ROLE OF HIGH RESOLUTION COMPUTED TOMOGRAPHY IN THE EVALUATION OF TEMPORAL BONE FRACTURE

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CHENNAI

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CERTIFICATE

This is to certify that this dissertation entitled " **ROLE OF HIGH RESOLUTION COMPUTED TOMOGRAPHY IN THE EVALUATION OF TEMPORAL BONE FRACTURE** " submitted by **Dr.R.Manimaran** to the faculty of Neurosurgery, The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfilment of the requirement in the award of degree of **MASTER OF CHIRURGIE IN NEURO SURGERY**, **Branch – II**, for the **August 2013** examination is a bonafide research work carried out by him under our direct supervision and guidance.

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DECLARATION

I, **Dr.R.MANIMARAN** solemnly declare that the dissertation titled "**ROLE OF HIGH RESOLUTION COMPUTED TOMOGRAPHY IN THE EVALUATION OF TEMPORAL BONE FRACTURE**" has been prepared by me under supervision of Professor and HOD, Department of Neurosurgery, Madurai Medical College and Government Rajaji Hospital, Madurai between **2012** and **2013**.

This is submitted to The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfilment of the requirement for the award of **MASTER OF CHIRURGIE, M.Ch., NEUROSURGERY** degree examination to be held in **AUGUST 2013.**

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I owe my prayers to The Lord, who gave me the inner strength to complete this work.

CONTENTS

INTRODUCTION

Head injury is one among the common killers in modern day road traffic accidents, young adults are the most common victims [21].Skull base and temporal bone fractures are frequently associated with severe high velocity head trauma. Most common sensory organ injured is ear [22]. Because of the seriousness and immediate care needed for the associated major brain parenchymal injuries, these fractures are often overlooked.

Temporal bone is one among the complex bones in the human body. Apart from protecting the brain by bordering middle and posterior cranial fossae, it contains various important organs such as middle and inner ear cavity with its contents, 7th and 8th cranial nerves, internal carotid artery and jugular vein.

Even though most of these fractures are not life threatening, they are often associated with severe morbidity which has got a major impact on the quality of life and also requires prolonged rehabilitation.

Routine practice in head injury is to have a conventional Computed Tomography of the brain and bone window in axial sections and treat accordingly. These conventional Computed Tomography has got its own limitations and often missed finer details of the temporal bone fractures. So it is imperative to include High Definition Computed Tomography [23] in the armamentarium of the investigations for head injury. There is no clear consensus about to whom this High Resolution Computed Tomography is needed.

AIMS AND OBJECTIVES

- To define the diagnostic value of the High Resolution Computed Tomography in Temporal bone fractures.

- To highlight the superiority of High Resolution computed Tomography in defining the extent of the fracture.

REVIEW OF LITERATURE

Embryology of Temporal Bone

The skull is derived from mesenchymal surroundings of the developing brain. These mesenchymal condensations are converted into mature skull bone in two ways,

- Membranous Ossification
- Cartilaginous Ossification

Temporal bone is formed partly in membranous and partly in Cartilaginous way.

Squamous and tympanic parts are formed in membrane.

Petrous and mastoid parts are formed in cartilage from Otic capsule

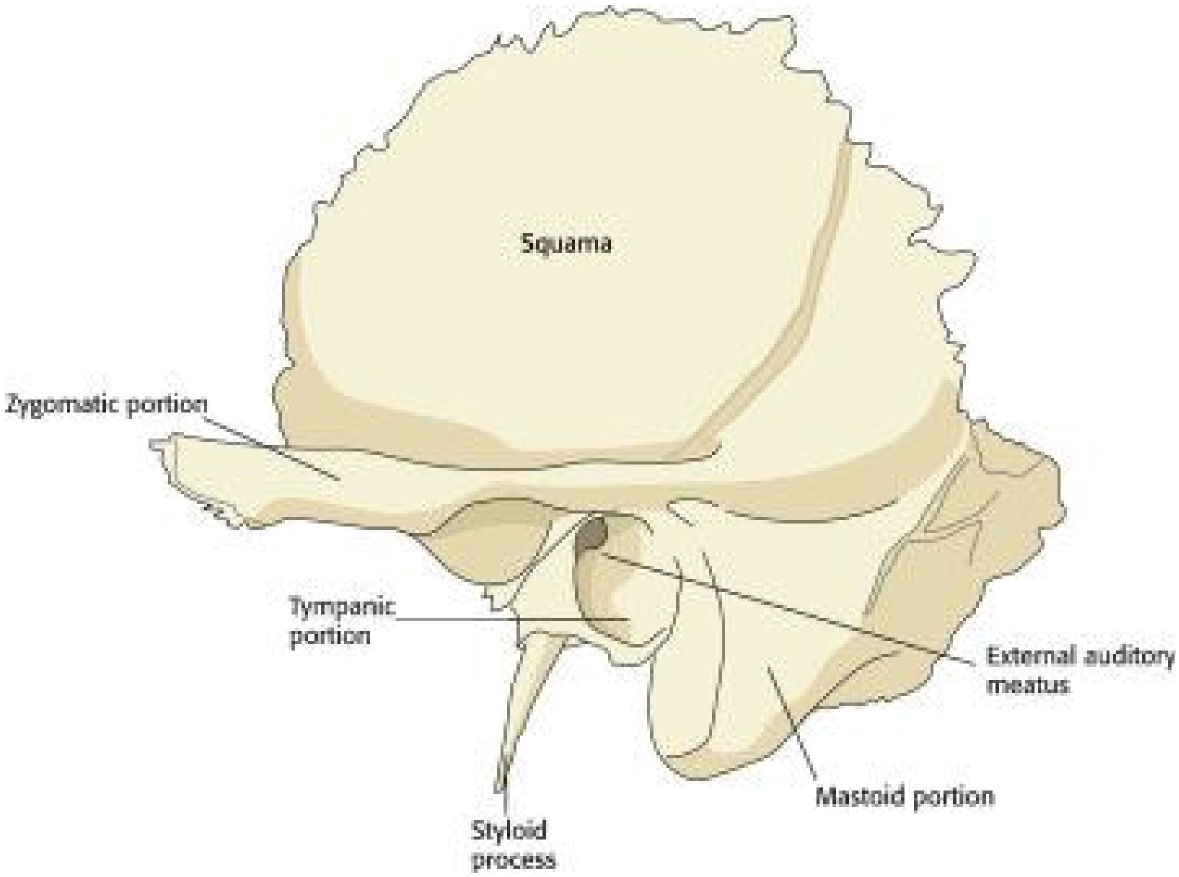
Styloid process is formed from 2nd branchial arch,

Anatomy of Temporal bone

Temporal bony anatomy is a complex one. Three dimensional anatomical knowledge is necessary to define the pathologies affecting this part of the skull. It forms the boundaries of middle and posterior cranial fossae and also houses middle and inner ear structures, 7th and 8^{th} cranial nerves, internal carotid artery and jugular vein.

It is divided into 5 parts

- Squamous part
- Petrous part
- Tympanic part
- Mastoid part
- Styloid part



Figure

Squamous part of Temporal bone

This anterosuperior part is very thin and translucent. It has two surfaces,

- Temporal surface
- Cerebral surface

Temporal surface is superficial and it contains a vertical groove for middle temporal artery.Suprameatal crest is in its posterior part gives attachment to temporalis fascia and muscle.Suprameatal triangle is in the anterior end of the crest which is an important landmark for mastoid antrum.

Cerebral surface covers the temporal lobe and contains groove for middle meningeal vessels. It has two borders,

- Superior
- Anteroinferior

Superior border continuous with parietal bone.Anteroinferior border merges with the greater wing of sphenoid bone.

Squama contains Zygomatic process and mandibular fossa. Superior border of the Zygoma gives attachment to temporal fascia and to few fibres of the masseter muscle.Mandibular fossa provides articulating surface for mandible and non articulating posterior part related to Parotid gland.

Petrous part of the Temporal bone

It is pyramidal in shape and wedged between occipital and sphenoid bones. It has a base,apex,three surfaces and three angles.

Base

Merges with Squama and mastoid parts of the temporal bone

Apex

Irregular and rough part which contains internal opening of carotid canal and makes foramen lacerum's posterolateral boundary.

Surfaces

- Anterior
- Posterior
- Inferior

Anterior surface has six landmarks,

- Arcuate eminence
- Tegmen tympani
- Facial hiatus
- Opening for lesser petrosal nerve
- Trigeminal ganglionic impression

Posterior surface consists,

- Internal acoustic meatus
- Area cribrosa media
- Foramen singulare
- Area cribrosa superior

- Area facians
- Vestibular aqueduct
- Subarcuate fossa

Inferior surface contains

- Carotid canal opening
- Jugular fossa for superior jugular bulb
- Depression for inferior glossopharyngeal ganglion
- cochlear canaliculus
- Mastoid canaliculus

Margins

- Superior
- Posterior
- Anterior

Tympanic part of Temporal bone

It lies between squama and petrous parts of the temporal bone.It has two surfaces and three borders.

Posterior surface is related to the floor of the external acoustic meatus and presents tympanic sulcus for the attachment of tympanic membrane.

Anterior surface is related to mandibular fossa and parotid gland.

Lateral border is related to external acoustic meatus.

Inferior border forms the sheath of vaginal process

Upper border is merged with glenoid tubercle.

Mastoid part of Temporal bone

It has two surfaces and

Outer surface presents

Mastoid foramen with a occipital artery branch and a vein to transverse sinus.

Mastoid process gives origin to Sternomastoid,Longissimus and splenius capitis.

Mastoid notch with Digastric muscle.

Occipital groove for occipital artery.

