RELATIONSHIP BETWEEN

SITE OF FACIAL NERVE INJURY

AND ELECTRONEURONOGRAPHY :

A RETROSPECTIVE STUDY

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DISSERTATION SUBMITTED IN PARTIAL FULLFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF MEDICINE (OTORHINOLARYNGOLOGY-HEAD AND NECK SURGERY)

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ABSTRAK

Objektif: Untuk menilai hasil klinik rekod pesakit yang patah tulang temporal dan kecenderaan saraf muka akibat traumatik. Matlamat adalah untuk menentukan perkaitan antara tapak kecederaan saraf muka dan elektroneuronografi (ENOG)

Reka bentuk kajian: Ini adalah kajian retrospektif (pemerhatian) yang telah dilakukan antara 1 Januari 2010 hingga 31 Januari 2020.

Lokasi: Hospital Universiti Sains Malaysia , Kubang Kerian, Kelantan

Pesakit : Seramai 82 pesakit yang mengalami patah tulang temporal dan kecederaan saraf muka traumatik ydi hospital kami. Data demografi pesakit, rekod pemeriksaan klinikal pesakit, Ujian Pendengaran, tahap kelumpuhan muka dengan House Brackmann (HB), ENOG dan keputusan Imbasan HRCT temporal telah di kumpul dan dianalisis.

Keputusan: Purata umur pesakit yang terlibat dalam trauma adalah 27.5 tahun. Kemalangan merupakan 92.7% punca trauma. Kebanyakannya melibatkan penunggang motosikal yang tidak memakai topi keledar (83.3%). Kelumpuhan muka bermula lambat didapati dalam 87.8% kes. Tahap kelumpuhan muka dicatat tertinggi ialah gred IV HB (50%). Kehilangan pendengaran konduktif yang paling banyak berlaku. Patah tulang temporal yang berjenis Longitudinal mempunyai kes yang tertinggi (60.5%). Berdasarkan klasifikasi baru patah tulang temporal, majoritinya kes ialah kapsul otik tidak terjejas (84.4%). Segmen tympani (28%) paling kerap cedera , diikuti oleh ‘first genu’(24.4%). Tidak terdapat perbezaan dalam ketaraan antara peratusan denervasi saraf (ENOG) dan tapak kecenderaan saraf muka ($p<0.075$).

Kesimpulan: Tiada kaitan antara tapak kecederaan saraf muka dan ENOG. Pemilihan pesakit untuk pembedahan tidak seharusnya hanya bergantung pada HRCT tetapi juga tahap lumpuh saraf muka secara klinikal (kali pertama ia berlaku) dan pemantauan ENOG bersiri.

ABSTRACT

Objective: To evaluate the clinical outcome of patients with temporal bone fracture (TBF) and traumatic facial nerve injury. The aim was to determine the association between site of facial nerve injury and electroneuronography(ENOG).

Study design: This a retrospective study (observational) which done between 1st January 2010 to 31st January 2020.

Setting: Tertiary university hospital

Patients : 82 patients who had TBF and traumatic facial nerve injury who treated in our hospital. The data on demography of patients, clinical findings, Pure Tone Audiometry, House Brackmann (HB), ENOG and High Resolution Computer Tomography (HRCT) Temporal result were collected and analysed.

Results: The mean age of who patients involved in trauma were 27.5 years old. Motor Vehicle Accidents (MVA) constituted 92.7% of cause of trauma. Mostly involving unhelmet motorcyclist (83.3%). Delayed facial paralysis was found in 87.8% cases. The HB grade IV was recorded highest (50%). The conductive hearing loss was most observed. The Longitudinal TBF had highest prevalence (60.5%). Based on new classification of TBF, majority were otic capsule sparing (84.4%). The tympanic segment (28%) commonly injured followed by first

genu (24.4%). There was no significant difference between the percentage denervation (ENOG) and the facial canal sites fracture (p value<0.075).

Conclusion: There is no association between sites of facial nerve injury and ENOG. The selection of patients for surgery should not solely rely on HRCT but also clinical grading (time of onset) and serial ENOG monitoring.

