.5; slice thickness = ≤2 mm; matrix = 512 × 512 pixels; gantry tilt = 0°). We used the medical image processing software (AW Volume Share 5) to show the 2-dimensional (2D) and 3-dimensional (3D) CT images that were acquired in the axial plane. The reformatted coronal and sagittal images were obtained from the axial images on a workstation. All images of the patients were reviewed for PPF and other accompanying facial fractures, and then they were separated into two groups (Le Fort and non-Le Fort [LF]) by one author who had 10 years of experience in neuroimaging.

Statistical Analysis

The descriptive statistics used for statistical analyses included mean and standard deviation for the numerical variables. The frequency and percentages were used for the categorical variables. The numerical variables were compared using independent-samples t-test for LF and non-LF groups. The qualitative data of the both groups were compared using chi-square test. The statistical analysis was conducted using statistical software (SPSS, version 21.0; SPSS Inc, Chicago, IL, USA). A p-value of <0.05 was considered statistically significant.

RESULTS

According to the medical records, 196 patients were diagnosed with PPF between April 2014 and April 2017. Eighteen patients were excluded because of inadequate CT scans. Finally, CT images of 178 patients [male (M)/female (F) = 121/57; mean age (MA) ± standard deviation (SD) = 37.3±18.9 years; range = 4–82 years] who had PPF were included.

Of these patients, 135 had LFF (M/F=86/49; M/F ratio=1.7/1; MA±SD=36.9±18.7 years, range 8–82 years), and the distribution of their fractures were as follows: type I (38/135; 28.1%), type II (72/135; 53.3%), and type III (25/135; 18.6%). Furthermore, 14 patients had more than one LFF type, and 43 patients (M/F=35/8; M/F ratio = 4.3/1; MA±SD=38.6±19.7 years, range = 4–80 years) had non-LFF (unilateral, n=37; bilateral, n=6). PPF patterns in these patients were as follows: temporal bone fracture (5/43; 11.6%) (Fig. 1), sphenotemporal buttress fracture (11/43; 25.5%) (Fig. 2), zygomaticomaxillary complex fracture (13/43; 30.2%) (Fig. 3), displaced mandible fracture (10/43; 23.3%) (Fig. 4), nasal bone fracture (2/43; 4.7%) (Fig. 5), and isolated fracture (2/43; 4.7%).

The causes of the trauma in the LF group were motor vehicle accidents (MVAs) (78/135; 57.8%), work-related injuries (12/135; 8.9%), assaults (35/135; 25.9%), and falls (10/135; 7.4%). In non-LFF group, the causes of the trauma were MVAs (23/43; 53.5%), work-related injuries (9/43; 20.9%), assaults (8/43; 18.6%), and falls (3/43; 7%). Fractures were more in males than in females in the LF (63.7%) and non-LF groups (81.3%). The most common cause of facial fractures

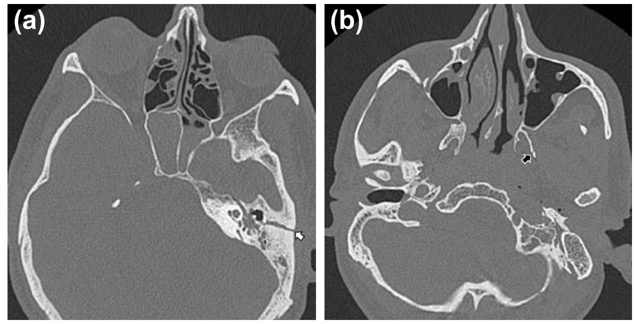

Figure 1. A 26-year-old man with temporal fracture. Axial computed tomography (CT) image **(a)** reveals an oblique fracture of the left temporal bone (arrow). The fracture extends through the left pterygoid plates (**b**, arrow).

