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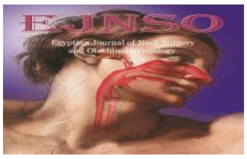

Accuracy of multislice computed tomography scanning in traumatic facial nerve paralysis

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Abstract:

Background: One of the most serious complications of temporal bone fracture is facial nerve paralysis. Early diagnosis of traumatic facial nerve paralysis has a very crucial impact on its outcome. Reaching an optimum diagnosis requires good imaging modalities .
Objective: We aimed to determine the validity of multislice computed tomography in temporal bone fracture.
Patients and methods: We enrolled 20 patients with traumatic facial nerve paralysis secondary to temporal bone fracture with a mean age of 23.10±11.44 years. Most of the patients were males, and motor car accident was the most frequent cause of trauma. All patients had preoperative high-resolution CT(HRCT) scanning, and the results were compared with the intraoperative findings.
Results: HRCT had the highest diagnostic accuracy (95%) for the detection of the mastoid process and otic capsule fractures, followed by squamous part fracture (80%). The least diagnostic accuracy was in the detection of fracture of the posterior meatal wall (45%). Fracture of the tympanic portion of the temporal bone was present in three patients while HRCT failed to catch it. Bone chips and edema of the facial nerve were the most frequent findings intraoperatively.
Conclusion: HRCT has an additive role in the assessment of facial nerve injury in case of temporal bone fracture, but should be interpreted with caution where it might underestimate the severity in some cases.
Keywords: Temporal bone, Facial nerve, HRCT, Facial paralysis

Introduction

Temporal bone fractures associated with facial paralysis are commonly spread among young males, and timing the onset deeply affects the outcome. The onset of facial nerve palsy could be immediate, delayed, or undetermined. The latter usually happens in unconscious patients. Complete paralysis may occur in up to 25% of cases. [1] Surgical exploration is indicated if there is 90-95% loss of function found on serial electroneuronography, or if there is axonal degeneration on electromyography (EMG) with no sign of recovery. [2] High-resolution multislice computed tomography (HRCT) is necessary for the management of traumatic facial paralysis. HRCT is

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considered the best tool for imaging the fallopian canal of the facial nerve. [3]

Patients and methods:

A cross-sectional study was conducted during the period from May 2018 to March 2020. The study was carried out on 20 patients who presented with facial nerve paralysis due to temporal bone trauma. The study included 18 males and 2 females aged ranging from 8 to 53 years old. All the patients were subjected to full history taking and general examination. Complete otolaryngological, head, and neck examination with special concern on ear examination was done. Then, an audiological assessment including pure tone audiometry, tympanometry, and stapedial reflex was performed. Finally, serial electroneurography and high-resolution multislice computed tomography (HRCT) were done. All patients underwent facial nerve exploration through a trans-mastoid approach from the first genu till the stylomastoid foramen, and the radiological and intraoperative findings were correlated .

High-resolution computed tomography: The patient was placed in the supine position to obtain axial CT images and the gantry was tilted until the acquisition planes were placed infra-orbitally parallel to the orbital floor. This leads to an oblique-axial imaging plane to spare the eye from direct radiation exposure. Coronal images were obtained perpendicular to the axial imaging plane, parallel to the mandibular ramus. Using a HRCT, the acquisition was done with 140 kV and 180-220 mAS utilizing a 0.75-1 S rotation time and a 512×512 matrix, and 60-90 mm field-of-view (FoV).

We used collimation of 2×0.5 mm slice thickness with a table feed of 0.8 mm per rotation. Images were calculated for each side separately utilizing an increment of 0.2-0.3 and a high-resolution algorithm. Window width and center of 4000 and 200 Hounsfield Units (HU) respectively were used to allow a better reading of these images. We used axial images to obtain 1-mm thick multiplanar reformats in coronal, sagittal, or oblique planes.

Image reformats :

The reformat is obtained with the superior semicircular canal can be seen enface (Figure 1A). To make the reformat, the axial images must be loaded. An image showing the apex of the superior semicircular canal (SSCC) is selected and a plane parallel to the superior semicircular canal is chosen (Figure1B).