CHAPTER 1:

INTRODUCTION

1.1 INTRODUCTION

Facial nerve injury can be a very devastating consequence of a blunt or penetrating trauma to the head and the neck. These injuries typically are caused by falls from height, motor vehicle accidents, assaults, and penetrating trauma like gunshot wounds[1]. The commonest cause of facial nerve injury is by blunt trauma from a fracture of the temporal bone[2]. A local study, conducted in the Tengku Ampuan Afzan Hospital in 2008, revealed that traumatic facial injury was seen in 24 out of 46 patients who sustained temporal bone fracture[3].

A thorough knowledge of the facial nerve courses is pertinent in diagnosing the sites of the facial nerve injury. It can be classified as intracranial, intra-temporal and extratemporal. The intra cranial course is from its origin at the pontomedullary junction of the brain stem to the apex of the Internal Auditory Canal (IAC).The intra temporal course is within the IAC to the stylomastoid foramen. It can be subdivided further into meatal, labyrinthine, tympanic, and mastoid segments[1]. Understanding the extent of the facial nerve damage is also crucial for surgeons to predict the prognosis and make decisions on the treatment.

Facial nerve injury can be grossly described as a simple traction injury of the anatomically intact nerve, crush injury or full transection, and loss of a segment of nerve[2]. In 1943, Seddon classified nerve damage into three levels which are neuropraxia, axonotmesis and neurotmesis[4]. Subsequently, in 1951, Sunderland further divided the Seddon III Neurotmesis category into third ,fourth and fifth degree based on the level of the neural tube affected[4].

A standard clinical grading of the facial nerve function is the House Brackmann (HB) scale. It approximates the quantity of volitional motion of the patient based on the clinical

observation of facial presentation. However, it can be subjective due to variations among observers[5]. The use of modern diagnostic tools such as High-Resolution Computer Tomography (HRCT) Temporal and Electroneuronography (ENOG) has made the diagnosis and treatment of facial nerve injury more accurate [6].

The HRCT Temporal is the best method to demonstrate the temporal fracture line in relation to the fallopian canal[7]. Traditionally, radiographic imaging of temporal bone fractures is classified into longitudinal, transverse, or mixed types, based on their orientation in relation to the petrous ridge[8]. In the new system, temporal bone fracture is classified into otic capsule sparing vs otic capsule violating, based on the integrity of the otic capsule bone[8].

A study of the HRCT Temporal in patients with facial paralysis in temporal bone fractures showed that the most frequently affected site was the geniculate ganglion (80.6%), followed by the tympanic segment (48.3%), labyrinthine segment (16.1%), pyramis (6.4%) and the mastoid segment (3.2%)[7]. Multiple studies concluded that the incidence of longitudinal fracture is higher than transverse fracture in the temporal bone. However, the traumatic facial nerve injury is more common in transverse fracture.

ENOG was first described by Esslen in 1973[9] . It is an objective test that measures the evoked compound muscle action potentials using skin electrodes[9]. The function of the affected nerve is expressed in a percentage relative to the normal side[9]. ENOG is dependent on Wallerian degeneration to progress from distal to stylomastoid foramen before testing can be meaningful[10].

Multiple studies have been conducted on the accuracy of the HRCT temporal to type temporal bone fractures and the site of the traumatic facial nerve injury. There are also studies

on the reliability of ENOG on the severity of the traumatic facial nerve injury. Despite all these literature, no study has evaluated the association between the types of temporal bone fracture and the sites of facial nerve injury with the severity of facial nerve injury using ENOG. The aim of this study was to evaluate the association between sites of facial nerve injury and ENOG. This study will broaden the knowledge of surgeons in understanding the nature and management of the traumatic facial nerve in future.

CHAPTER 2:

OBJECTIVES OF THE STUDY

2.0 OBJECTIVES OF THE STUDY

2.1 General Objective

To study patients with traumatic facial nerve injury (based on the House Brackmann(HB) scale , ENOG and radiological evidence of temporal bone fracture).

