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CT VIRTUAL ENDOSCOPY IN ASSESSING OSSICULAR CHAIN DISRUPTION CSUSED BY TEMPORAL BONE FRACTURE AND EAR TRAUMA

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Abstract

Objective To explore the value of computed tomography virtual endoscopy (VE) in assessing ossicular chain disruption in temporal bone fracture and ear trauma with intact tympanum. **Methods** High resolution spiral computerized tomography (CT) was completed in 35 cases of temporal bone fracture and 5 cases of tympanum trauma, all with intact or healed tympanum. Three-dimensional reconstruction was completed using a virtual endoscopy software. Audiological tests were conducted in all patients and evaluation of facial nerve injury in patients with facial paralysis. Patients with mild conductive deafness, ossicular chain subluxation on VE, and no facial paralysis were treated conservatively for 4-12 weeks with repeated hearing evaluation; those with facial paralysis underwent surgery if no recovery after 4-8 weeks of conservative treatment. Patients with moderate to severe conductive hearing loss or mixed hearing loss, incus long process fracture or dislocation on VE and facial paralysis, underwent ossicular chain reconstruction and facial nerve decompression after conservative treatment for 4-8 weeks, or exploratory tympanotomy only if no facial paralysis. VE, audiological tests and facial nerve function tests were repeated in 3-6 months after surgery. **Results** Of the 6 cases with mild conductive hearing loss, ossicular chain subluxation and no facial paralysis, 3 recovered to normal hearing spontaneously and 3 showed no significant improvement, after 4-12 weeks of conservative treatment. After conservative treatment for 4-8 weeks, 3 of the 12 cases with mild conductive deafness, ossicular chain dislocation on VE and facial paralysis recovered to normal hearing and House-Brackmann (HB) grade I facial function from HB grade II ,4 showed facial function recovery to HB grade I (n=2) or II (n=2) from HB grade III but no hearing recovery, and 5 gained no recovery and went on to receive exploratory tympanotomy and facial nerve decompression. The 11 cases with moderate to severe conductive deafness, incus long process fracture or dislocation on VE and facial paralysis all received ossicular chain reconstruction and facial nerve decompression after 4-8 weeks of conservative treatment. The 7 cases with moderate to severe conductive deafness, dislocated or fallen incus on VE but no facial paralysis received ossicular chain reconstruction after conservative treatment. The 4 cases with mixed hearing loss, dislocated or fallen incus on VE and no facial paralysis received ossicular chain repair via the intact canal wall epitympanum approach after conservative treatment. Pharmacological therapies continued postoperatively in these patients to treat sensorineural deafness. Although temporal bone CT scans displayed the fracture line and malleus/incus abnormalities, VE provided additional detailed information on dislocation of incudomalleal and incudostapedial joints, incus dislocation or fracture, separation between crus longum incudis and stapes, and incus shifting. These were all confirmed during surgery. VE results and surgery findings were 100% consistent in patients with ossicular chain disruption. **Conclusion** VE can provide reliable visual evidence for accurate assessment of traumatic ossicular chain disruption, timing of surgery and individualizing surgical strategies and postoperative follow-up.

Key words: temporal bone fracture, ear trauma, virtual CT endoscopy (VE), computerized tomography (CT), ossicular chain disruption

