En bloc temporal bone resection using a diamond threadwire saw for malignant tumors

Technical note

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The purpose of this study is to describe a new technique for en bloc temporal bone resection using a diamond threadwire saw (T-saw) as an alternative to cutting the temporal bone with an osteotome. This technique has been performed in 10 patients with external auditory canal and middle ear cancers without any injury to the internal carotid artery or jugular vein. The authors conclude that the use of a diamond threadwire saw after transposing the internal carotid artery anteriorly is a safe, simple, and reliable technique for en bloc temporal bone resection. (DOI: 10.3171/2010.8.JNS10294)

Key Words • temporal bone resection • malignant tumor • internal carotid artery • internal auditory canal • threadwire saw

Recently, en bloc temporal bone resection for malignant temporal bone tumors has been performed safely because of advances in skull base surgical techniques, reconstructive techniques, and radiological diagnosis. In this approach, however, the critical stage of final bone cuts using an osteotome is the point at which most surgical disasters occur, and reports also document difficulties encountered in treating the petrous carotid segments. The problem is that the internal cuts that sever the temporal bone from the skull run adjacent to the course of the ICA and the jugular bulb. Injury to the jugular bulb is not a serious problem because bleeding can be controlled by tamponade of the sigmoid sinus or transverse sinus, and umbilical taping of the internal jugular vein. However, bleeding from a rent of the ICA can be life threatening because it can be only partially controlled in the neck. Moreover, occlusion of the vessels may result in cerebral infarction and even death. Intraoperative trauma to the ICA that was associated with massive stroke and subsequent death has been reported in temporal bone resection. Osteotome cuts require several surgical steps and they can be difficult. To circumvent such drawbacks, we have developed a new technique for performing final cuts in en bloc temporal bone resection using a diamond threadwire saw (T-saw; Mani, Inc.).

Operative Technique

In this technique, incisions are extended to permit adequate exposure for a mastoidectomy, mandibular condylar resection, parotidectomy, and cervical dissection, while the patient is supine and the head is rotated to the opposite side. The mandible is divided to expose the important structures such as the ICA, internal jugular vein, lower cranial nerves, and parotid gland in the retromandibular space. To obtain a view of the jugular bulb, the transverse process of the atlas is removed. To expose the infratemporal fossa space, mandible nerve, and foramen ovale, the zygomatic arch is removed. Exposure of the temporomandibular joint makes it easy to open the carotid canal. After the temporal craniotomy, small occipital craniectomy, and sigmoid plate drilling are performed, the sigmoid sinus and presigmoid dura mater are dissect-
ed from the bone epidurally. A simple mastoidectomy is impossible to perform because the tumor extends to the mastoid process and jugular foramen.

The posterior transjugular approach is performed and the jugular foramen is opened. From the temporal bone side, the foramen ovale, foramen spinosum, and greater superficial petrosal nerve are identified. The petrosal segment of the ICA is exposed under the greater superficial petrosal nerve and it extends to the C7 segment of the ICA and the carotid canal without entering the anterior margin of the tumor, and finally the ICA is available to transpose anteriorly. From the posterior fossa the IAC is dissected and the cranial nerve VII and VIII complex is cut without injury to the meatal loop of the anterior inferior cerebellar artery after opening the dura mater of the IAC.

After these preparations for diamond T-saw resection, the resection lines are determined (Fig. 1). The upper and middle resection line is located from the transition point of the C6/C7 segment of the ICA that continues to the cochlea and IAC to the tegmen mastoideum (upper and middle resection line); to just behind the C7 segment of the ICA, which is transposed anteriorly (anterior resection line); and from the tegmen mastoideum to the IAC and jugular foramen (posterior resection line).

Fig. 1. Illustrations of the operative technique. Left: Schema of the final cuts in en bloc temporal bone resection using a diamond T-saw. Right: Illustration of en bloc temporal bone resection using the diamond T-saw. Nicks for the diamond T-saw (dashed line) represent the following: from the transition point of the C6/C7 segment of the ICA that continues to the cochlea and IAC to the tegmen mastoideum (upper and middle resection line); to just behind the C7 segment of the ICA, which is transposed anteriorly (anterior resection line); and from the tegmen mastoideum to the IAC and jugular foramen (posterior resection line).

Fig. 2. Intraoperative photographs of the technique. Left: Image showing the C6 and C7 segments of the ICA and the third branch of the trigeminal nerve (V3). Right: Image showing the anterior resection line that is just behind the C7 segment of the ICA, which is transposed anteriorly (dashed line).
the middle fossa to the IAC and jugular foramen. With this procedure, subtotal en bloc temporal bone resection can be performed without injuring the ICA and jugular bulb (Fig. 3). After the resection, complete occlusion of the IAC with fat tissue is mandatory to avoid postoperative CSF leakage, because it is impossible to suture the dura mater of the IAC.

Illustrative Case

This 54-year-old woman had been experiencing otorhea, otalgia, and hearing impairment for several months. Examination of a biopsy sample revealed a squamous cell carcinoma. Magnetic resonance imaging demonstrated a mass lesion in the left external ear canal (Fig. 4A and B). An en bloc subtotal temporal bone resection using a diamond T-saw and the revascularized rectus-fat free flap procedure were performed (Fig. 4C). Her postoperative course was uneventful.

Discussion

The T-saw, which was developed by orthopedic surgeons in 1996,10 was introduced for spinal surgery (such as cervical spine laminoplasty to split the spinous process in the midline with minimal bone gaps) and its use has continued to increase.8,11 The final cutting technique using the T-saw in en bloc temporal bone resection has been used by the authors in 10 patients with temporal bone malignant tumors during the past 2 years. Compared with our previous approaches, the duration of the final cuts in en bloc temporal bone resection has become dramatically shorter. We reviewed the videos of 7 patients who underwent previous approaches and the time for the final bone cut required 67 minutes on average. However, this duration was shortened to only a few minutes using this new technique.

Recently, radiotherapy combined with chemotherapy has a tendency to be given priority compared with surgery in the treatment of external auditory canal and middle ear cancers, and resection is required for the reduced-size tumor. However, osteoradionecrosis of the temporal bone is a well-documented complication of radiotherapy to the ear.7 In surgical cases for these cancers, we often observe infection and inflammation of the mastoid sinus after radiotherapy. In preparing for the final cut with the use of the osteotome, a wide exposure is necessary to obtain a favorable angle and to avoid strong brain retraction by a chisel, and mastoid air cells are often opened widely. In these cases, the risk of postoperative infection becomes higher. However, wide exposure and opening of mastoid air cells are less necessary in the preparation for the use of the diamond T-saw, because the T-saw is flexible enough to cut bone without requiring strong brain retraction. In the case of diffuse temporal bone osteoradionecrosis, the final cut using an osteotome involves a risk because the temporal bone is very fragile and the cutting line using chisels occasionally proceeds in an unexpected direction. Therefore, we believe resection using a diamond T-saw has an advantage in surgical cases after radiotherapy.

In en bloc temporal bone resection, the critical stage of final bone cuts with an osteotome is the point at which most surgical disasters occur, and an ICA injury can be life threatening.2 To avoid an ICA injury, techniques such as exposure of the ICA from the petrosal segment to the carotid canal, transposition of the ICA anteriorly, and use of the diamond T-saw are safe, simple, and reliable.
En bloc temporal bone resection using a diamond threadwire saw

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Jimbo, Kamata. Acquisition of data: Miura, Masubuchi, Ichikawa. Reviewed final version of the manuscript and approved it for submission: all authors. Study supervision: Ikeda, Haraoka.

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