2.2 Specific Objectives

1. To identify the site of the facial nerve injury based on the HRCT Temporal (with a Bone window algorithm).
2. To correlate the severity of facial nerve injury with ENOG.
3. To determine the association between the sites of facial nerve injury with the severity of the facial nerve injury based on ENOG.
4. To evaluate the agreement between old classification of Temporal Fractures and Otic Capsule Violation

CHAPTER 3

MANUSCRIPT

3.1 TITLE PAGE

Relationship Between Site of Facial Nerve Injury and Electroneuronography

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ENOG was first described by Esslen in 1973[9] . It is an objective test that measures the evoked compound muscle action potentials using skin electrodes[9]. The function of the affected nerve is expressed in a percentage relative to the normal side[9]. ENOG is dependent on Wallerian degeneration to progress from distal to stylomastoid foramen before testing can be meaningful[10].

Multiple studies have been conducted on the accuracy of the HRCT temporal to type temporal bone fractures and the site of the traumatic facial nerve injury. There are also studies on the reliability of ENOG on the severity of the traumatic facial nerve injury. Despite all

these literature, no study has evaluated the association between the types of temporal bone fracture and the sites of facial nerve injury with the severity of facial nerve injury using ENOG. This study will broaden the knowledge of surgeons in understanding the nature and management of the traumatic facial nerve in future.

3.4 MATERIALS AND METHODS

This was a retrospective observational study done on patient in Hospital Universiti Sains Malaysia , Kubang Kerian, Kelantan. This study approved by our university Human Research Ethics Committee with code number USM/JEPeM/21050379. The study was performed according to Helsinki Declaration.

The data was collected from the medical record department ,clinic of ORL-HNS and PACS online (Picture Achieve Communication System). We collected data between 1st January 2010 and 31st January 2020 , total 82 patients who had temporal bone fracture with traumatic facial nerve paralysis (strictly based on inclusion and exclusion criteria). The inclusion criteria were patients involved in trauma with complete documentation of facial nerve function with HB score , ENOG assessment and post trauma HRCT Temporal. Patients with bilateral facial nerve injury, pre-existing facial nerve palsy prior to trauma due to other causes, comatose and uncooperative patients or patients on any form of muscle relaxants were excluded from the study.

The Performa filled for all patients that fulfil above criteria. Following variables recorded for each patients which include demographic history, date of trauma, mode of injury, side of facial palsy, date of onset of facial palsy and also other associated symptoms like ear bleed , ear fullness, hearing loss ,tinnitus , true vertigo. Furthermore, variables on clinical examination post trauma added such as hemotympanum , tympanic perforation, Cerebrospinal fluid otorrhea , bleeding external ear canal/blood clot , injury of external ear and battle sign. The severity of facial nerve palsy grading from I to VI classified clinically based on HB facial nerve grading. We included Pure Tone Audiometry findings, ENOG finding, HRCT temporal post trauma findings and any treatment done – medical and surgical management.

The data was analysed using IBM Statistical Package for Social Sciences (SPSS version 27.0). Categorical data was summarized with frequency and percentage. The first objective which is prevalence of site of facial nerve injury with ENOG calculated. For objective 4, Spearman Correlation between HB grading and denervation percentage. For objective 5, Kruskal-Wallis Rank Sum Test to evaluate comparison of percentage denervation (ENOG) at fractures site. For objective 6, Cohen Kappa method to assess agreement between old classification of TBF and otic capsule violation (new classification). A p-value <0.05 was considered a statistically significant association.

3.5 RESULTS

Demographic

There were 82 traumatic facial nerve injury cases were included in the analysis. The demography of the cases was summarised in **Error! Reference source not found.**. The mean age of the participants was 27.5 years old. Among the participants, 67(81.7%) were males and 15(18.3%) were females, with a male-female ratio of 7:2. Largely, 80 (97.6%) Malay participants seen in the study followed by 1 Chinese (1.2%) and 1 other (1.2%).

The major cause of trauma is MVA (n=76;92.7%). Of the 76 MVA, highest case involving motorcycle (n=65:83.3%), followed by car (n=6;7.7%), bicycle (n=3;3.8%), pedestrian (n=2;2.6%) and lorry and truck (n=2 ;2.6%). Among the 65 motorcyclists, more than half of them (n=41;63%), were not wearing protective gear like helmet at time of trauma.