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INTRODUCTION

Traumatic ossicular chain disruption commonly occurs in cranial and ear trauma. In the past, the diagnosis of traumatic ossicular chain disruption was mainly based on the medical history and hearing test. Confirming diagnosis required exploratory operation. Sometimes, ossicular chain disruption may be the only sequela of temporal bone fracture and ear trauma. With the extensive application of high resolution CT, temporal bone CT has become a routine examination in otology, in which temporal bone thin-layer CT is used to evaluate traumatic ossicular chain disruption. However, thin-layer CT does not meet the clinical demand for 3D visualization of the complex and sometimes unique structures of the tympanum and ossicles, especially in the case of conductive deafness caused by temporal bone fracture and ear trauma in which it is difficult to determine the integrity of ossicular chain [1]. Virtual endoscopy (VE) is the application of virtual reality technology in clinical medicine, in which computerized 3D reconstruction technology is used to process original data of middle ear disorders obtained by spiral CT to clearly display structures of the tympanum and ossicular chain, assuming the function an endotoscope [2]. VE provides useful images of improved visual representation and helps understanding of complex structures in the tympanic cavity including the ossicular chain. And it may play an especially useful role in pre-operative evaluation of the ossicular chain, epitympanum and retrotympanum [3, 4]. VE is a useful addition to routine CT and provides reliable evidence for the diagnosis and therapeutic effect assessment in traumatic ossicular chain disruption. Moreover, VE is beneficial for otologists to create new surgical approaches and improve methods for exploratory tympanotomy, and it provides a reliable index for postoperative follow-up. Some authors state that VE is valuable for the evaluation of ossicular and prosthesis dislocations and of morphological anomalies of the malleus, incus, and stapes superstructure. They have suggested that VE should be used only as an adjunct to standard axial and coronal CT images [5]. Some authors' studies have demonstrated that VE can greatly improve the diagnostic accuracy of ossicular chain separation in preoperative evaluation, and the evaluation of incus, incudomalleal joint and incudostapedial jiont. VE provides a reliable basis for evaluating the diagnosis and treatment of traumatic ossicular chain disruption. One important limitation of the VE is that the stapes footplate cannot be evaluated well, especially in otitis media [6]. Jiang et al [7] have reported similar findings and believe that VE is valuable for providing accurate assessment in peri-operative evaluation. In this paper, we mainly discuss the clinical value of VE in preoperative assessment and postoperative follow-up in traumatic ossicular chain disruption.

MATERIALS AND METHODS

Case data

Data from 35 cases of temporal bone fracture following head or craniocervical trauma diagnosed between May 2004 and May 2011 with complete medical history and temporal bone CT scan data and from 5 cases with healed ear canal trauma and/or tympanum perforation were reviewed. Fracture of temporal bone was longitudinal in 30 cases and combined longitudinal and horizontal in 5 cases. Causes of ear trauma and tympanum perforation included planner chips hitting pars flaccida (n=1), chopsticks stabbing the upper part of tympanum (n=1), electric welding spark splashing into posterosuperior external auditory canal (n=1) and tearing wound of external auditory canal and posterosuperior tympanum from traffic accidents (n=2). There were 30 males and 10 females with an average age of 30 years, ranging from 18 to 50 years. Injury was in the left ear in 22 cases and in the right ear in 18 cases. Varying degrees of hearing loss existed in all 40 cases: mild conductive deafness in 18 cases, severe conductive loss with an average air-bone (A-B) gap of up to 55 dB in 18 cases, and mixed hearing loss with an average speech frequency air conduction hearing loss of 35 dB in 4 cases. Various degrees of peripheral facial paralysis were seen in 23 cases.

Audiological tests

Patients with hearing loss and/or facial paralysis after temporal bone fracture or ear trauma underwent pure tone audiometry, acoustic immittance and stapedial reflex tests, and auditory brainstem response (ABR) examination both pre- and post-operatively.

Evaluation of facial nerve injury

Electromyography (EMG) and electroneurography (ENoG) were conducted in the 23 patients with facial nerve paralysis. Other facial nerve tests included the taste test, Schirmer's test and acoustic reflex test.

VE Examination

A GE HiSpeed NX/I spiral CT scanner with Inner Ear scanning software was used, with the following technical parameters: 170 mAs, 120 kV, 0.5 mm cut thickness, SFOV; small, 0.8:1 in thread pitch; and following reconstruction parameters: 0.5 mm cut thickness, 0.2 mm reconstruction gap, Fov 80 mm. Middle ears on both sides were reconstructed. VR software was used to demonstrate reconstructed images. Value -600 was chosen as upper threshold when there was no soft tissue in middle ear cavity and +200 in temporal bone reconstruction. All images were reviewed by an experienced radiologist who had been specialized in this area for 10 years.

Treatments

Non-surgical treatment

Non-surgical conservative treatment was given in 13 cases, including 6 cases with mild conductive hearing loss and 7 cases with mild facial paralysis (facial function was HB grade Ⅲ in 3 cases and HB grade Ⅲ in 4 cases).

Surgical treatment

For cases with moderate to severe conductive deafness or ENoG demonstrating > 90% degeneration of the facial nerve (HB grade IV or V facial function) which showed no signs of recovery after conservative treatment, surgical treatment was offered at the earliest time possible.