Inner surface consists of

Sigmoid Sulcus houses transverse sinus.

Styloid part of the Temporal bone

It has two parts

- Tympanohyal (proximal) related to tympanic plate.
- Stylohyal (distal) related to ligamentous attachments.

Important structures related to styloid process are parotid gland laterally, facial nerve in the base, external carotid artery at its tip.

Epidemiology of Temporal bone Fracture

Among all cases of blunt head trauma, temporal bone trauma accounts for 30 t0 70%[24,25] cases. High velocity road traffic accidents account for most of these cases because temporal bone being a tough structure requires very high energy impact to get fractured. On the other side, because of the presence of numerous foramina within the temporal bone, it is vulnerable to get fractured.Eventhough safety measures have helped reduce the incidence of head injuries, temporal bone injuries are increasing in frequency. Penetrating head injuries such as gunshot injuries and assault with sharp instruments are very rarely observed. About more than half of such penetrating injuries are associated with life threatening intracranial injuries as well [26,27].

Iatrogenic injuries to the the temporal bone in children is a common scenario where cerumen extraction is attempted in an uncooperative child. External ear canal and middle ear cavity are often injured in this maneuver.Surgical procedures particularly mastoid surgeries are notorious for causing facial nerve injuries and about 80% of those injuries are often unnoticed during surgery [29] .

History and Clinical Examination

Most of the cases of temporal bone injuries are clinically apparent due to some characteristic signs and symptoms.

Local examination of the injury site and mechanism of injury will often have a clue. Some of the important signs which are associated with temporal bone fractures are

- Hemotympanum:

Blood within the middle ear cavity which can be seen through the intact tympanic membrane by otoscopic examination.

- Battle's sign:

  Ecchymosed dark curvilinear spot over the post auricular region.

- Raccoon eye sign:

  Ecchymosis around the periorbital region.

- Ear bleeding
- CSF otorrhea:

  Most often the presence of CSF leak is obscured by ear bleeding in the acute setting. The presence of CSF can be appreciated as a dilute pale yellow margin surrounding the ear bleed.

- Paradoxical CSF rhinorrhea:

Even though a rare occurrence and often head trauma have an associated local nasal injury, nasal CSF leak known to occur in the setting of temporal bone injuries. The mechanism underlying paradoxical CSF rhinorrhea is the intact tympanic membrane prevents the escape of CSF through the external ear canal and the CSF within the middle ear cavity due to temporal bone injuries find its way through the Eustachian tube to the nasal cavity.

These are all some important signs which are highly suspicious of temporal bone trauma. The symptomatology also of importance because the symptoms associated with temporal bone injuries are unique.

Hearing loss:

This is the most common symptom following temporal bone injuries and often immediately apparent but at times there may be delayed hearing loss. The incidence of hearing loss is estimated about 40% of head injury patients. The type of the hearing loss may be

- ✓ Conductive hearing loss
- ✓ Sensorineural hearing loss
- ✓ Mixed hearing loss

According to this classification, those injuries which are proximal to the cochlea are termed conductive type and those which are distal to the cochlea are sensorineural in type.

The type of the fracture often dictates the type of the hearing loss.Longitutinal fractures of the petrous part of the temporal bone often associated with conductive type of hearing loss but sensorineural hearing loss can also occur in this type of fractures. Transverse fractures of the petrous temporal bone are often associated with sensorineural type of hearing loss.

Detailed audiometric evaluation in the acute setting is often not possible. Simple tuning fork testing is all required immediately to determine the type of fractures in the acute setting.

Conductive deafness carries good prognosis irrespective of timing of surgical intervention. But on the other hand, sensory deafness has worst prognosis whether surgery is performed or not. So determining the variety of the fracture is prognostically significant, but not influencing the timing of surgery.

Vestibular apparatus damage

Vestibular dysfunction can be in the form of

- Nystagmus
- Vertigo
- Imbalance

Nystagmus

It is rare event and does not cause any significant morbidity. This sign often disappears as days progresses.

Vertigo & Imbalance

Frequently head injury is associated with dizziness even in the absence of significant vestibular damage. Even if it is due to vestibular disturbance, this symptoms don’t warrant any treatment. Sometimes it may be necessary to give vestibular sedatives for a short period of time.

The causes for vertigo are

- Vestibular concussion injury
- Perilymph and endolymph imbalance
- Perilymphic fistula
- Post traumatic endolymphatic hydrops

Facial Paresis

Facial asymmetry is difficult to assess in the presence of facial oedema often accompanied with acute trauma. It could be either immediate which occurs within hours of trauma or delayed which evident days or weeks after injury. The timing of occurrence of weakness is very much significant in determining treatment.

Facial nerve mapping is not needed in all cases of 7^{th} nerve weakness. Electroneuronograph is a novel investigatory modality to define whether the nerve weakness is improving or worsening. It needs to done after 2^{nd} to 3^{rd} post traumatic day but within two to three weeks. Most of these injuries require surgical intervention. Indications for surgery [28] in 7^{th} nerve injuries are,

- Early weakness and no recovery after 1 week.
- Early and progressive weakness which is less than 10 percent of other side.
- Computed tomogram evidence of severe nerve damage.

Cerebro spinal fluid leak

CSF leak can occur either through the ear if the tympanic membrane is injured or damaged early or through the nostril if the tympanic membrane is uninjured.

Early identification of CSF rhinorrhea/otorrhea is necessary because it may predispose to meningitis. Preventive measures against meningitis can be taken early in the course of injury such as prophylactic meningitic dose of empirical antibiotics. Apart from that,herniation of brain tissue through the dural and bony defect into the middle ear cavity is one of the deadliest complications following tegmen injury. So significant and persistent leak can be managed surgically if not subsided spontaneously.

Cranial nerve injuries

Fifth cranial nerve injury in the form of facial numbness

Sixth nerve injury in the form of Diplopia

These cranial nerve injuries are rare occurence.Spontaneous resolution of these symptoms can definitely be expected because only the oedema not the nerve damage is the cause here.

Vascular injury

Major catastrophic bleeding can occur as a result of injury to

- Carotid canal
- Jugular fossa
- Sigmoid groove

With all these features and mode of trauma, temporal bone injury is often diagnosed presumptively.

Delayed complications

- Meningocoele/Encephalocoele
- Cholesteatoma
- Delayed CSF otorrhea
- Delayed meningitis

Pathophysiology of temporal bone fractures

It requires considerable amount of force to fracture temporal bone and it is estimated around 1875lb lateral energy is required to cause a longitudinal fracture in the petrous portion. The fracture line is usually parallel to the direction of force and follows the least resistant path through the bone. About 60 percentage of these fractures are considered open. Open injuries are the ones with ear bleed,CSF leak, brain herniation and penetrating injuries. About 8 to 29 percentage of these fractures are bilateral.

Classification

Although temporal bone consists of five parts, the clinically significant part which is often gets injured is the petrous part. There are two types of classification systems.

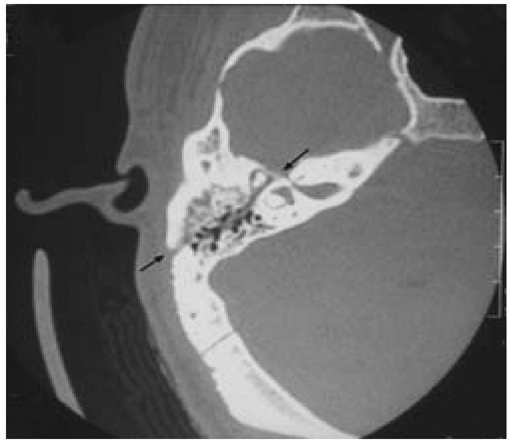
One which is commonly used in clinical practice is based on the orientation of fracture line.

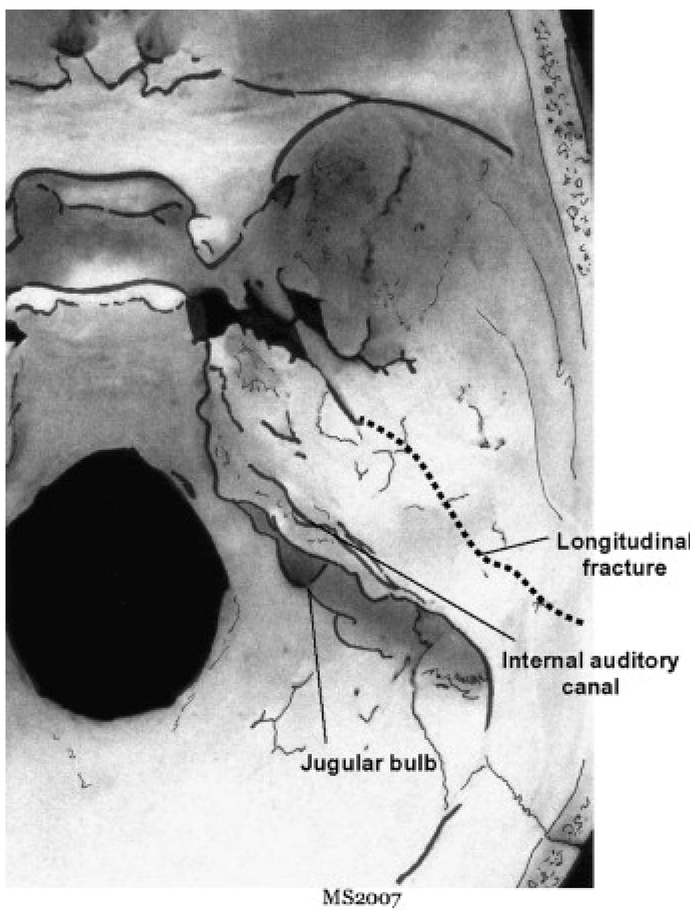
Another system which is more relevant clinically is based upon the otic capsule involvement.