Clinical findings among patients with Traumatic facial nerve palsy

In the study, about 48 patients had ear bleeding (58.5%) post trauma which is the major presenting complaint. Some patients experienced hearing loss (52.4%), tinnitus (20.7%), vertigo (15.9%), ear fullness (12.2%) and headache (9.8%). The otology examination in emergency department revealed most patients had blood clot in external meatus (73.2%), followed by hemotympanum (28.0%), tympanic perforation (17.1%), pinna laceration (13.4%) and Battle's sign (4.9%).

As Pure tone audiometry (PTA) is a standardized and sensitive equipment for hearing assessment, it is used to diagnose types and severity of hearing loss in this study. PTA of 82 participants revealed 76 (92.7%) of them had hearing loss, leaving about 6 (7.3%) of them

normal hearing post trauma. Majority of the hearing loss were moderate in severity (43.9%). About half of hearing loss were conductive hearing loss (CHL) (52.4%) while one third were mixed (25.6%), leaving about 14.6% of cases to sensorineural hearing loss (SNHL) category.

Clinical assessment of Traumatic facial nerve palsy

There were 10 (12.2%) patients who had acute, and 72(87.8%) patients had delay facial palsy. On average, the onset of facial palsy occurs at day 5 post trauma. About 48 (58.5%) of them had facial palsy on right side and 34 (41.5%) on left side. The clinical evaluation of facial nerve dysfunction using HB in these patients revealed that half of them (50.0%) were Grade IV (moderate severe dysfunction). This was followed by 20.7% Grade II injury (mild dysfunction), 17.1% Grade V injury (severe dysfunction), 11.0% Grade III injury (moderate dysfunction) and 1.2% Grade VI injury (total dysfunction).

HRCT temporal findings in traumatic facial nerve palsy

The HRCT in 82 patients revealed TBF in seen 76(92.6%) in cases, leaving minority about 6 (7.3%) of them without evidence of fracture line (Table 2). We observed that all the six patients without fracture line had delayed onset facial nerve palsy , around day 4 to day 5 of post trauma.

The old classification of TBF based on fracture line in respect to the long axis of petrous ridge revealed that 46/76 (60.5%) were longitudinal fractures, 14/76 (18.4%) were transverse fractures and 16(21.2%) were mixed fractures (Table 3). On new classification of TBF which is based on otic capsule invasion, we found 64 had otic capsule sparing fractures and 12 had otic capsule violation fracture(Table 2). We found 26 (31.7%) cases had ossicular involvement and 49(59.8%) cases had fluid collection in middle ear post trauma(Table 2).

Interestingly, the HRCT Temporal in our study had reported there were cases with intact facial canal 22 (26.8%) among patients with traumatic facial nerve palsy. Almost all of these intact facial canal (21/22 cases) had delayed onset of facial palsy. There were also cases with more than one site (multiple segments) of facial canal fracture 12 (14.6%)(Table 2). Of these 12 cases with multiple segments of facial canal fracture, commonest combination was tympanic and first genu segments (50%) (Table 2). In term of sites of facial canal fracture, the tympanic (28.0%) were the commonest , followed by first genu(24.4%), mastoid(19.5%), labyrinthine(8.5%) and second genu(6.1%)(Table 2).

Electroneuronography findings in traumatic facial nerve palsy

The percentage of denervation of injured nerve were summarised in table 3 and the distribution is visualized in **Error! Reference source not found.**. In our study, all our first ENOG assessment done between day 5 to day 14 from trauma (median of 7.5). The ENOG recorded the denervation of injured facial nerve ranges between 47.7% to 94.2% (median of 82.0%). Of 82 our patients, 31(37.8%) of them had denervation more than 90% at first ENOG reading.

Correlation between HB grading and denervation percentage

Spearman correlation show that there is insignificant and low correlation between the clinical assessment using HB grading and percentage of denervation of injured nerve of first ENOG, as summarised in Table 4 and visualized in **Error! Reference source not found.**.

Comparison of percentage denervation (ENOG) at facial nerve fractures site.