Exploratory Tympanotomy

Tympanotomy and exploration via the attic route were performed in 11 cases, including 5 cases with healed tympanic membrane perforations and 6 cases of temporal bone fracture with intact tympanic membrane and no facial paralysis [8]. The atticus was open while preserving the posterosuperior canal wall and tegmen tympani. Exposure reached the anterior recess anteriorly and the aditus ad antrum tympanicum posteriorly with full visualization of the malleoincudal joint. The posterior tympanum was exposed by removing the bone lateral to the lateral semicircular canal and pyramidal segment of facial nerve for exploration of the entire ossicular chain. Incus dislocation was reduced if present and malleus-stapes joining was performed in case of crus longum incudis fracture. Facial nerve decompression was conducted concurrently if facial paralysis was present.

Geniculate Ganglion Decompression via a Subtemporal-supralabyrinthine Approach

This was done in 16 cases of temporal bone fracture with facial paralysis. The attic was opened to expose the malleoincudal and incudostapedial joints, followed by radical mastoidectomy. Then facial recess was opened and the incus buttress removed for a full visualization of the malleoincudal joint, incudostapedial joint and tympanic segment of facial nerve. The incus was removed if there was dislocation or long process fracture. The head of malleus was removed if the space below the tegmen was narrow. Air cells of the supralabyrinthine recess was removed beside the anterior and lateral semicircular canals to fully expose the middle cranial fossa skull base and the interspace between the anterior and lateral semicircular canal eminences. The geniculate ganglion and labyrinthine segment of the facial nerve were decompressed by removing the lateral wall of the bony canal. This was extended posteriorly to decompress the mastoid segment to complete a sub-total facial nerve decompression [9].

Managements of mixed Deafness

For patients with mixed deafness, exploratory tympanotomy was performed after their craniocerebral injury had been stabilized, while early pharmological treatment was also provided, including vasodilators, neurotrophic agents, and agents that might improve inner ear circulation, as well as glucocorticoids and hyperbaric oxygen to reduce facial nerve inflammation and edema.

Postoperative Follow-up

VE was repeated in 20 patients to examine the ossicular chain 3-6 months after surgery. Other patients were lost due to geographical and economic reasons. Audiological tests were repeated in 18 patients at 3 months after surgery.

RESULTS

VE in revealing ossicular chain damage

Fracture lines and malleoincudal joint disruption were visible on axial CT scans, which did not allowing viewing of the incudostapedial joint. Coronal CT scans in patients with ear trauma provided visualization of disrupted ossicular continuity, but failed to clearly demonstrate ossicular joints. Although high resolution computed tomography (HRCT) images correlated well with operative findings regarding the overall type of ossicular disruption, its accuracy varied and was proportional to the size of the particular ossicle, i.e. highest for malleus (100%), less for incus (85.29%) and the lowest for stapes (76.97%). It also failed to show subtle injuries, especially regarding ossicular joint. VE served as a good supplement in middle ear structure evaluation [10] (Fig.3), allowing viewing of middle ear structures from all angles. Important structures such as the tympanum, external auditory canal, hypo-tympanum, epitympanum, ossicular chain and orifice of eustachian tube, as well as their anatomical relations, were all clearly and accurately visualized on VE. Three-D images of ossicular chain on VE could be compared to those from healthy young people without middle ear disorders (Fig.1). VE revealed distinct images of ossicular joint disruption, showing soft tissues linking the crus longum incudis with stapes in incudostapedial joint dislocation and separation of crus longum incudis from the head of stapes or separation of incudal body from the head of malleus in incus dislocation. In 17 cases of temporal bone fracture, VE showed crus longum includs fracture in 3 cases, incus incomplete dislocation in 9 cases and complete incus dislocation in 5 cases. In 5 cases of ear trauma, VE revealed partial incus dislocation in 2 cases and complete incus dislocation in 3 cases.

Among the 20 patients who received postoperative VE reexamination, 11 had temporal bone fracture accompanied with facial nerve paralysis. Incus was completely dislocated in 4 of these patients which was returned to its normal position and showed satisfying anatomy on postoperative VE. Partial incus dislocation was reduced in 7 of these patients and completely normal anatomy was maintained on follow up VE. In 4 of the 20 patients in whom complete incus dislocation was caused by ear trauma, postoperative follow up VE showed normal ossicular chain anatomy. In the remaining 5 cases of temporal bone fracture accompanied with incus fractures or dislocation, postoperative VE also demonstrated normal ossicular structures.