According to imaging studies, petrous temporal bone fractures can be classified into,

- ✓ Longitudinal
- ✓ Transverse
- ✓ Oblique

Longitudinal type





This is the most frequent type of petrous bone fracture, accounting for approximately 70 to 80 percent of temporal bone fractures [32].This type occurs due to blow to the side of the skull either over the temporal or parietal bone. The fracture line runs parallel to the long axis of petrous temporal bone. Fracture line starts in the squama,extending to the posterosuperior wall of the external auditory canal, middle ear cavity's roof, along the surface of the petrous pyramid anterior to the labyrinth, ending near the foramen spinosum and lacerum.

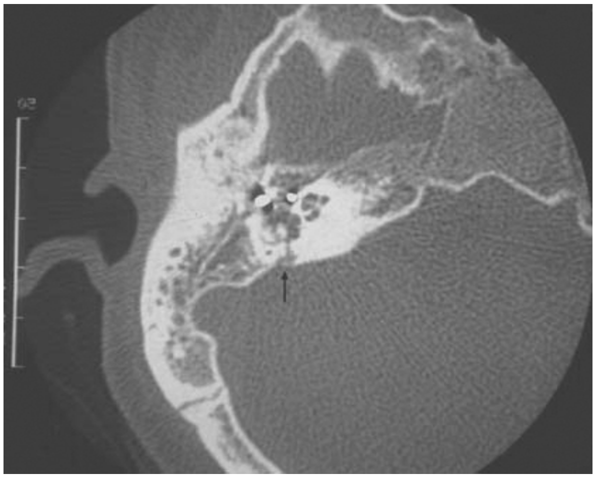
Ear bleeding is a constant feature in this type of injury because the external ear canal and tympanic membrane are almost always injured.

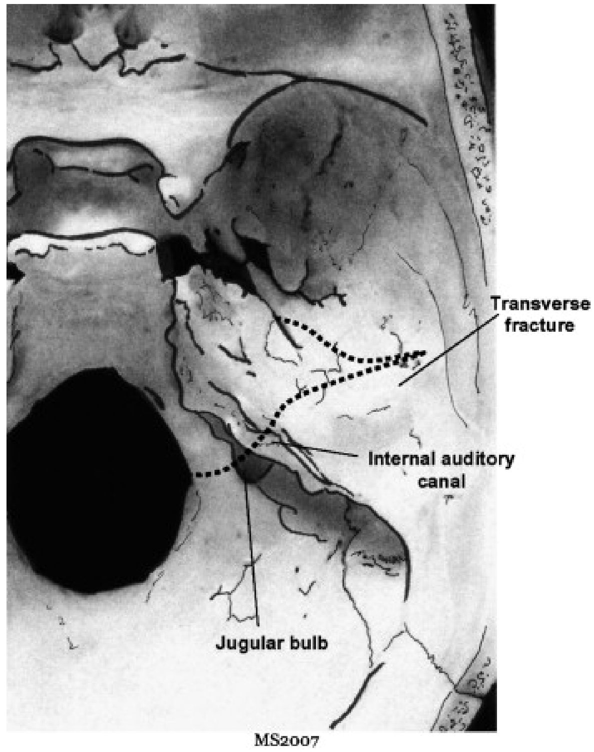
CSF otorrhea is also a common symptom due to the involvement of tegmen tympani [35],Which is seen in 50 percent of this type of fractures.

Conductive hearing loss is frequently observed, which accounts for about 65 percent of these cases. Most of them are temporary [36],but severe permanent deficit due to ossicular damage can be seen in 15 to 20 % [35] of those who are having conductive deafness. Concussion type of sensorineural deafness can rarely occur.

Seventh cranial nerve palsy is observed in 20% of these injuries, commonly in the horizontal segment of the nerve distal to geniculate ganglion. About 75% of them are transient and only 10% are permanent [36].

Transverse type





This is the least common type of petrous bone fracture. The blow delivered either to the frontal or occipital bone frequently lead to this type of injury. Fracture runs through the internal auditory canal, across the petrous pyramid, into the labyrinth capsule injuring both cochlea and vestibule. Sometimes it may extend into the middle ear and external auditory canal.

Bleeding from the ear or hemotympanum is seen in 50% of these cases.

Deafness, usually sensorineural due to cochlear damage seen in about 50 percentage of these fractures.

Facial nerve damage is observed in 40 to 50 percent of these fractures. Usually nerve injuries are immediate and permanent due to severe nerve damage rather than oedema which is observed in longitudinal types.

Nystagmus and vertigo are commonly seen, which are transient and resolves on its own.

Another classification system

Fractures of the petrous bone can also be classified as

- Otic capsule sparing
- Otic capsule disrupting

Otic capsule sparing type

It constitutes about 95% of petrous bone fractures. Mode of injury is blow to the tempero parietal region. Mostly this type is associated with conductive hearing loss sometimes sensorineural hearing loss can also occur. Facial nerve involvement is seen in 6 to 13 percent of these fractures.CSF leak is less common in this fracture type.

Otic capsule disrupting type

It is seen in about 4% of temporal bone fractures. Occipital region blow is implicated in this type.Senorineural type of hearing loss is commonly seen in this type. Seventh nerve injury is quite common in this fracture catagory,constituting about 30 to 50 percent of cases.CSF leak is thrice common than that of otic capsule sparing type.

This classification scheme is very much reliable for treatment and prognostication aspect.

Radiological Investigations

Clinical diagnosis alone missed about one third of the significant temporal bone injuries [30]

Temporal bone trauma can be detected by means of

- ✓ X-Ray skull
- ✓ Conventional Computed Tomography
- ✓ High resolution Computed Tomography

Of all these imaging studies, the gold standard investigatory modality is High Resolution Computed Tomography, which can diagnose as well as clearly define the fracture line. It has got an important role in case of preoperative evaluation if surgical intervention is planned. Plain X ray skull alone has limited value in assessing these cases, detecting only 17 to 30 percentage of fractures [33,34].

HRCT allows thinner slice sectioning and coronal,saggital reconstruction from the axial images. It is not only useful in detecting the fracture but also delineating important adjacent structures such as facial canal,Ossicles,Otic capsule, Carotid canal and middle cranial fossa.

In special circumstances, other imaging modalities can be offered such as

- ✓ Magnetic Resonance Imaging
- ✓ Magnetic Resonance Angiography
- ✓ Conventional Cerebral Angiography

Magnetic resonance can be useful in identifying the site of facial nerve injury. Angiography is inevitable if the fracture line traverses the carotid canal or other vascular injuries are suspected such as Jugular bulb or sigmoid sinus injuries.

Management aspects

Urgent intervention is needed in two scenarios

- Carotid artery injury with bleeding
- Brain tissue herniation into the mastoid, middle ear and external auditory canal

For Facial nerve injury requiring surgery

- Distal to Geniculate ganglion – Transmastoid approach
- Proximal to ganglion without sensorineural deafness – Middle cranial fossa approach
- Proximal to ganglion with sensorineural deafness – Transmastoid translabyrinthine approach

For CSF leak

- If it is not resolved in 14 days, surgery is indicated.
- If failed to resolve with 72 hrs of lumbar drainage, surgery is indicated.

For deafness

- ➢ Conductive type

- Hemotympanum resolves spontaneously
- Ossicular disruption need surgical correction electively
- Not earlier than 3 months

- ➢ Sensorineural type

- May resolve on its own
- Refractory to treatment

For vestibular symptoms

- ➢ Intravenous droperidol for acute symptoms
- ➢ Intramuscular promethazine subsequently

MATERIALS AND METHODS

STUDY DESIGN:

Prospective study

PATIENT SELECTION:

This study was conducted after getting permission from the Institutional Ethical Committee. We enrolled patients with head injury who had been admitted in Head injury ward at GOVT.RAJAJI HOSPITAL, Madurai Medical College, during the period from February 2012 to February 2013.

After obtaining informed written consent from the patient/patient's reliable attender, all patients are enrolled and studied as soon after admission to emergency department as possible.

Clinical information was collected to establish the following parameters:

- Type of head injury (Open or Closed)
- Cause of injury (Road traffic accidents, fall, assaults and bull gore injury)

- Glasgow Coma Score (GCS)
- Symptoms associated with head injury
  - Ear bleeding
  - CSF otorrhea
  - Deafness (conductive/sensorineural)
  - Facial nerve weakness

Inclusion criteria for this study:

All patients admitted with Head injury, irrespective of Age/GCS score with symptoms/signs suspicious of temporal bone fracture such as

- Ear bleeding
- Hearing loss
- CSF otorrhoea
- Facial nerve weakness

The aim of this study is to define the importance of High Resolution Computed Tomography so that we have included all head injured patients not taking the age, mode of injury and GCS into consideration.

Exclusion criteria for this study:

- Those who had traumatic head injury that required emergency surgical intervention
- Images degraded by motion artefacts
- Those patients who were not willing to participate in this study.

IMAGE ACQUISITION:

All patients were subjected to

- Conventional Computed Tomography with Bone window in axial section (10mm axial sections with 9 sec scan time)
- High Resolution Computed Tomography of Temporal bones with axial and coronal reconstruction (1.5mm sections with exposure factor of 120 kVp and 200-500 mAs).

IMAGE ANALYSIS:

All images were analysed to detect the presence of temporal bone fractures by an attending neuroradiologist and neurosurgeon, in which the former was blinded to the clinical condition of the patient.

