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Technical Note:

Vibration producing dissector in dissection and separation of high grade glial tumors from brain tissue

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ABSTRACT

Previously, some different techniques had been presented in terms of precise dissection and separation of tumors from surrounding brain. Purpose of this study was to describe the effect of vibration in the surgical dissection and separation of malignant brain tumors.

We recently developed an instrument for micro-dissection and separation of brain lesions from brain tissue. This instrument was produced by a medical instrument producing factory in Samsun. This instrument has the capability of producing mechanical vibration. The holding and using of this instrument was described.

In this study, we used this instrument in four high grade glial tumors for dissection and separation of these lesions from surrounding brain tissue. Dissection and separation were graded as poor, moderate and good. Vibrato-dissection technique was superior to those of conventional technique in the aspect of dissection and separation of brain tissue.

The capability of dissection and separation with this instrument during surgical treatment of brain tumors may enhance dissection and separation of lesions.

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1. Introduction

Microsurgical intervention to the brain tissue is an extremely delicate procedure in terms of protecting functional neurons located within the gray matter and fibre tracts located within the white matter of the brain. Fissural, sulcal, cisternal and cortical interventions may be used for the reaching down to the lesions. Fissural, sulcal and cisternal interventions are quite different from the transcortical surgical route. During the dissection of fissural and cisternal structures, arachnoidal membranes are opened with sharp dissection techniques. Separation of the brain tissue covering the cisternal and fissural walls is necessary to create a wide-enough surgical corridors. In the other hand, if the lesion is located within the brain tissue it is necessary to open the brain tissue before dissection and separation for reaching down the lesion.

Diffuse brain tumours has an infiltrative characters inside the brain tissue. Because of this properly dissection and separation of these types of lesions are difficult (Shahbabian et al., 1983; Hirsch and Sainte-Rose, 1991; Abraham et al., 2003; Cokluk et al., 2004). Some dissection techniques had been described in neurosurgical practice such as sharp, blunt, micro balloon for facilitation and proper dissection of lesions (Shahbabian et al., 1983; Madrazo et al., 1990; Hirsch and Sainte-Rose, 1991; Abraham et al., 2003; Cokluk et al., 2004). In the sharp dissection technique, micro-scissor is used for gentle dissection. In blunt dissection, the tip of bayonet forceps, a microbaloon, and water-jet are used with or without cotton paddies (Shahbabian et al., 1983; Madrazo et al., 1990; Hirsch and Sainte-Rose, 1991; Abraham et al., 2003; Cokluk et al., 2004). These techniques have some advantages and disadvantages (Shahbabian et al., 1983; Madrazo et al., 1990; Hirsch and Sainte-Rose, 1991; Abraham et al., 2003; Cokluk et al., 2004). In the other hand, brain tissue may be functionally separated as eloquent and non-eloquent areas depend on the functional characteristics. Dissection and separation for reaching down the lesions should pass along the non-eloquent routes as much as possible in the preserving of brain function. It is necessary to keep in

mind that dissection and separation techniques should be minimally invasive and minimally traumatic to the brain tissue in eloquent and/or non-eloquent regions.

In our daily practice, we generally use a combination of blunt and sharp techniques using microscissors, bipolar forceps, cotton paddies, and dissectors. It is very clear that the membranes over the brain such as pia mater and arachnoid mater should be opened by using microscissor. After opening this coverings, the brain tissue should be dissected and separated with blunt dissection because of the soft characteristics of brain tissue.

We recently developed an instrument for micro-dissection and separation of brain lesions from brain tissue. This instrument was produced by a medical instrument producing factory in Samsun. This instrument has the capability of producing mechanical vibration. It was hypothesised that micro-vibration can facilitate gentle dissection of the diffuse lesions seated within the brain tissue. This is a new micro-instrument was designed for gently dissection of lesions from the healthy brain tissue. In this study, we used this instrument in four high grade glial tumors for dissection and separation of these lesions from surrounding brain tissue.

2. Methods

2.1. Patients

Patient population includes four patients underwent the surgical intervention at Ondokuz Mayis University, Medical Faculty, Department of Neurosurgery. All patients had glial tumors and were in adult ages.

2.2. Description of the Instrument

A dissector shape vibration generator was designed for brain separation and dissection. This instrument produces vibration with using of an electrical source. The prototype of this instrument was produced by Aygun Surgical Instruments Co, Inc. The photo of this instrument is shown in Fig. 1. The drawing was shown in Fig. 2. Dissection and separation of ship cadaver brain using micro-vibrato-dissector was shown in Fig. 3.

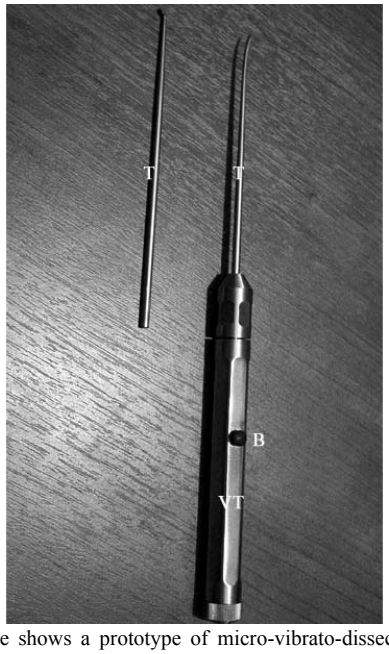

Fig.1. This figure shows a prototype of micro-vibrato-dissector produced by Aygun surgical instruments Co. Inc., (T; Tip of the instrument, VT; Vibrating tool and Battery Cap, B; On/Off button).