Surgical findings

In cases of temporal bone fracture accompanied with facial paralysis, surgical findings included incudomalleal joint separation, soft tissues wrapping the body of incus, compression of tympanic segment of facial nerve, partial incudostapedial joint dislocation with residual connection by soft tissues (Fig.4). In temporal bone fracture cases without facial paralysis, fracture lines tended to pass the posterosuperior external auditory canal and mastoid, often with crus longum incudis fracture and complete separation of malleoincudal or incudostapedial joint as well as incus dislocation. VE representation of ossicular chain disruption was confirmed by findings during surgery in all patients (100%).

Auditory function recovery

Upon discharge, the A-B gap in 18 cases with mild conductive deafness was reduced by 25 to 40 dB (less than 10 dB remaining). In 3 cases of mixed hearing loss, average speech frequency threshold improved by 15 dB at discharge. Repeat hearing test at 3 months postoperative in 18 cases showed an average improvement across speech frequencies by 30 dB, reaching to useful hearing levels. In 6 cases of mild conductive hearing loss who received non-surgical conservative treatments, hearing recovered to normal in 3 cases, while the other 3 showed no improvement.

Facial function changes

In the 23 cases with facial paralysis, facial function was House-Brackmann (HB) grade II in 3 cases, HB grade III in 4 cases, HB grade IV in 9 cases and HB grade V in 7 cases. In 16 of the 23 cases, repeated preoperative ENoG demonstrated>90% degeneration of the facial nerve, with no regeneration potentials on EMG. Taste test showed loss of taste in the anterior 2/3 of the tongue in these 16 cases. Schirmer's test was positive in 7 of these cases and negative in 9 cases (although all of the 9 cases showed no stapedius reflex). Other clinical signs of facial paralysis included loss of wrinkles, widened palpebral fissure, loss of corneal reflex, epiphora, shallow or absent nasolabial fold and droopy mouth corner. These16 cases were surgically treated, and facial function began to improve 2 weeks after operation and eventually recovered to HB grade I in 7 cases, HB grade II in 6 cases and HB grade III in 3 cases at 6 months after operation. Facial function in patients receiving conservative treatments recovered to HB grade I in 5 cases and HB grade II in 2 cases.

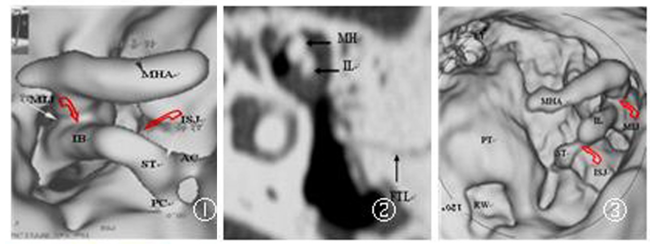


Fig.1: Virtual CT otoscopy (VE) of the normal right ear.

Fig.2: Temporal bone axial CT scan shows a longitudinal fracture line of the left temporal bone. FTL: Fracture line MH: malleus IL: incus

Fig.3: VE preoperatively shows the separation of malleoincudal joint and the dislocation of incudostapedial joint. RW: round window

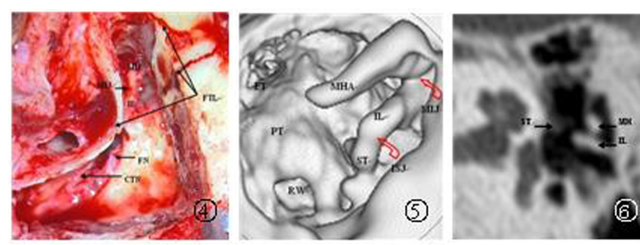


Fig.4: Surgical image shows the separation of malleoincudal joint and some soft tissue connected incudostapedial joint. CTN: chorda tympani nerve.

Fig.5: VE shows the structure of the ossicular chain is approximately normal after hearing reconstruction surgery.

Fig.6: Oblique coronal CT scan of the temporal bone shows the deformity of malleoincudal joint and incudostapedial joint are discontinuous.