Images were evaluated for

- Whether Fracture of temporal bone is present or not
- If present, the part of temporal bone affected (squama/petrous/mastoid/tympanic/styloid)
- In petrous fractures, the type of fracture (Longitudinal/Transverse/oblique)
- Extend of the fracture line into
    - Cochlea
    - Semicircular canal
    - Vestibule
    - Ossicular chain
    - Tegmen
    - Carotid canal
    - Foramen ovale
    - Internal auditary canal
    - Jugular foramen
    - Sigmoid sinus

STATISTICAL ANALYSIS:

Computer analysis of statistical data was done utilizing Epidemiological Information Package (EIP 2003) developed by World Health Organization. Frequencies, percentages, standard deviations, mean and ‘p’ values were calculated using this package.

ASSESSMENT:

All imaging datas were analyzed and the percentage of fractures missed by Conventional CT scan which can be diagnosed by High Resolution CT scan were calculated.

In all fracture cases, the definition of fracture line both in Conventional CT as well as in HRCT were analyzed and compared.

RESULTS AND ANALYSIS

Table 1

Clinical profile of patients in our study

Feature	**Value**	**Range**
Age	37.7 yrs	14 to 75 yrs
<u>Sex</u>		
Male	46	
Female	14	
GCS score	13	7 to 15
<u>Symptoms</u>		
Ear bleeding	45	
Hearing loss		
Conductive	16	
Sensorineural	5	
CSF otorrhea	10	
Facial nerve weakness	3	

Table 2

Symptomatology Vs Imaging study

Imaging Study/ Fracture status	**No**	**%**
Conventional CT (Fracture positive)	15	25%
HRCT (Fracture positive)	40	66.7%
HRCT (Fracture Negative)	20	33.3%

Among the total of 60 enrolled patients, 20 patients were not having temporal bone fractures. That means, even those patients with clinical suspicion of temporal bone trauma,33.3% of them may not have fractures in imaging studies. Of the remaining 40 patients, Conventional CT can pick up only 15 fractures (25%).But HRCT diagnosed temporal bone fractures in all 40 patients (66.7%).

Table 3

HRCT Vs Conventional CT

Imaging Modality	**Fracture Incidence**	
	No	**%**
HRCT	40	100%
Conventional CT	15	37.5%

We have found statistically significant difference in fracture detection rate between HRCT and Conventional CT.Chi squared equals 5.161 with 1 degrees of freedom. The two-tailed P value equals 0.0231.By conventional criteria; this difference is considered to be statistically significant.

Table 4

Mode of injury Vs Fracture Incidence

Mode	**Fracture Incidence**	
	No	**%**
RTA	30	75%
Accidental fall	6	15%
Assault	3	7.5%
Bull gore injury	1	2.5%

Even though there were more number of road traffic accident victims had fracture of temporal bone, it was only because of increased percentage of RTA victims included in this study. There were no statistically significant association between mode of injury and presence of fracture.

Table 5

Symptomatology Vs Fracture incidence

Symptoms	**Fracture Incidence**	
	No	**%**
Ear bleeding	26	57.8%
Hearing loss		
Conductive	10	62.5%
sensorineural	2	40%
CSF otorrhea	8	80%
Facial nerve involvement	3	100%

We have found significant proportion of patients with CSF otorrhea and Facial nerve injury were having high chance of temporal bone fracture, eventhough the number is smaller. In our study, all 3 facial nerve injuries were associated with mastoid part of temporal bone fracture.

Table 6

GCS Vs Fracture incidence

GCS	**Fracture incidence**	
	No	%
3 to 8	5	100%
9 to 13	23	82.1%
14 and 15	12	44.4%

In our study there were no statistically significant relationship between GCS and the presence of fracture.

Table 7

Gender Vs Fracture Incidence

Sex	**Fracture Incidence**	
	No	**%**
Male	32	69.6%
Female	8	57.1%

In our study, among the total of 60 patients,46 male and 14 female patients are randomly selected for study. The incidence of fracture was not having any preponderance towards a particular gender.

Table 8

Distribution of fracture location

Location	**Fracture Incidence**	
	No	%
Squamous	13	32.5%
Petrous	20	50%
Tympanic	1	2.5%
Mastoid	3	7.5%
Styloid	0	0%
Both squama & petrous	3	7.5%

In this study, the most common location of fracture in the temporal bone is petrous part, followed by squamous part. There was no case of styloid fracture in our study.

Table 9

Specific types of Petrous bone fracture

Type of fracture	**Fracture Incidence**	
	No	**%**
Longitudinal	16	80%
Transverse	2	10%
Oblique	2	10%

The most common type of fracture was longitudinal which constituted 80% in our series.

Table 10

Type of Fracture Vs Type of Hearing loss

Type of Fracture	**Conductive hearing loss**		**Sensorineural hearing loss**	
	No	**%**	**No**	**%**
Longitudinal	10	62.5%	3	15%
Transverse	1	50%	1	50%
Oblique	1	50%	1	50%

Longitudinal type of petrous bone fracture was frequently associated with conductive hearing loss, accounting for 62.5%.But sensorineural deafness was commonly seen with transverse fractures, about 50%.

2 patients with squamous fracture and one patient with mastoid fracture had conductive type of hearing loss.

Table 11

Type of Fracture Vs Facial nerve injury

Type of Fracture	**Facial nerve involvement**	
	No	**%**
Longitudinal	0	0%
Transverse	1	50%
Oblique	1	50%
Mastoid	1	33.3%

One out of two patients with transverse fracture and oblique fracture had facial nerve involvement. None of the longitudinal group had facial nerve injury.

Table 12

Type of fracture Vs CSF Otorrhea

Type of Fracture	**CSF otorrhea**	
	No	**%**
Longitudinal	6	37.5%
Transverse	2	100%
Oblique	2	100%

We found all the 4 patients who sustained transverse and oblique fractures had CSF otorrhea. Only 37.5% of longitudinal group had Otorrhea.

Table 13

Finer details of fracture by HRCT

Structure	**No**
Cochlea	3
Semicircular canal	2
Vestibule	4
Ossicular chain	8
Tegmen	4
Carotid canal	none
Foramen Ovale	none
Internal auditary canal	2
Jugular Foramen	none
Sigmoid sinus	none

This table is showing the value of HRCT in depicting the fracture line clearly and in showing the involvement of important adjacent structures also. Conventional CT in our study was not able to pick up any of these details.

DISCUSSION

The symptoms of temporal bone trauma are unique in that most often the diagnosis depends heavily on symptoms. But relied entirely on symptomatology can miss considerable amount of significant temporal bone fractures. According to a study by J. Waldron & S. E.J. Hurley et al., in spite of full detailed clinical examination,8 cases were missed and 5 of them developed complications of temporal bone fractures. This was a significant number of false negativity.

In our study, we were not analysing in that aspect of symptomatology. Our analysis was entirely different. We have taken those patients who had symptoms highly suspicious of temporal bone fracture. Ear bleeding was the most common symptom in our study which had 57.8% yield of fracture positivity. Hearing loss had 62.5% and 40% positivity for conductive and sensorineural loss respectively. But traumatic facial nerve injury had 100% positivity rate, followed by CSF otorrhea which had 80% positivity. One limitation in this aspect is a smaller number of patients with these latter two symptoms.

Next aspect is mode of injury. Motor vehicle accidents are the most often implicated mode for temporal bone trauma (Alpen Patel, M.D., and Eli Groppo, M.D., et al). In our study also, road traffic accidents are the most common mode of trauma causing temporal bone injury, accounting for 75% of fracture cases, followed by accidental fall contributing 15% of cases. Gunshot injuries, in contrary to the international studies, were rarely observed in our population. Penetrating temporal bone injuries were commonly observed in assault cases. In our study, all 3 assault cases were associated with penetrating trauma to the temporal bone. But the type and part of temporal bone fracture were not influenced by the mode of injury.

Next aspect of study is on gender difference. Even though the incidence of temporal bone fracture was higher in male patients in this study, it was only because of increased number of male patients participated in the study when compare to female patients. In our study, male : female ratio was 4 : 1.Whether the gender difference in the thickness of skull has any impact on this gender difference of temporal bone fracture was not studied here.

Next is on Glasgow Coma Score. In this study, those patients with moderate to severe head injury according to GCS [moderate-GCS 9 to 13(82.1%), severe – 3 to 8(100%)] had high chance of temporal bone trauma as well. But in this aspect of analysis, this difference was not statistically significant.

In imaging the temporal bone in trauma, plain X ray was previously used. The study by J. Waldron & S. E. J. Hurley et al.,showed a significant false negative rate in detecting temporal bone fractures with plain radiograph and symptomatology alone. The role of HRCT in detecting temporal bone trauma is undoubtedly established by various studies. But there is no clear consensus about to whom this modality is indicated. Because performing HRCT in all head injured patients is cumbersome in population like ours.

HRCT has got a role not only in diagnosis but also in accurately delineating the finer details of fracture line. The study conducted by Betsy A. Holland, Michael Brant-Zawadzk showed that high-resolution Computed Topographic images are taken more efficiently and with minimal radiation, and reformation in multiple projections regardless of the original scanning plane. Delineation of more subtle fractures of the petrous bone and thorough evaluation of associated findings are possible with HRCT. And also the three dimensional capability of HRCT offers a specific advantage over Conventional computed tomography.

HRCT is initially taken in axial section and then coronal and saggital reconstruction is carried out with a specific software which allows maximum flexibility in detailing the course of fracture line. A valuable advantage is for those structures which are vertically oriented (descending part of facial canal). Furthermore dynamic sequential scanning and low-milliampere-second technique allows rapid imaging and minimizing the radiation exposure.