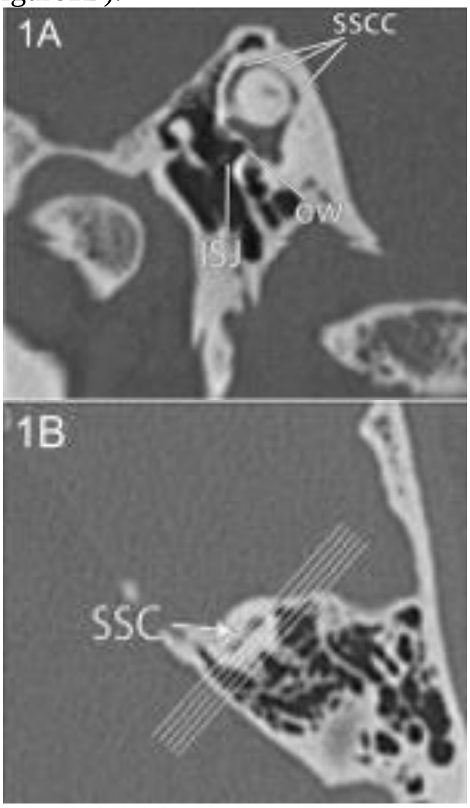

Figure 1: (A) Poschl-view CT reformats showing the whole superior semicircular canal (SSCC) (ISJ; incudostapedial joint, OW; oval window). (B) Axial CT image close to the dome of superior semicircular canal showing the reformatting plane (lines). [4]

Statistical analysis:

Data was collected and analyzed using SPSS (Statistical Package for the Social Science, version 20, IBM, and Armonk, New York).

Nominal data were expressed in form of frequency (%) while continuous data were expressed in form of mean ± SD.

The diagnostic accuracy of HRCT was assessed by the receiver operating characteristics curve. Confidence level was kept at 95%. P value < 0.05 was considered significant. We analyzed the statistical significance of the obtained results using sensitivity, specificity, and predictive value.

Results

We enrolled 20 patients with unilateral immediate post-traumatic facial paralysis, their ages ranged from 8 to 53 years old with a mean age of 23.10 ± 11.44 years. Eighteen (90%) patients were males and 2 (10%) patients were females.

The commonest cause of trauma was motor car accidents (75%) followed by assault injuries (15%). Nine (45%) patients had perforated tympanic membranes.

As regards hearing; 7 (35%) patients had unilateral conductive hearing loss, 6 (30%) patients had unilateral mixed hearing loss, and one patient had unilateral sensorineural hearing loss as shown in table 1.

As regards HRCT scanning, the otic sparing fracture was found in 17 (85%) patients and the otic fracture was found in two patients (figure2), while we could not detect a fracture line in one patient. Fracture mastoid process, squamous part, posterior meatal wall, tegmen, otic capsule and scutum were present in 8 (40%), 9 (45%), 6 (30%), 1 (5%), 3 (15%) and 2 (10%). Each of the second genu and mastoid portion of the fallopian canal was affected in 8 (40%) patients, while each of the labyrinthine part, first genu, and the tympanic portion of the fallopian canal was affected in two patients. Disrupted Ossicles were found in 5(25%) patients as shown in table 2.

Table 1: Baseline data of enrolled patients.

Variables	N= 20
Age (years)	23.10 ± 11.44
Sex	
Male	18 (90%)
Female	2 (10%)
Mode of trauma	
Motor car accident	15 (75%)
Assault	3 (15%)
Blunt trauma	1 (5%)
Fall from height	1 (5%)
Perforated tympanic membrane	9 (45%)
Audiogram	
Unilateral conductive hearing loss	7 (35%)
Unilateral mixed hearing loss	6 (30%)
Unilateral sensorineural affection	1 (5%)
Bilateral affection	6 (30%)

Intraoperatively, we found fractures of the mastoid process, squamous part, tympanic part, posterior meatal wall, tegmen, otic capsule, and scutum of the temporal bone in 7 (35%), 9 (45%), 3 (15%), 13 (65%), 3 (15%), 2 (10%), and 5 (25%) patients, respectively (figure 3). Also, we noticed fractures of the first genu, second genu, tympanic portion, and mastoid portion of the fallopian canal in 1 (5%), 3 (15%), 3 (15%), and 5 (25%) patients respectively. The majority (70%) of the patients had disrupted ossicles. As regards the facial nerve, we found complete cuts in 2 (10%) patients while dehiscence was found in 3(15%) patients. We found bone chips compressing the nerve in 13 (65%) patients and, the lacerated nerve in 4 (20%) patients as shown in table 3.