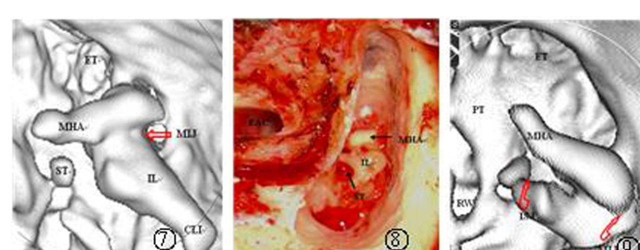
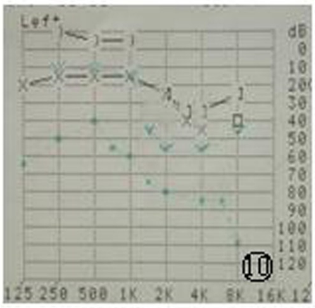


Fig.7: VE shows the incus is shedding and dislocation.

Fig.8: Surgical image shows the separation of malleoincudal joint and incudostapedial joint, incus is shedding and reversing. EAC: external auditory canal.

Fig.9: The reexamination of VE observed that malleoincudal joint and the incudostapedial joint connected completely.



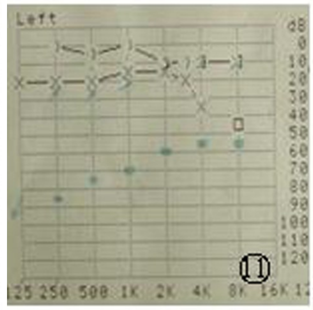


Fig.10: The reexamination of pure tone threshold of cases 1. (blue for preoperative)

Fig.11: The reexamination of pure tone threshold of cases 2. (blue for preoperative)

Note: MHA: malleus handle IB: incus body ST: stapes AC: anterior crus of stapes PC: posterior crus of stapes MIJ: malleoincudal joint ISJ: incudostapedial joint ET: eustachian tube PT: promontory

Discussion

Temporal bone fracture and ear trauma often result in ossicular chain disruption. Routine clinical indicators such as high resolution temporal bone CT and audiometric tests are often inadequate to determine the condition of the ossicular chain. While axial and oblique high-resolution thin-layer CT can display the location and morphology of the three ossicles, it does not demonstrate dislocation of incudomalleal or incudostapedial joint clearly [10]. It was demonstrated in this group that axial and oblique coronal high resolution spiral CT indicated disruption of the ossicular chain but failed to show the extent of damage, while VE clearly revealed incudostapedial joint dislocation and incudomalleal joint separation which were confirmed in following surgeries. Therefore, three-dimensional (3D) VE provides more accurate and clear observation of structures of the tympanum and ossicular chain than regular axial and coronal CT, showing its unique values in the diagnosis of ossicular chain disruption caused by temporal bone fracture and ear trauma, especially when other examination methods such as otoscopy and endotoscopy fail to provide adequate evidence for diagnosis,.

In the past, exploratory tympanotomy was performed on patients with traumatic ossicular chain disruption diagnosed based mainly on trauma history and the degree of deafness. In a routine exploratory tympanotomy, tympanum-auditory canal flap is lifted to explore the incudostapedial joint. Incus reduction is carried out when incus dislocation is found and suprastapedial malleus-stapes joining is performed on patients with crus longum incudis fracture. However, this approach is difficult to handle damages of the attic and the incudomalleal joint even with endotoscopy, making exploratory tympanotomy less than ideal in these situations. Three-dimensional VE images of the tympanic space and ossicular chain offer ear surgeons a new opportunity to evaluate anatomical structures of the operative site with increased accuracy before the surgery. VE can not only confirm the connection status of ossicular chain but also crus longum incudis separation or fracture, as well as the degree of damage regarding the incudomalleal and incudostapedial joints to improve diagnosis accuracy, establish individualized operation program, perform targeted procedures to decrease or avoid unnecessary complications, and shorten the operation time [7,11]. In this group, 5 patients with history of ear trauma and 6 patients of temporal bone fracture without facial paralysis presented with intact tympanum or healed perforations, but VE indicated damaged incudomalleal and incudostapedial joints. Exploratory tympanotomy by attic route with preservation of the posterosuperior external auditory canal wall allowed exposure and management of both joints after opening the epi- and posterior tympanum, with consequently satisfactory hearing outcomes. Hence, VE can provide useful evidence for operation planning before the surgery and guidance for operation during the surgery.