Contrary to High Resolution scanning, conventional CT (10mm slices) is inefficient in diagnosing as well as for screening purposes. In our study, Conventional Computed tomography diagnosed only 15 cases of temporal bone injury out of total 40 cases which were diagnosed by High Resolution Computed Tomography. But this routine conventional tomography could be able to give clues such as opacification of mastoid air cells, intracranial air pockets etc.

Analysing the site of fractures in temporal bone, petrous part was the most frequently injured, followed closely by squamous part. We found that petrous fractures accounted 50% and that of squamous was 32.5% in total number of 40 temporal bone fractures. Mastoid part was involved in 7.5% of cases and Tympanic part in 2.5% (only one case).

Among the petrous bone fractures, Longitudinal type of fractures which runs along the long axis of petrous bone were the most common type, constituting 80%of the cases. Hearing loss frequently seen in this type of fracture was conductive hearing loss which was 62.5% and rarely causing sensorineural hearing loss, constituting only 15%. Facial nerve injury was not seen in this type of fractures.CSF Otorrhea were seen in 37.5% of longitudinal fractures.

Transverse fractures which runs right angle to the petrous axis were seen in 10% and oblique type in 10% of cases. Sensorineural type of hearing loss was the most frequent type seen in these fractures, accounting for 50% of transverse fractures. Facial nerve involvement observed in 50% of cases and CSF otorrhea also seen in 50% of these fractures. These results are paralleling the international studies. A similar sort of study was done by Betsy A. Holland1Michael Brant-Zawadzki also showed results similar to our study.

Apart from categorizing the fracture types, HRCT has got a major role in precise and complete delineation of fracture line. For those patients who need surgical intervention for any of the complications of temporal bone injury, preoperative High Resolution Tomography is definitely needed to plan the surgical approach. In our study, HRCT showed Ossicular chain disruption in 8 cases, tegmen involvement in 4 cases, Vestibular injury in 4 cases, Cochlear damage in 3 cases, Semicircular canal injury in 2 cases. But none of these details about the extent of fracture line was seen in conventional Computed Tomography.

Early identification of these temporal bone injuries and their detailed description avoids some of the delayed complications of these injuries which may have a strong impact on the quality of life and sometimes may cause mortality also. Those complications are delayed facial nerve palsy, delayed CSF leak and meningitis.

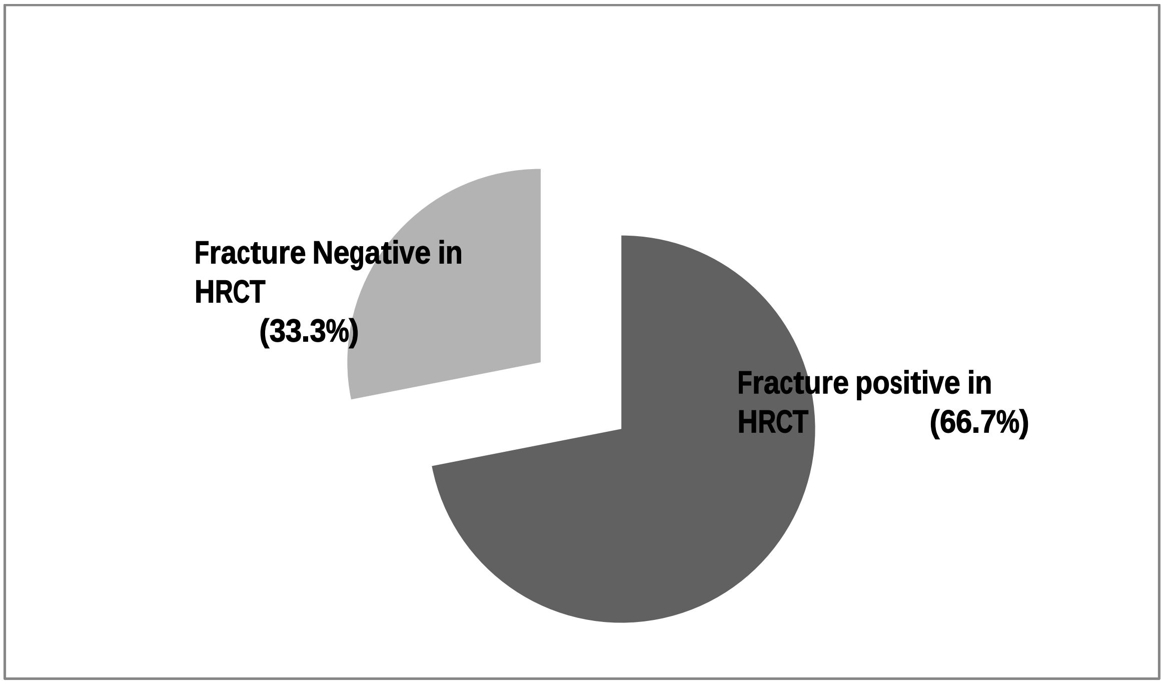
LIMITATIONS

- Paediatric age group patients were not included in this study. During the study period, no paediatric temporal bone fracture was reported.
- This study is not addressing the treatment benefits of HRCT details of temporal bone fractures.
- CSF otorrhea in this study was assessed only by clinical means and not by any laboratory investigations.

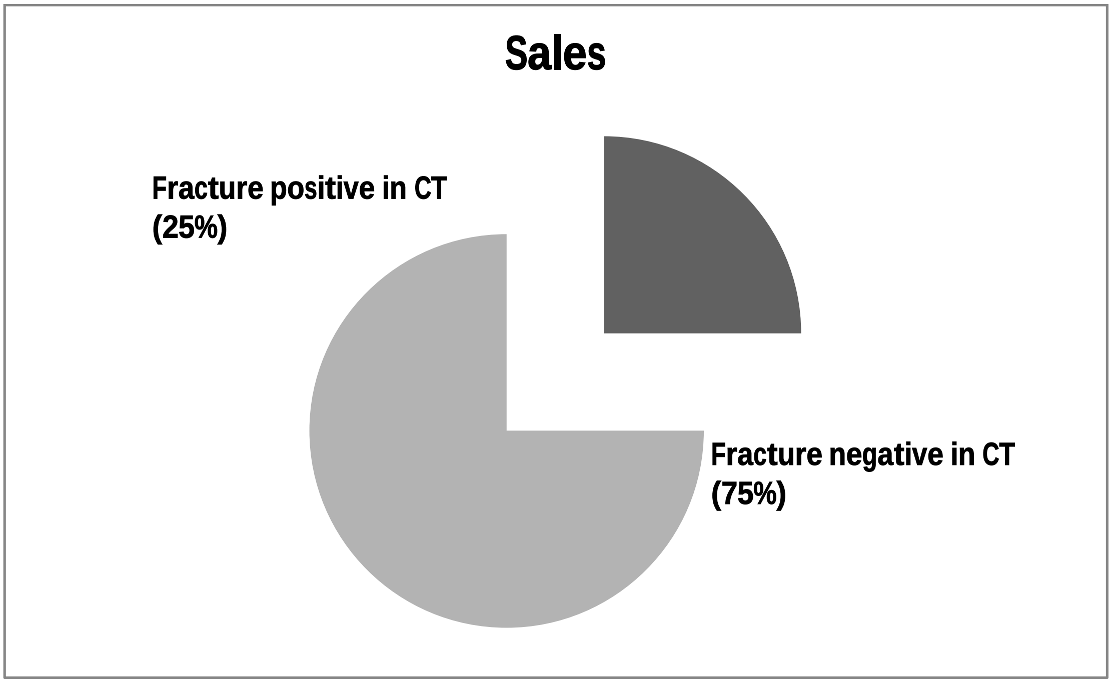
CONCLUSION

1) High Resolution Computed Tomography of Temporal bone is more sensitive and specific than Conventional Computed Tomography in diagnosing temporal bone fracture.
2) High Resolution Computed Tomography is highly efficient in assessing the extent of the fracture line in temporal bone trauma.
3) Longitudinal fracture of petrous part of temporal bone is the most common type of traumatic temporal bone fracture.