When we correlated both results, we found HRCT had 95% overall diagnostic accuracy in the detection of disrupted ossicles and fracture of both mastoid process and otic capsule. The overall diagnostic accuracy decreased to 85% in case of fracture of the first genu, second genu, and tympanic portion of the fallopian canal. Diagnostic accuracy was 80% in the case of squamous part fracture, while the least diagnostic accuracy was in the detection of posterior meatal wall fracture. We also noticed that HRCT failed to detect fracture of the tympanic portion of the temporal bone, although it was present in three patients. Also, HRCT showed a fracture of the labyrinthine part of the fallopian canal in two patients although we could not detect it intraoperatively as shown in table 4.

Table 2: HRCT scanning results among enrolled patients.

HRCT results	N= 20
Type of fracture	
Otic sparing	17 (85%)
Otic fracture	2 (10%)
No fracture	1 (5%)
Temporal bone fracture	
Mastoid process	8 (40%)
Squamous part	9 (45%)
Posterior meatal wall	6 (30%)
Tegmen	1 (5%)
Otic capsule	3 (15%)
Scutum	2 (10%)
Fallopian canal fracture	
Labyrinthine part	2 (10%)
First genu	2 (10%)
Second genu	8 (40%)
Tympanic portion	2 (10%)
Mastoid portion	8 (40%)
Disrupted Ossicles	5 (25%)

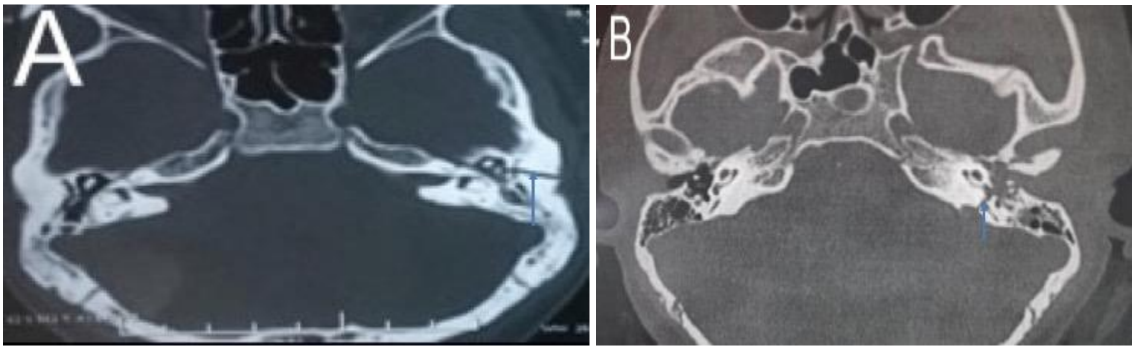

Figure 2: Axial HRCT scanning of the temporal bone (A) Left otic sparing fracture showing fracture involving squamous part of the temporal bone and 1st genu with disrupted incudo-malleolar joint, (B) Left otic fracture showing fracture involving the inner ear with disrupted ossicles.

Table 3: Operative findings among enrolled patients:

Intraoperative findings	Number
Temporal bone fracture	
Mastoid process	7 (35%)
Squamous part	9 (45%)
Tympanic part	3 (15%)
Posterior meatal wall	13 (65%)
Tegmen	3 (15%)
Otic capsule	2 (10%)
Scutum	5 (25%)
Fallopian canal fracture	
First genu	1 (5%)
Second genu	3 (15%)
Tympanic portion	3 (15%)
Mastoid portion	5 (25%)
Disrupted ossicles	14 (70%)
facial nerve condition	
Dehiscence	3 (15%)
Bone chips	13 (65%)
Complete cut	2 (10%)
Lacerated	4 (20%)