There was no significant difference of percentage denervation between the facial canal segments fracture sites, as shown in Table 5. Hence, there were no association between sites of facial nerve injury and electroneuronography (p value <0.075). However, we observed that tympanic segments fracture (91.2%) and multiple segments fracture (92.6%) had significant

result that is more 90% denervation (Table 5). This means injury or damage of the nerve tends to be worse in those fracture at tympanic segments and multiple segments of facial nerve.

Agreement between Old Classification of Temporal Fracture and Otic Capsule Violation

Among those with longitudinal fracture in HRCT, only 10(16.1%) had otic capsule violation. Similarly, among those with transverse fracture, only 6 (20.0%) had otic capsule violation (Table 6). In term of agreement between old and new classification, neither longitudinal fracture (P value < 0.459) nor transverse fracture (P value < 0.320) had agreement with otic capsule violation as shown in Table 6. Nevertheless, the otic capsule violation seen higher in transverse fracture (20%) in comparison to longitudinal fracture (16.1%), as seen in table 6.

3.6 DISCUSSION

There are many aetiologies for facial paralysis but the commonest cause is trauma. It is the most devastating outcome in term of functional and aesthetic in a patient. It is life debilitating effect causing emotional stress and increase risk of post-traumatic stress disorder like depression or anxiety.

Studies by Rajati M et al and Darrouzet V et al concluded MVA is a number one cause of trauma, similar to our finding[7,11]. The average age of our participants are 27.5 years old, similar to the literature[7,11]. The majority patients were males which are consistent with other study[7].This cis due to majority of motorcyclist are males hence their exposure to accident is higher. The young adults prone to make impulsive decision and negligent in their driving habits which contribute to MVA. Among the key risk factors of MVA were failure to wear safety gear like helmet, excessive speeding, alcohol consumption, bad traffic conditions, poor road surfaces and roadside hazards.

Predominantly, Malay race seen among our participants as the study conducted in East Malaysia which has preponderance of Malay community. The bloody otorrhea or blood clot were most frequent presentation in our patients. A Study by Darrouzet V et al showed similar high percentage of bloody otorrhea (73%) in their otoscopy examination[11] . This is because bony and soft tissue injury of external auditory meatus are prone MVA.

Moderate hearing loss (43.9%) were seen the most in our patients. About half of the hearing loss were conductive hearing loss (CHL) (52.4%) while one third were mixed (25.6%), leaving about 14.6% of cases to sensorineural hearing loss (SNHL) category. CHL are common in temporal bone fracture [11]. The bloody otorrhea, ossicular disruption and hemotympanum

especially early phase of trauma are the main reason. SNL are usually result of inner ear concussion during trauma. Therefore, we should not delay hearing assessment as good outcome seen in treating ossicular dislocation which ensure a good prognosis in chronic otitis media related to middle ear trauma.

In our study, 10 (12.2%) had acute and 72(87.8%) had delay facial palsy. The average onset of facial palsy is day 5 post trauma. The probable reason for higher incidence of delay diagnosis could be partly due to poor general or neurological condition associated with head trauma. These makes longer duration of ventilation and sedation which makes facial assessment difficult.

HRCT is known choice in traumatic facial nerve injury because of its ability to delineate the osseous structures and fracture line. It also able to identify other related injury like ossicular disruption, hemotympanum and fistula. Darrouzet V et al. reported not all traumatic facial paralysis had fracture line seen in HRCT as 7.6% of his cases had intact facial canal. We agreed with the author as 6/82 (7.3%) of our HRCT had absence of fracture line. This is due to the possibilities of HRCT may miss fracture line as a study quoted that sensitivity and specificity of HRCT temporal to detect fracture line were 77.5 and 77.7% only[7].

Interestingly, we observed that those patients with no fracture line had delayed onset facial nerve palsy , around day 4 to day 5 of post trauma. This can possibly be explained by a microtrauma causing reversible facial nerve oedema which usually missed in HRCT[12]. Subsequently, the oedema will result in reversible pressure effect of within the fallopian canal which could be treated by medical treatment.