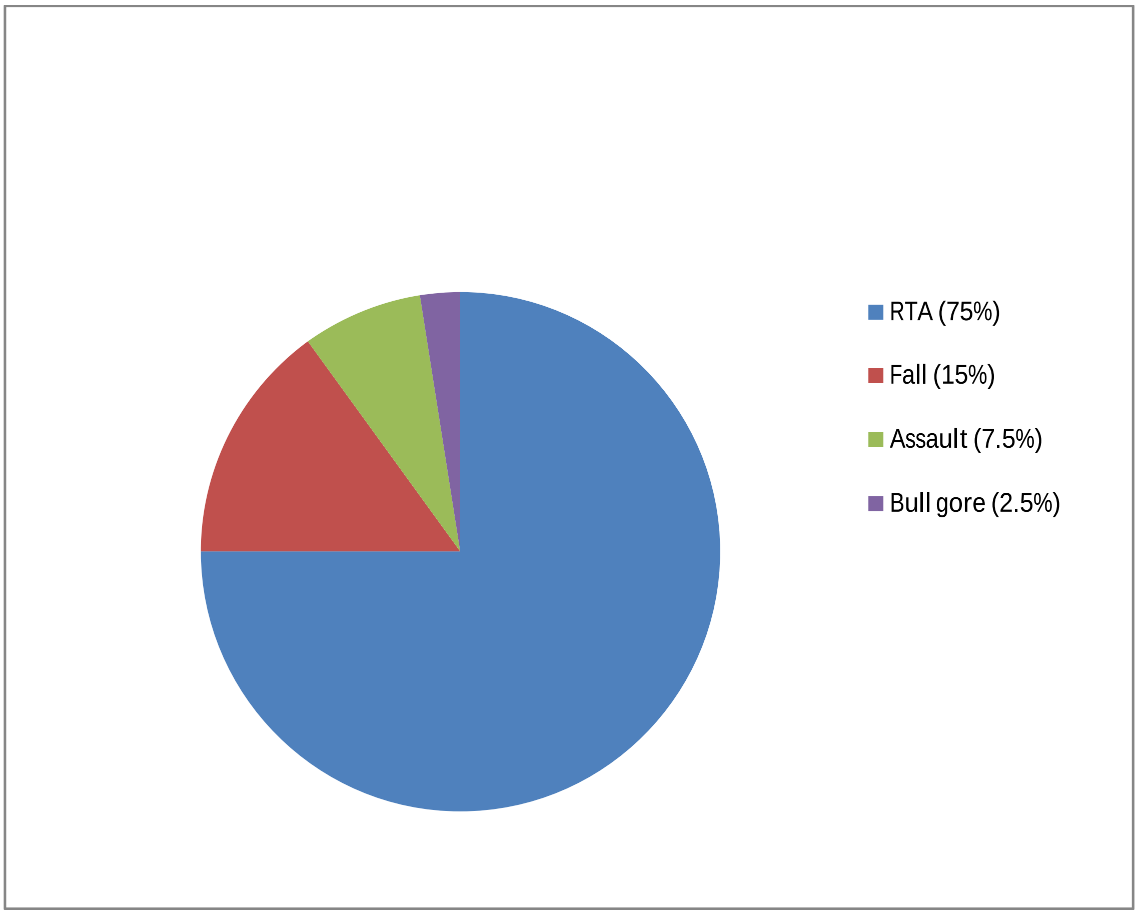
Symptomatology Vs HRCT



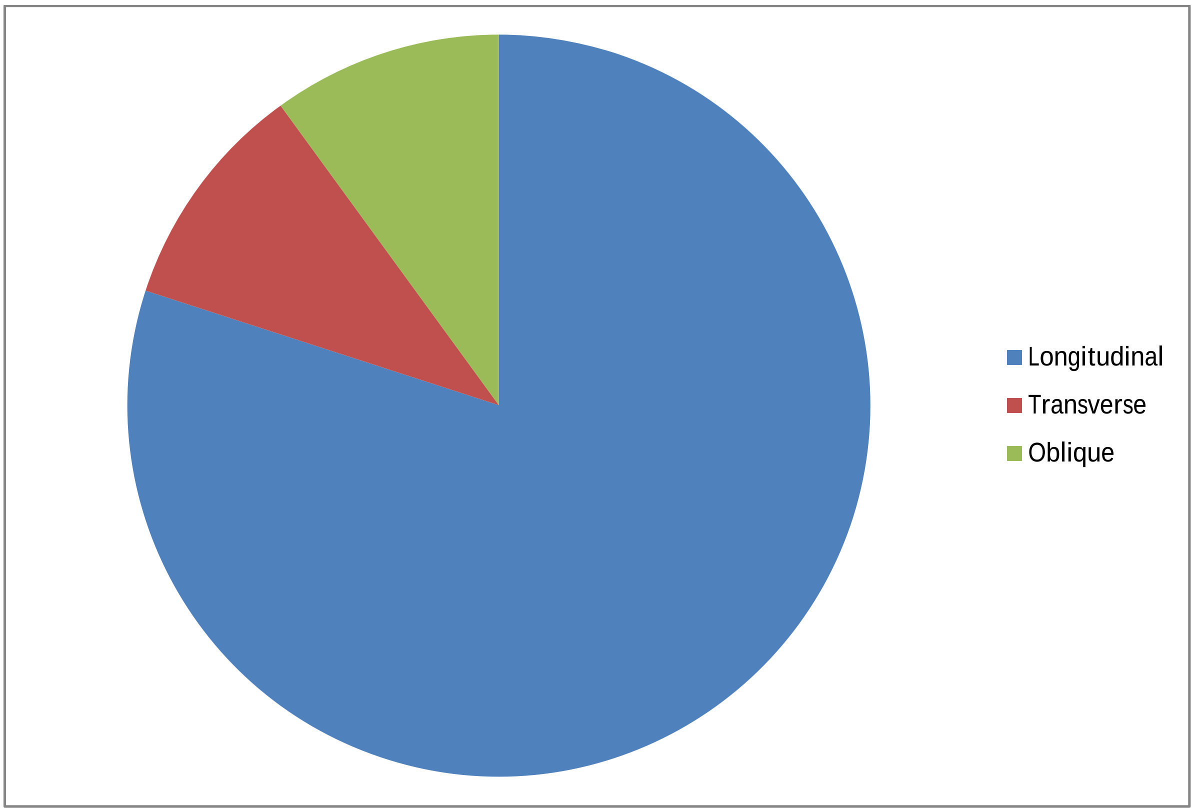
Symptomatology Vs Conventional CT


Sales
Fracture positive in CT (25%)
Fracture negative in CT (75%)