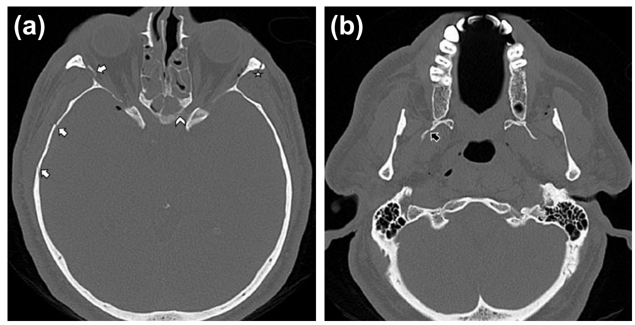

Figure 2. A 36-year-old man with sphenotemporal buttress fracture. Axial CT image **(a)** reveals a fracture of the right sphenotemporal buttress (arrows). The left zygoma is also fractured (asterisk). The fracture extends through the central skull base (**a**, arrowhead) and into the right pterygoid plates (**b**, arrow).

was MVAs in the LF (57.8%) and non-LF groups (53.5%). The etiologies of facial fractures were not significantly different between the sexes (p=0.576). No significant difference between the LF and non-LF groups was found for age (p=0.603) and the causes of trauma (p=0.183).

DISCUSSION

Facial fractures occur in many severely injured patients with facial trauma. The causes of fractures vary for different countries because of various contributing factors such as environmental, cultural, and socioeconomic factors. Collecting regional data on trauma patients is important as it allows for better management and prevention in that region. In Europe, assault and fall are the main causes of facial fractures, whereas in our country, MVAs and assaults are the main causes.[2,3] According to our study, the most common causes of facial fractures were MVAs and assaults, as previously demonstrated by other studies.[3–8] Violation of speed limits, failure to wear seat belts, use of intoxicating agents, behavioral disorders, and inadequate road safety awareness are the major reasons for the large numbers of MVAs in our country. Our patients were predominantly male, as in the previous studies.[3–8] The male predominance in a country depends on the culture and socioeconomic status of that country. In Turkey, there is male dominance. In our study, the mean age of patients with non-

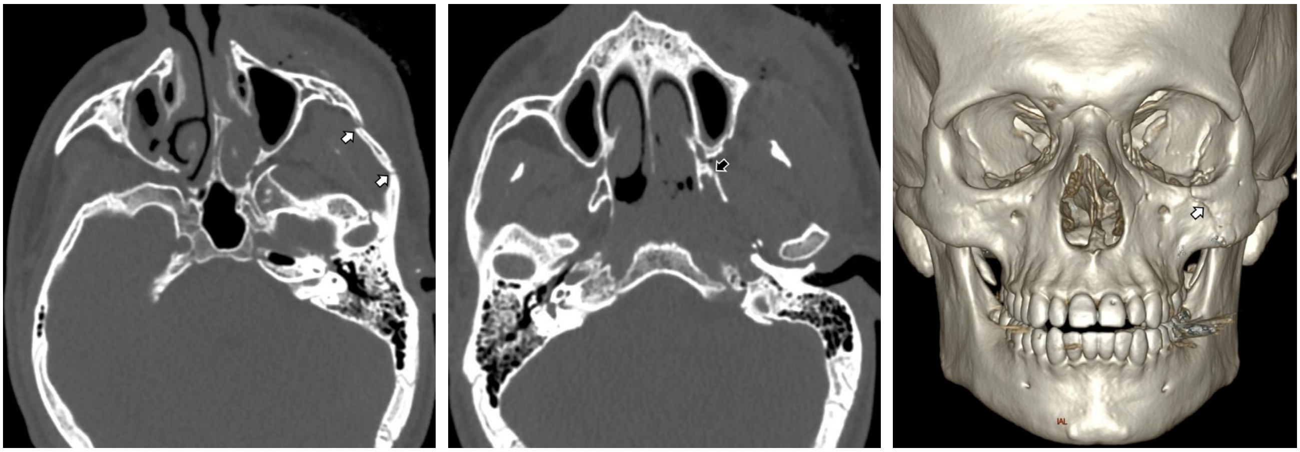

Figure 3. A 28-year-old man with zygomaticomaxillary complex fracture. Axial **(a)** CT image shows the left zygomaticomaxillary complex fracture (white arrows). The fracture extends into the ipsilateral pterygoid plates (**b**, black arrow). Coronal reformatted CT image **(c)** reveals the maxillary components of this complex fracture (white arrow).