Longitudinal fracture is the main type in temporal bone fractures. It most frequently traverse at some point through the middle ear and may cause disruption of the middle ear ossicles while rarely damaging the labyrinth, usually creating a conductive hearing loss. It needs to be noted that conductive hearing loss mostly is caused by hemotympanum 3-6 weeks after injury. Final diagnosis is often made 3-6 weeks after injury when hemotympanum has disappeared [12]. There are different opinions on the treatment of temporal bone fractures with conductive hearing loss. Wennmo et al[13]. suggest that temporary conductive hearing loss caused by temporal bone fracture is mostly a result of hemotympanum, perforation of tympanic membrane and damage of ossicular chain, and persistent conductive hearing loss is mainly related to ossicular chain disruption. Surgical exploration should be considered if conductive hearing loss persists 6-7 weeks after injury. While, Grant et al[14]. suggest that conductive hearing loss caused by temporal bone fracture should be treated with conservative treatment first, and surgical management should be considered if it lasts more than 6 months after trauma. Johnson et al[12], note that patients suspected of ossicular chain disruption after temporal bone trauma should undergo tympanic exploration when conductive hearing loss is clear, even if the diagnosis is not confirmed by other tests. Patients should undergo tympanum exploration and ossiculoplasty 3-4 months after injury when perforations have healed but conductive hearing loss persists - likely an indication of ossicular chain disruption. Patients with vertigo and nystagmus at an early stage with suspected stapes invaginate fracture should undergo surgery as soon as possible to prevent irreversible damage to the inner ear, which can lead to permanent deafness. In this series, cases with VE confirmed ossicular chain disruption and persistent conductive hearing loss underwent surgical treatment within 4-8 weeks after trauma.

Traumatic ossicular chain disruption, including fracture of ossicles and joint dislocations, often occurs in direct middle ear injury or longitudinal fracture of the temporal bone. The malleus is protected by its anterior and lateral ligaments, and by tensor tympani and its tendon, while the stapes is protected by the stapedial ligament and stapedius muscle. In contrast,incus has no protection by muscles and its loose connection with the malleus and stapes is the weakest among the three ossicles, which determines that the incus is the most vulnerable to dislocation or complete separation in trauma. Wysocki et al[15]. found from his experience of ossicular reconstruction that incudostapedial dislocation was the most common form of ossicular chain damage caused by temporal bone fracture, followed by incudomalleal joint separation, and that ossicular fracture was the rarest. Incudomalleal and incudostapedial joint dislocation is also the most common ossicular disruption in this series. Possible mechanisms of incus injury may be related to the attachment of the stapedius tendon to the posterior stapedius crus near the incudostapedial joint and of the tensor tympani tendon to the neck of malleus. Clonic contraction of these muscles during trauma may create a central tensile force on the incus and backward tensile force on the head of stapes, and the resulting shearing force may result in dislocation, especially at the incudostapedial joint. In addition, some structures along the ossicular chain, such as the incus long process, are prone to ischemic necrosis at certain times after temporal bone fracture. The link between the incus long process and stapes is weak, making the incudostapedial joint prone to dislocation upon strong impact. Saitod et al[16] .and Tsai et al.[17] speculated that incus might rotate backward along the long process and toward the external auditory canal, or protrude through fracture lines along the canal wall. Both may lead to sufficient range of shifting for incus separation. VE can provide 3D relations of the entire ossicular chain in one image, with clear representation of the incudomalleal and incudostapedial joints, which is useful in establishing diagnosis and correct understanding of epitympanic incudomalleal joint injury at an early time. This will help prevent long term conduction deafness due to inadequate treatment caused by misdiagnosis.

There are different views about the treatment of temporal bone fracture with facial paralysis. Fisch et al.[18] believe that decompression should be considered immediately when ENoG demonstrates >90% degeneration of the facial nerve. But in theory, the motor neuron body begins to recover on the 21st day after injury, with highest levels of anabolic activities that potentially may provide the best outcomes of nerve decompression. On the other hand, facial nerve identification and tension-free anastomosis are easier when performed at an early time following injury. Delayed surgical treatment may lead to nerve contraction, scar formation between nerve stumps and formation of neuroma, as well as peripheral muscular atrophy and irreversible loss of function. Opposition to surgical decompression often stem from inability to establish clear diagnosis and determine condition of the ossicles regarding their relations to the facial nerve, due to lack of adequate imaging evidence. Some patients may be left with permanent facial paralysis or paresis as a result of lack of timely intervention. Yetiser et al.[19] believe that satisfying facial function can be obtained through timely decompression even in facial paralysis caused by transverse temporal bone fracture, but the longer the delay, the worse the outcomes. Ulkü et al[20] . state that facial paralysis is a difficult complication in temporal bone fracture, and surgery provides the best opportunity for facial function improvement. Facial nerve damage after temporal bone fractures often results from bone chip injury and nerve edema. Along with time, axonal transaction and even facial nerve transaction can occur, resulting in worsened facial function. Therefore, timing of surgical intervention is a very important issue. In principle, the sooner the better. VE can demonstrate compression of facial nerve by hematoma or dislocated ossicles, which can provide indication for surgical intervention at an early time. Facial nerve decompression at an early stage can can not only remove factors directly damaging the facial nerve but also extenuate secondary injuries by ischemia and edema from elevated pressure in the facial nerve canal [7], consequently promoting recovery from facial paralysis. Comprehensive treatments in addition to decompression, such as neurotrophic agents, vasodilators, corticosteroids, antibiotics, vitamins and other agents, as well as physical therapy and facial massage, may also be beneficial to early recovery of nerve function in patients with facial paralysis [21].