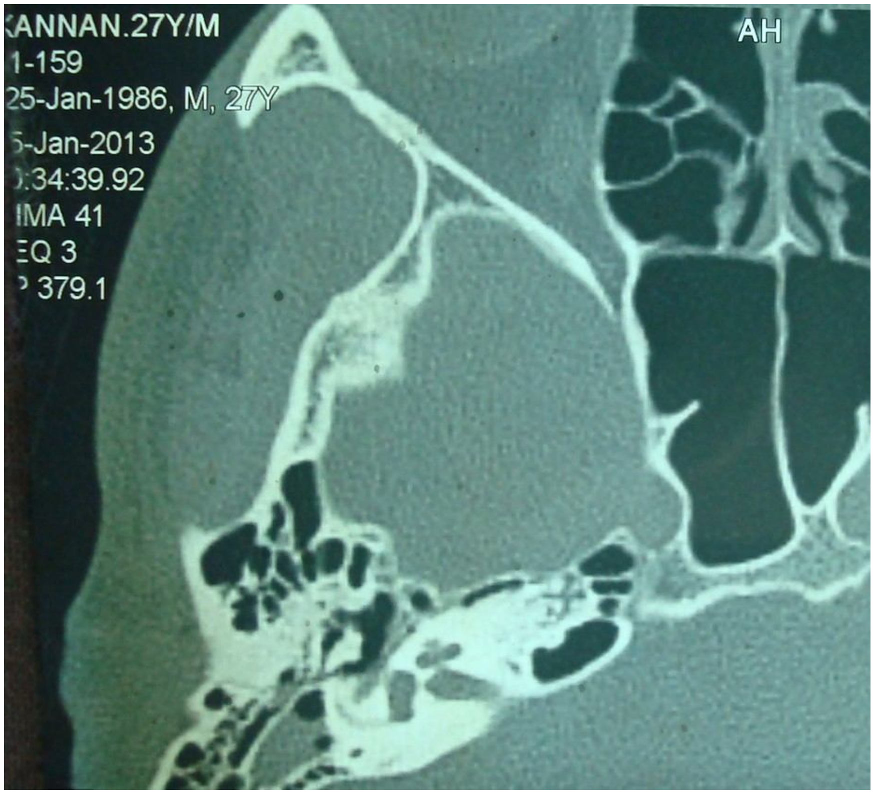
Mode of injury Vs Fracture Incidence

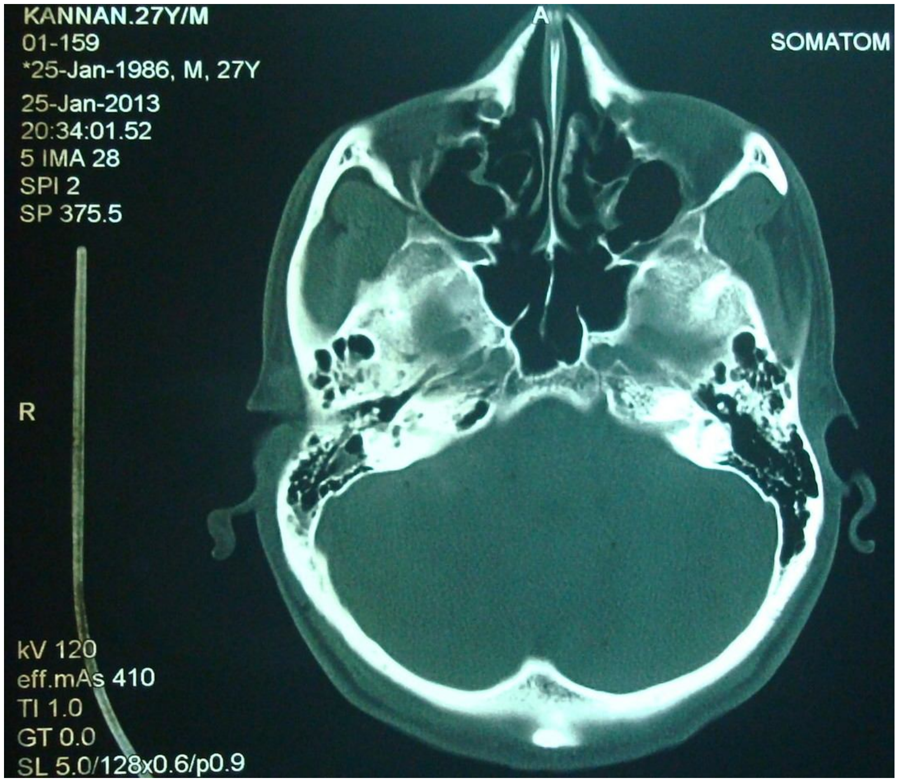


Specific types of Petrous bone fracture



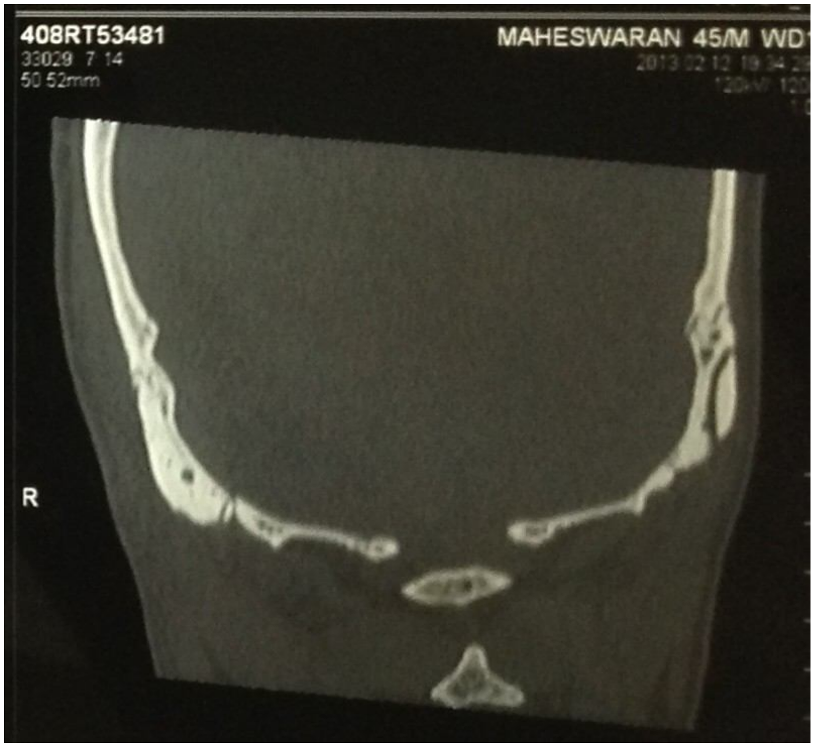
Longitudinal fracture of petrous bone shown by HRCT/missed by CT





Fracture of Squamous bone shown by HRCT/missed by CT

Fracture of mastoid bone shown by HRCT/missed by CT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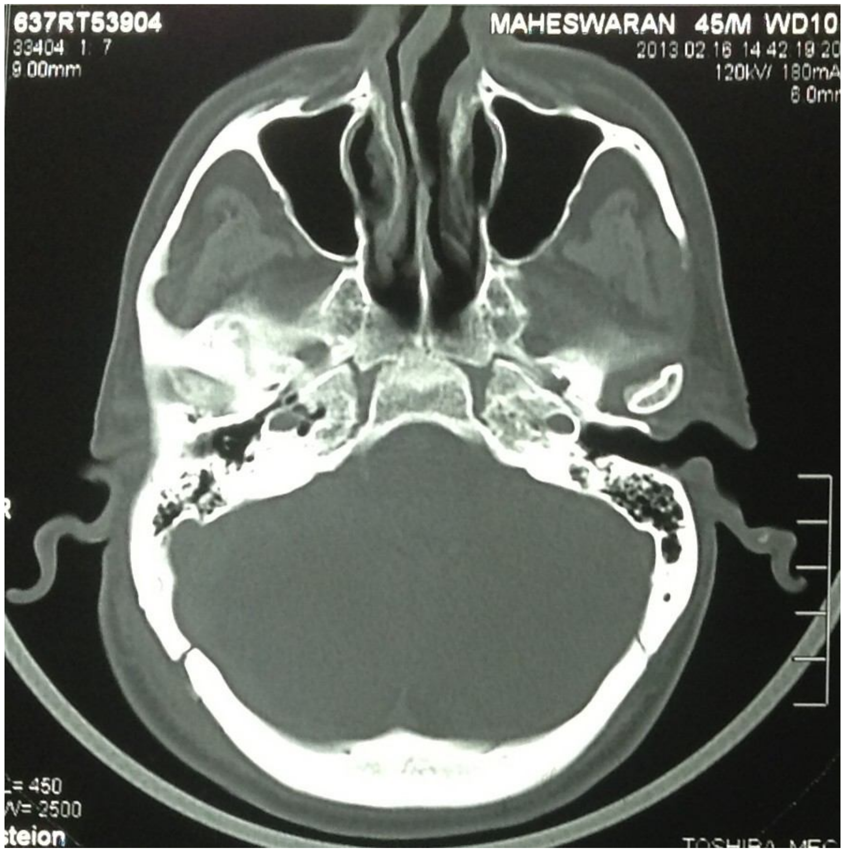
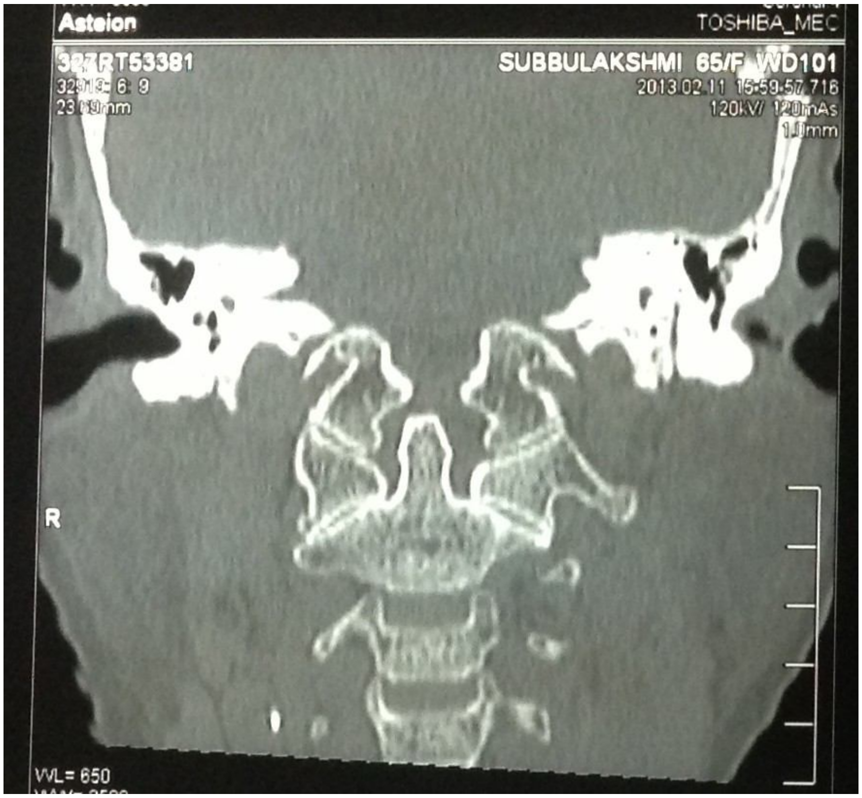


Fracture of mandibular fossa(tympanic part) shown by HRCT/missed by CT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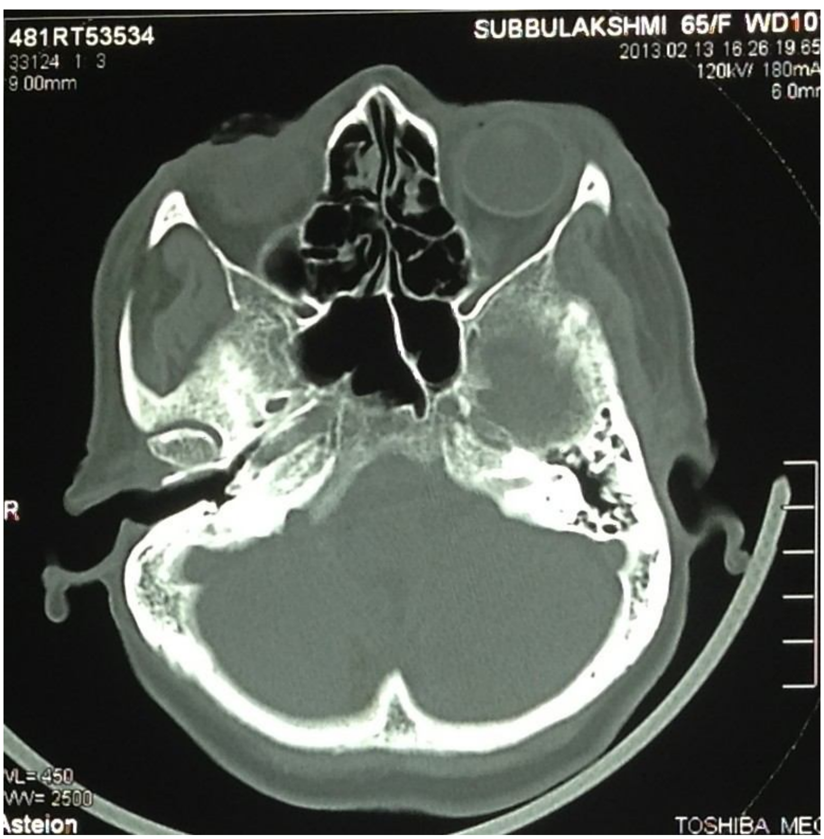
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PROFORMA

Name :

Age :

sex :

IP No. :

Mode of Injury :

GCS Score :

Chief Complaints :

- Ear bleeding -
- Hearing Loss

    Conductive -

    Sensorineural -

- CSF Otorrhea -
- Facial nerve involvement -

Parameters to be assessed in Conventional / HRCT

- Fracture + or – -
- Type of fracture

  Longitudinal -

  Transverse -

- Extend of fracture into

  Cochlea -

  Semicircular canal -

  Vestibule -

  Ossicular chain -

  Tegmen -

  Carotid canal -

  Foramen ovale -

  Internal auditary canal -

  Jugular foramen -

  Sigmoid sinus -

Turnitin Originality Report

ROLE OF HIGH RESOLUTION COMPUTED TOMOGRAPHY IN THE EVALUATION OF TEMPORAL BONE FRACTURE by Manimaran Ramiah 17101601 M.Ch. Neuro Surgery

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Ref. No. 990/E4/3/2013 — Govt. Rajaji Hospital, Madurai.20. Dated: .03.2013

Institutional Review Board / Independent Ethics Committee.