In cases with severe facial nerve palsy with absence of a visible fracture line on HRCT, electrophysiologic and clinical monitoring are recommended[11]. Those not recovered by 6

months post trauma, surgery may be done [11]. We recommend Magnetic Resonance Imaging (MRI) with contrast in cases with traumatic facial palsy and no evidence of fracture line in HRCT. The MRI enables direct visualization of injured nerve, and able to detect neural oedema, ischaemia (abnormal enhancement on contrast) or an intraneural hematoma (presence of blood degradation products along the course of the nerve)[13,14].

The head injuries are prone seen in MVA especially among un helmeted motorcyclist [15].In a study with 47 facial paralysis with TBF, 28(60%) had longitudinal, 6(13%) had transverse, and 13(27%) had mixed fractures[12,16]. We had similar outcome in our study where the commonest were 46(60.5%) longitudinal fractures followed by 14(18.4%) were transverse fractures and 16 (21.2%) were mixed fractures. Based on new classification, the otic capsule sparing had higher prevalence than otic capsule violation, in consistent with the literature[512].

Many literatures found peri geniculate as commonest involved in facial nerve injury in trauma[17,18.] In contrast , we observed in our study, mainly the tympanic segment injury (28.0%), followed by first genu (24.4%), mastoid(19.5%), labyrinthine(8.5%) and second genu(6.1%). Relatively, the tympanic segment of facial nerve are prone injury attributed to MVA related to motorcycle where injury is often sustained to the temporal bone while falling to the side. Also, the tympanic segment susceptible to traction along its axis in longitudinal fracture (which is most frequent type of temporal bone fracture).

We also observed about 12 cases with multiple segments of facial canal fracture, half of them 6 (50%) had combination of tympanic and first genu segments. Darrouzet et al noted similar findings where 4/52 (6.1%) geniculate segment injury associated with mastoid segment[11]. Fast speed motorcyclist result in high impact trauma on skull explains the multiple segments facial involvements.

In our study, we found there were low correlation between the clinical assessment using HB grading and percentage of denervation of injured nerve of ENOG. The reason being HB is a subjective in comparison to electrophysiological test like ENOG. Although the HB simple assessment tool ,the assessment can be deceptive and bias in judgment. A multicentre trial study concluded HB interobserver variability increased depending on severity of facial nerve palsy and there is no uniformity among those reporting facial nerve palsy[5.] Chee GH and Nedzelski JM study reported similar result and they advocated Sunny Brook Facial Grading System as it has improved sensitivity and reliability[19].

There were no association seen between sites of facial nerve injury and electroneuronography. This could be due to the only first ENOG assessment were used to evaluate the association. ENOG is found to be more reliable if done in few series over period as it is more valuable in assessing progression of facial nerve injury post trauma. We also observed multiple sites of facial nerve injury had significant ENOG result (more than 90% denervation). This is explained by injury or damage of the nerve tends to be worse when there is more than one site facial nerve. Hence, we would suggest analysing association of serial ENOG (progression of facial nerve injury) with sites of facial nerve sites in future so it would give reliable outcome.

In term of agreement between old and new classification of TBF, neither longitudinal fracture nor transverse fracture had agreement with otic capsule violation. Nevertheless, the otic capsule violation seen higher percentage in transverse fracture (20%) in comparison to longitudinal fracture (16.1%). This result shows prevalence of otic capsule violation were higher in transverse fracture than longitudinal fracture of TBF. Hence, we need to be prudent in facial nerve assessment post trauma especially in cases with transverse fracture because facial nerve injury 5 times more likely develop in otic capsule violation[12].

3.7 CONCLUSION

MVA are major cause of trauma with motorcyclist without helmet were largely involved. Hence it is crucial to wear helmet as protective gear to skull when riding motorcycle. The most common site of traumatic facial nerve injury is tympanic segment. In cases with absence of fracture line in HRCT with severe facial paralysis, MRI can be consider to visualise any microinjury of the nerve itself. In cases with transverse TBC , high likely it cause otic capsule violation , hence we need to be vigilant in diagnosing facial nerve paralysis post trauma. There is no association between sites of facial nerve injury and ENOG. The selection of patients for surgery should not solely rely on HRCT but also clinical grading (time of onset) and serial ENOG monitoring. When a medical management initiated, facial nerve function must be monitored and the decision subsequently may need to re-evaluated.

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