CONCLUSION

Virtual CT endoscopy is a noninvasive examination that provides a full 3D representation of intratympanic structures in the temporal bone beyond cavity walls. Additionally, the zoom feature of VE allows close examination of desired areas in a way that traditional imaging techniques cannot [22]. VE enables otologists to better prepare for areas that may present a challenge during the operation and allow them to plan the best trajectory to target tissues [23]. Our study shows that VE is beneficial for otologists to accurately evaluate traumatic ossicular chain disruption, grasp the timing of surgery, establish an operation plan and choose an appropriate operative approach. Meanwhile, it provides a reliable index for postoperative follow-up. In general, VE has important clinical values for preoperative diagnosis and postoperative follow-up in ossicular chain disruption caused by temporal bone fracture and ear trauma.

Example Cases

Case 1: A 34 years old female, was admitted on March 15 2006. She suffered closed injury in left temporal region with facial paresis for 4 weeks. Examinations showed intact tympanum, left facial paralysis (HB grade V) and more than 95% facial nerve injury on electroneurography. Temporal bone CT showed longitudinal temporal bone fracture and abnormal malleus and incus (Fig.2). VE indicated incudomalleal joint separation and incudostapedial joint dislocation (Fig.3). Audiometry revealed speech frequency conductive hearing loss of 40-70 dB HL in the left ear. Facial nerve decompression and ossicular chain exploration were performed under general anesthesia with endotracheal intubation. Surgical findings included incudomalleal joint separation wrapped in soft tissues, with soft tissue connections between the incudostapedial joint (Fig.4). Incus was removed and preserved in normal saline. The tegmen fracture line was followed anteriorly and medially to the geniculate ganglion and posteriorly and inferiorly to the lower part of pyramidal segment of the facial nerve, with opening of the facial nerve canal to complete the subtemporal-supralabyrinthine subtotal facial nerve decompression. A temproalis fascial pedicled flap was used to cover facial nerve. The incus was then replaced and a drop of ear-brain glue was applied to incudomalleal and incudostapedial joints. A 2×2 mm fascia graft was laid under the posteroinferior part of the crus breve incudes, supported with a piece of gelfoam. Speech frequency hearing improved on average by 25 to 30 dB and facial function improved to HB grade II 8 weeks after the operation and to HB grade I 13 weeks later. VE follow up at 5 months after the operation showed essentially normal ossicular chain structure (Fig.5) with an average speech frequency hearing improvement of 40 dB (Fig.10).

Case 2: A 31 years old female was admitted on January 13 2007 for left ear stabbing injury by chopsticks with hearing loss of 4 weeks. Examination showed healed scar in the posterosuperior part of left pars flaccida, and speech frequency conductive hearing loss of 60-75 dB HL in the left ear. An oblique coronary temporal bone CT scanning showed discontinued ossicular chain (Fig.6). VE showed fallen out incus, crus longum incudis lateral dislocation and incus body posterior protrusion (Fig.7). Ossicular chain reduction by attic route was performed under general anesthesia with endotracheal intubation. Exploration showed complete separation of incudomalleal and incudostapedial joints and incus dislocation by 90° (Fig.8). The incus was replaced, reinforced with a drop of ear-brain glue applied to the incudomalleal and incudostapedial joints and gelfoam. The patient noticed significant improvement of hearing following surgery. VE follow up 3 months later indicated well-connected incudomalleal and incudostapedial joints (Fig.9) with speech frequency hearing improvement by an average of about 50 dB (Fig.11).

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