Dr. N. Mohan, M.S., F.I.C.S., F.A.I.S.,
Dean, Madurai Medical College & 2521021
Govt Rajaji Hospital, Madurai 625020.
Convenor
grhethicssecy @gmail.com.

Sub: Establishment-Govt. Rajaji Hospital, Madurai-20-
Ethics committee-Meeting Minutes- approval -regarding.

The Ethics Committee meeting of the Govt. Rajaji Hospital, Madurai was held at 10.00 am to 12.00.pm on 25.02.2013 at the Surgery Seminar Hall, Govt. Rajaji Hospital, Madurai. The following members of the committee have attended the meeting.

1.Dr. V. Nagarajan, M.D., D.M (Neuro) Ph: 0452-2629629 Cell.No 9843052029	Professor of Neurology (Retired) D.No.72, Vakkil New Street, Simmakkal, Madurai -1	Chairman
2. Dr.Mohan Prasad , M.S M.Ch Cell.No.9843050822 (Oncology)	Professor & H.O.D of Surgical Oncology(Retired) D.No.72, West Avani Moola Street, Madurai -1	Member Secretary
3. Dr.L. Santhana Lakshmi,MD Cell.No 9842593412	Associate Professor of Physiology/V.P Madurai Medical College	Member
4. Dr. Parameswari M.D (Pharmacology) Cell.No.9994026056	Director of Pharmacology Madurai Medical College	Member
5. Dr.Moses K.Daniel MD(Gen.Medicine) Cell.No 09842156066	Professor & H.O.D of Medicine Madurai Medical College	Member
6. Dr.D. Soundara Rajan,MS(Gen.Surgery) Cell.No 9842120127	Professor & H.O.D of Surgery Madurai Medical College	Member
7. Dr.Angayarkanni MD(O&G) Cell.No 9443567724	Professor & H.O.D of O&G Madurai Medical College	Member
8. Dr.P.V. Pugalenthi M.S, (Ortho) Cell.No 9443725840	Professor & H.O.D Ortho Madurai Medical College	Member
9. Dr. M. Sundarajan M.S., Mch Cell.No 9994924369 (Neuro Surgery)	Professor (Neuro Surgery) Madurai Medical College	Member
10 Thiru..Pala. .Ramasamy , BA.,B.L., Cell.No 9842165127	Advocate, D.No.72.Palam Station Road, Sellur, Madurai -2	Member
11. Thiru. P.K.M. Chelliah ,B.A Cell.No 9894349599	Businessman, 21 Jawahar Street, Gandhi Nagar, Madurai-20.	Member

Following Project was approved by the committee

Name of P.G.	Course	Name of the Project	Remarks
Dr. R. Manimaran	PGin Mch (Neurosugery) Govt. Rajaji Hospital & Madurai Medical College, Madurai.	Role of HIGH Resolution computerized tomography in the evaluation of temporal bone fractures.	Approved

Please note that the investigator should adhere the following: She/He should get a detailed informed consent from the patients/participants and maintain Confidentially.

1. She/He should carry out the work without detrimental to regular activities as well as without extra expenditure to the institution to Government.
2. She/He should inform the institution Ethical Committee in case of any change of study procedure site and investigation or guide.
3. She/He should not deviate for the area of the work for which applied for Ethical clearance.

She/He should inform the IEC immediately, in case of any adverse events pr Serious adverse reactions.

4. She/he should abide to the rules and regulations of the institution.
5. She/He should complete the work within the specific period and apply for if any Extension of time is required She should apply for permission again and do the work.
6. She/He should submit the summary of the work to the Ethical Committee on Completion of the work.
7. She/He should not claim any funds from the institution while doing the word or on completion.
8. She/He should understand that the members of IEC have the right to monitor the work with prior intimation.

Member Secretary **Chairman**

DEAN/Convenor
Govt. Rajaji Hospital,
Madurai- 20.

12/3/13

To
The above Applicant
-thro. Head of the Department concerned.

MASTER CHART

S.N	Name	A/S	IP No	MOI	GCS	EB	HOH	7 CN	CSF Oto	CT	HRCT
1	Kannan	27/m	6154	RTA	14	-	c	-	+	-	Pet Long
2	kannan	45/m	5854	Fall	14	+	-	-	-	-	Sq
3	Muthu	23/m	4759	RTA	14	-	c	-	-	-	-
4	Balakrishnan	68/m	3412	Fall	15	+	c	-	-	+	Pet Long
5	Palanisamy	55/m	5456	RTA	15	-	c	-	-	-	-
6	Mariappan	45/m	2636	RTA	13	+	-	-	-	+	Sq
7	Gurusamy	65/m	740	RTA	9	+	-	-	-	-	Sq
8	Ravichandran	38/m	1225	RTA	10	+	-	-	-	-	Sq
9	Veerapandian	30/m	2916	RTA	15	-	s	-	+	+	Pet Long
10	Kumaran	45/m	2365	RTA	12	+	-	-	-	+	Sq
11	Jeyaprakash	28/m	3254	Fall	15	+	-	-	-	-	-
12	Pandi	45/m	3135	RTA	13	+	-	-	-	-	-
13	Kannan	24/m	3251	RTA	15	+	-	-	-	-	-
14	Gnanasekar	43/m	3252	RTA	12	+	s	-	-	-	Pet Obl
15	Devi	28/f	2615	fall	11	+	-	-	-	+	Sq
16	Panchu	50/f	4328	RTA	15	+	-	-	-	-	Sq
17	Panchavarnam	50/f	5643	RTA	15	+	-	-	-	-	-
18	Rajkumar	20/m	3741	RTA	15	-	c	-	-	+	Pet Long
19	Rajeswari	58/f	5690	RTA	10	+	-	-	-	-	-
20	Velmani	44/f	3908	RTA	12	+	-	-	-	-	Sq
21	Kaleeswaran	14/m	3128	RTA	15	+	-	-	-	-	-
22	Pitchiammal	60/f	4501	RTA	15	+	-	-	-	-	-
23	Chellapandi	22/m	3513	Bull gore	15	+	-	-	-	-	-
24	Raja	37/m	4445	RTA	9	+	c	-	-	+	Pet Long
25	Nagarajan	36/m	2808	RTA	12	+	-	-	-	-	-
26	Sundarajan	40/f	4403	Assault	15	+	-	-	-	-	-
27	Suresh	27/m	3863	RTA	7		c	-	-	+	Pet Long
28	Shanthi	35/f	5161	RTA	15	+	-	-	-	+	Pet Long
29	Manivasagam	33/m	4435	RTA	9	+	-	-	-	-	-
30	Ravi	38/m	4684	RTA	5		c	-	+	+	Pet Long
31	vellakutty	75/f	5889	Assault	9	+	-	-	-	-	Sq
32	Vasanthi	35/f	6288	RTA	10	+	-	-	+	-	Pet Long

33	Sathyamoorthy	37/m	5065	Fall	10	+	-	-	-	-	
34	Maragatham	65/f	7213	RTA	13	+	-	-	-	-	Sq
35	Gopi	27/m	5682	RTA	13	+	-	-	-	-	Pet Long
36	Karupasamy	27/m	8504	RTA	15	+	-	-	-	-	-
37	Chandra	30/f	9198	Fall	15	+	-	-	-	-	-
38	Arumugam	15/m	97155	RTA	15	+	-	-	-	-	-
39	Kandasamy	42/m	7464	RTA	15	+	-	-	-	-	Sq
40	Nagarajan	40/m	7563	Fall	13		c	-	-	-	Mas
41	Narayanan	50/m	9230	RTA	12	+	-	-	-	+	Both
42	Malairani	18/f	8245	RTA	15	+	-	-	-	-	-
43	Senthilkumar	23/m	9459	RTA	12		s	-	+	-	Pet trans
44	Kuppuraja	20/m	8173	RTA	7	-	c	+	+	+	Pet Obl
45	Suresh	25/m	7619	RTA	10		s	-	-	-	Pet Long
46	Ranjith	14/m	3710	Bull gore	15	+	-	+	-	-	Mas
47	Sekar	35/m	9833	RTA	13		c	-	+	+	Pet Obl
48	Vasantharaja	14/m	10473	RTA	11	+	c	-	-	-	Pet Long
49	Ramasamy	55/m	8939	RTA	13	+	-	-	-	-	Both
50	Subbulaxmi	65/f	9890	RTA	13	+	-	-	-	-	Tymp
51	Ponnammal	55/f	9408	RTA	14	+	-	-	-	-	-
52	Kasirajan	48/m	744	RTA	15	+	-	-	-	-	Sq
53	Anandharaj	25/m	10233	RTA	13		c	-	-	-	Pet Long
54	Vanathan	68/m	10418	RTA	9	+	c	-	-	-	Pet Long
55	Ramar	53/m	11201	RTA	15	+	c	-	+	-	Pet Long
56	Laxmanan	20/m	9613	Assault	11	+	-	-	-	+	Sq
57	Sundar	32/m	10371	RTA	15	+	-	-	-	-	-
58	Ramkumar	16/m	9584	RTA	7	+	-	-	-	-	Mas
59	Maheswaran	45/m	9912	RTA	7	-	c	+	+	-	Pet trans
60	Panchavarnam	48/f	11333	Fall	14	+	s	-	+	+	Pet Long