Figure 4. A 44-year-old man with displaced mandible fracture. Reformatted axial oblique CT image reveals fractures of the right basis and the left angle region of the mandible (white arrows). The left pterygoid plates are also fractured (black arrow).

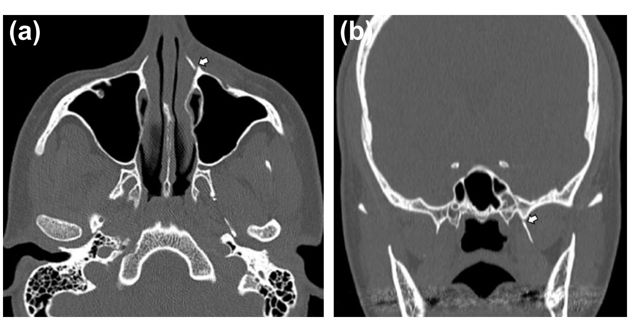

Figure 5. A 17-year-old man with nasal fracture. Axial CT image **(a)** reveals fracture of the left nasal process of the maxilla (arrow). The left pterygoid plate is also fractured (arrow) on coronal CT image **(b)**.

LFF was 38.6 years. Previous studies have shown that facial fractures are more common between the second and fourth decades of life and can affect both sexes, and our results correspond with these studies.[4,9]

For the diagnosis of facial fractures, knowledge of the regional anatomy is important. In practice, the buttresses that represent areas of the relative increased bone thickness supporting the functional units of the face are used to systematically evaluate the facial anatomical structure.[10] One such buttress is the posterior maxillary buttress, which is a column of bone at the pterygomaxillary junction. PPs, which are posteroinferior projections of the sphenoid bone, connect to the base of the middle cranial fossa and the posterior of the maxilla at this junction. Different types of fractures may affect this region, and LFF is mostly observed in these fractures.[11] LFF can be unilateral or bilateral, symmetrical or asymmetrical, and are often concomitant with other facial fractures such as frontal sinus and naso-orbital-ethmoid fractures. The findings of PPF don't refer to only LFF, but other fracture types may cause PPF unrelated to LFF. Jingang et al. reported that if CT images reveal PPF in patients with maxillofacial injury, LFF is likely to have occurred.[12] In our study, about one-fourth of the patients with PPF did not have LFF. Garg et al. reported that 37.3% of the cases with PPF did not have LFF.[13] Similar findings were reported by different studies.[14,15] Our results show that PPF can be used as an indirect diagnostic evidence of LFF, but not in all patients, since other types of fractures can involve PP such as temporal and sphenotemporal buttress. These fractures result from a direct or indirect traumatic force exerted on the calvarial, skull base, and facial structures. There are several mechanisms of injury that propagate along the zones of weakness within the facial structures. In the skull base fractures, the temporal bone is usually involved, and the temporal fracture extends toward PP. This finding is in line with the work of Lanigan et al.[16] The status of the external canal and facial nerve can be the most important aspect of temporal fractures. Ecchymosis of the postauricular skin and periorbital area may be noted in the skull base/temporal fractures. In sphenotemporal buttress fractures, the connections with the temporal, zygomatic, and sphenoid bones are lost, and the fracture line extends to PP. Also, the fracture line may radiate into the weak structures around the superior orbital fissure or the optic canal, and the visual acuity and ocular motility may be affected in patients with sphenotemporal buttress fracture. The zygomatic arch fracture can be a component of the zygomaticomaxillary complex fracture, LFF, or may be isolated. The zygomaticomaxillary complex fracture is the result of an oblique injury to the face, and the depressed zygoma fractures are frequently accompanied by this injury. PPF can be seen in this complex fracture due to displaced bone fragments. There may be entrapment, dystopia, enophthalmos, and numbness in the infraorbital nerve distribution because of orbital floor and/or lateral orbital wall fractures. When the mandible is fractured by a lateral force, it may be displaced medially toward the posterior maxillary sinus or PP.[17,18] Contusions over the jaw or preauricular area, malocclusion, and neurapraxia of the facial nerve can be observed. We also identified a small number of patients who had nasal fractures accompanied by PPF or isolated PPF that was only seen one side. The possible causes of these unilateral fractures may be penetrating trauma or traction of the pterygoid muscle.[13,19] It is worth noting that Garg et al.[13] reported PPF patterns similar to the ones we observed in our study.