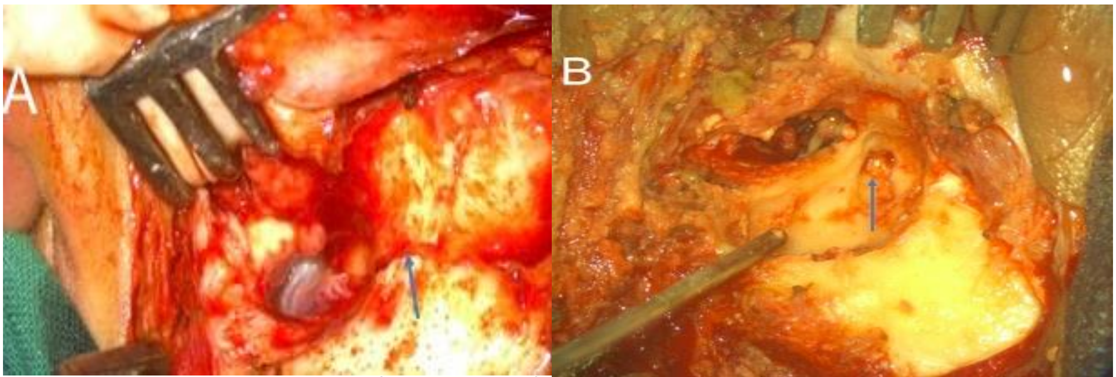

Figure 3: Intraoperative view (A) Left otic sparing fracture showing the fracture line in the squamous part of the temporal bone and involving the external auditory canal with extension to the lateral attic wall, (B) Left otic fracture involving the lateral semicircular canal.

Table 4: Accuracy of HRCT in comparison to operative findings

Variables	HRCT	Operative	SE	SP	PPV	NPV	AC
Temporal fracture							
Mastoid process	8 (40%)	7 (35%)	100%	92.3%	87.5%	100%	95%
Squamous part	9 (45%)	9 (45%)	78%	82%	78%	82%	80%
Tympanic part	0	3 (15%)	--	--	--	--	--
Posterior meatal wall	6 (30%)	13 (65%)	30.8%	71.4%	66.7%	35.7%	45%
Tegmen	1 (5%)	3 (15%)	33.3%	100%	100%	89.5%	90%
Otic capsule	3 (15%)	2 (10%)	100%	94.4%	66.7%	100%	95%
Scutum	2 (10%)	5 (25%)	20%	93.3%	50%	77.7%	75%
Fallopian fracture							
Labyrinthine	2 (10%)	0	--	--	--	--	--
First genu	2 (10%)	1 (5%)	0	89.5%	0	94.4%	85%
Second genu	8 (40%)	3 (15%)	100%	70.6%	100%	37.5%	85%
Tympanic portion	2 (10%)	3 (15%)	33.3%	94.1%	88.9%	50%	85%
Mastoid portion	8 (40%)	5 (25%)	60%	66.7%	37.5%	83.3%	65%
Disrupted ossicles	5 (25%)	14 (70%)	100%	83.3%	93.3%	100%	95%

MSCT: multi-slice computed tomography; SE: sensitivity; SP: specificity; PPV: positive predictive value; NPV: negative predictive value and AC: Accuracy

Discussion :

Temporal bone trauma is a common finding in the emergency unit, especially in adolescent males. Advances in radiology have enabled us to obtain thin-section images with multiplanar reconstructions hence, the anatomy can be evaluated precisely. Temporal bone contains tiny structures, canals, and fissures that must be excluded from true fractures. Structures such as the tympanic cavity, ossicles, otic capsule, fallopian canal, internal carotid artery, and jugular foramen must be examined. Injury of these vital structures may lead to serious complications. [5]

Usually, 6-10% of patients who suffered from temporal bone fractures may have facial nerve paralysis. Fortunately, otic capsule fractures occur in 2.5-5.8 % of temporal bone fractures, of which 30-50 % of patients may have a facial paralysis. On the contrary, in patients with otic sparing fractures, which are more common, the incidence of facial paralysis is 6-14 %. [6]

If temporal bone fractures are not discovered early, this may result in a permanent disability that might affect the quality of life. HRCT is helpful for evaluating such fractures, and multiplanar reconstructions have become available and facilitate early diagnosis. [7]