The cause of trauma may be important in predicting the fracture pattern and clinical findings (e.g., assaults most often cause mandibular fractures).[9] For the accurate diagnosis and treatment of patients, the clinical and radiological evaluation should proceed systematically. On physical examination, some findings may suggest underlying abnormality such as bony step-offs, maxillary mobility, malocclusion, and enophthalmos. Airway compromise is not uncommon in patients with facial fractures, and the airway should be secured. Indications and methods of surgical treatment of facial fractures are quite diverse. It is important for clinicians/surgeons to know the location of the fracture and affected bones. If any abnormalities are encountered on physical examination that may suggest an underlying fracture, maxillofacial CT scans should be ordered. A thin-slice high-resolution CT scan has become the standard imaging method for evaluating the facial fractures and decisions for treatment.[20,21] As the facial films frequently lack the details of facial involvement seen on CT, both nondisplaced and minimally displaced fractures can be overlooked.[22] Axial and reformatted CT images can easily show the fractured bones, degree of displacement of the fragments, and soft tissue changes.[23] In our study, axial reformatted and 3D-CT images helped to show and characterize the fracture patterns.

Our study has some limitations. First, not all patients with facial trauma underwent CT scans in clinical settings. Second, in the facial trauma cases examined using CT; it is possible to miss PPF due to the different levels of experience of clinicians and radiologists. Third, we did not do the clinical follow-up of the majority of the patients.

In conclusion, PPF is most commonly seen with LFF, but may be seen alone or with other non-LFF, indicating that all PPF are not related to LFF. Axial and reformatted CT images can easily show PPF and the degree of displacement of the fragments, and they can be used to guide surgical reduction of the fractures.

Conflict of interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZET*

Bilgisayarlı tomografide Le Fort dışı pterygoid plate kırıkları

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AMAÇ: Bu çalışmada geriye dönük olarak bilgisayarlı tomografide (BT) saptanan pterygoid plate (PP) kırıkları incelenerek, Le Fort kırıkları ile ilişkisiz olan PP kırık paternlerinin tanımlanması ve sınıflandırılması amaçlandı.
GEREÇ VE YÖNTEM: Hastanemizde Nisan 2014 ile Nisan 2017 tarihleri arasında BT'de PP kırığı saptanmış hastaların tıbbi bilgileri etik kurul onayı (37–05) alındıktan sonra incelendi. Klinik bilgilerine ulaşılamayan, BT görüntüleri tanısal kalitede olmayan hastalar çalışma dışında bırakıldı.
BULGULAR: Çalışmaya 178 hasta dahil edildi. Hastaların 135'inde Le Fort tipi kırıklar (Erkek/Kadın = 86/49; ortalama yaş 37.2), 43'ünde (Erkek/Kadın = 35/8; ortalama yaş 38.6) Le Fort kırıkları ile ilişkisiz PP kırıkları saptandı. Le Fort dışı PP kırıkları; zigomatikomaksiller kompleks (%30.2), temporal (%11.6), sphenotemporal buttress (%25.5), deplase mandibula (%23.3) ve nazal (%4.7) kırıklara eşlik ediyordu. Ayrıca PP kırıkları, hastaların %4.7'sinde izoleydi. PP kırıkları, Le Fort ile birlikte olan ve olmayan hasta grupları arasında cinsiyet, yaş, travmanın tipi bakımından istatistiksel olarak anlamlı ilişki bulunmadı ($p>0.05$).
TARTIŞMA: Klinik ve radyolojik olarak PP kırıkları sıklıkla Le Fort tipi kırıkları işaret etse de izole veya Le Fort dışı diğer kraniofasial kırıklarla da az olmayan oranda birlikte görülebilir. Bilgisayarlı tomografi, farklı PP kırık paternlerinin tanısında, tedavi şekillerinin belirlenmesinde ve takiplerinde değerlidir.
Anahtar sözcükler: Bilgisayarlı tomografi; Le Fort kırıkları; pterygoid plate.

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