The current work was done to assess the role of HRCT in evaluating the facial nerve in case of temporal bone fracture. Rajati et al.[3] studied 41 patients with traumatic facial nerve paralysis and found that the mean age was 22.60 ± 13.23 years. Also, most of the patients (80.5%) were males and motor car accidents were present in 87.9% of patients. Also, they noticed that conductive hearing loss was present in 43.9% of patients, 22% of patients had sensorineural hearing loss, and 4.8% had mixed hearing loss. [3] This was in agreement with our study, as the mean age of patients was 23.10±11.44 years and most of them were males. Also, the motor car accident was the most frequent cause of injury and Conductive, mixed, and sensorineural hearing losses were present in 35%, 30%, and 5% of patients respectively.

In another study, the previous authors reported that tegmen tympani was the most frequently affected site [3], while Hato et al., [8] found that geniculate ganglion was the most common site followed by the tympanic segment. Based on our surgical findings, the most commonly affected sites were the posterior meatal wall (65%) and the least affected site was the otic capsule .

In our study, we found that the facial nerve was mostly affected by bone chips in 65% of patients followed by edema and lacerations in 30% and 20% of patients respectively. This was in agreement with Yetiser et al., [9] who stated that bone chips, edema, and hematoma were the most frequent findings. In contrast, previous studies reported that fibrosis and dehiscence were the most common findings. [3, 10]

Guo A. et al., [11] found HRCT had a high predictive diagnostic rate above 90 % in traumatic facial paralysis. In our study, HRCT had 95% overall diagnostic accuracy in the detection of disrupted ossicles, fracture mastoid process, and otic capsule. Rajati et al. reported that the overall sensitivity and specificity of HRCT to delineate the fracture line were 77.5 and 77.7 %, respectively. Depending on fracture location, the temporal bone cortex had the highest sensitivity while the medial wall of the antrum had the lowest sensitivity. [3]

We found that HRCT had low diagnostic accuracy for Scutal fracture, although it had a high specificity (93.3%). This was consistent with other authors' results, which could be explained by the complex three-dimensional anatomy of the sutum, which might decrease the imaging sensitivity. [3]

The overall diagnostic accuracy of HRCT in fracture of the first genu, second genu, and tympanic portion of the fallopian canal reached up to 85%, with the least diagnostic accuracy in the detection of posterior meatal wall fracture. Also, HRCT failed to detect a fracture of the tympanic plate of the temporal bone, although it was present in three patients, and HRCT revealed a fracture of the labyrinthine part of the facial canal in two patients although it could not be seen intraoperatively.

In agreement with our results, a previous study stated that the sensitivity of HRCT is higher in the vertical facial canal than in the tympanic segment[3]. This might be explained by the oblique route of the tympanic segment or the eggshell bone over the nerve. However, the vertical segment has a longer vertical course and is surrounded by air cells, so the fracture line could be delineated clearly in this segment.

On the other hand, Yan C. et al.[12] reported that the sensitivity of HRCT in detecting fracture at the pyramid and mastoid segment was only 16.7% and 11.1%, respectively. In other words, HRCT could not detect fractures at the pyramid and mastoid segment in most cases. While the sensitivity for the tympanic segment of the facial canal was 52.6%.

According to our study, the accuracy of HRCT scanning depends on the fracture location. Mastoid cortex and squamous part fractures have a low incidence of false negative results so; we can depend on their appearance in HRCT scanning. On the other side, the vertical facial canal had the highest false negative results so; we cannot exclude facial nerve injury in the presence of a normal CT scan. Also, the scutum had the lowest false positive results so; HRCT is considered a good tool to delineate the fracture. On the contrary, HRCT had the highest false positive results in the case of the mastoid cortex and otic capsule fractures so; this should be in mind during surgery.

Conclusion:

Temporal bone fractures are associated with high-speed trauma. Early management depends on stabilization of the general condition and treatment of the associated intracranial injury. HRCT of the temporal bone was able to accurately delineate fractures in most cases but highly underestimated fractures in some cases. So, the results of HRCT should be taken with caution .

Conflict of interest: There is no conflict of interest**.**

Ethical considerations: An informed written consent was obtained from all participants and their parents in case of child patient. The study was approved by the Ethical Committee of Faculty of Medicine at Assiut University (No;17100449).

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