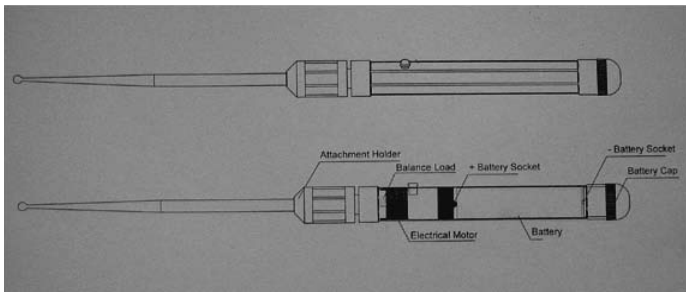

Fig.2. This schematic figure shows mechanical and electrical parts of the instruments

This instrument (micro-vibrato-dissector) has two different parts. The first is the dissector part. This part has different shape and size depends on the necessity for dissection. The second part is the vibration part. This part covers an electrical motor producing vibration in the range between 150-250 Hz. The mechanism of production is the asymmetric turning of the balanced metallic tip of the electrical motor. Three Volt recharcable battery source supply the motor. Fig. 2 shows mechanical and electrical parts of the instruments.

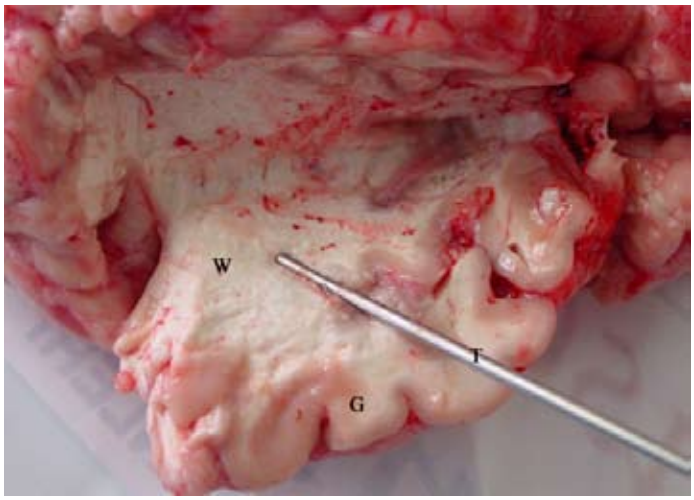

Fig.3. Dissection and separation of ship cadaver brain using micro-vibrato-dissector (W: white matter, G: Gray matter, T: Tip of the instrument).

2.3. Handling of the instrument

Methalic microdissector is commonly used during the microsurgical operations. In many ways, the tip of this device resembles with methalic microdissector. In the other hand, the back of this device is different from those of simple methalic microdissector. Vibration producing components of the device is put in the back part of the instruments. Because of this, the posterior part is thicker than those of anterior part of the instrument. This instrument has a ring in front of the thick section. This part can be used for handling of the device. The vibration function of the device may not work with hand contact. The handling of the device was shown in Fig. 4. If the device was used the normal function (without vibration) with off the button, surgeon can hold any part of the instrument.

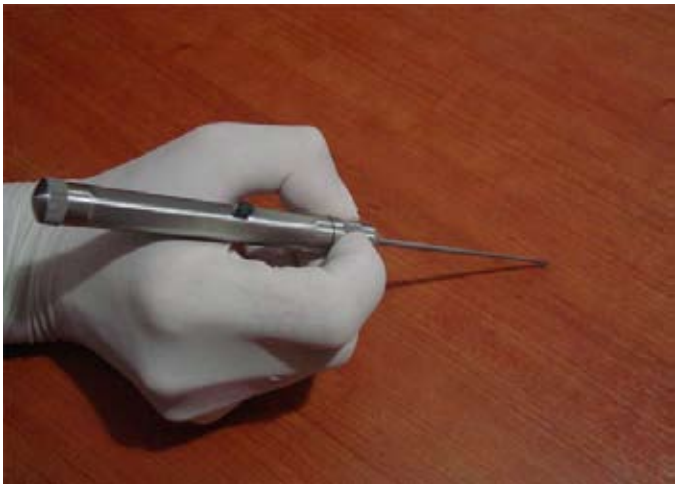

Fig. 4. This figure shows the handling of the instrument

2.4. Operative procedure

During the operation of brain tumors, if the micro-fragmentation of the mass is necessary, generally we use the ultrasonic aspiration instrument. But before reaching down the lesion we should separate the brain tissue if we use the transcortical route. The microvibration-dissector may be used for separation of the brain tissue as. In the other hand after reaching the brain lesions, it is necessary to separate the lesion from the peritumoral brain tissue. In this step we generally use the tip of bipolar forceps, the tip of aspirator and cotton paddies. In this step of the operation the microvibration dissector may also be used for gentle separation of the tumor. Another step of tumor surgery is the fragmentation of the tumors for removing of small pieces of the lesion. For fragmentation of the lesion into small pieces this device may also be used during surgery.

2.5. Evaluation of the usability

The evaluation parameters were as follows; weight and handling of the instrument, dissection and separation of the brain tissue, and pieces fragmentation of the tumours. Dissection and separation were evaluated as poor, moderate and good. These parameters were evaluated during surgery. The results obtained during the operations were evaluated.

3. Results

3.1. Patients

The patient population included four cases aged between 45-70 years old of age. Two of the cases were female and remaining two of them was male. One of them underwent primary surgery and the remaining three of them were operated because of recurrent tumours. In two cases, the tumour located in the right frontal lobe, one left frontal lobe and one right temporal lobe.

3.2. Weight and handling

The major disadvantage of this instrument is the weight in comparison with microdissector. This instrument is heavier than those of classic dissector. The device is opened with on/off button. During the use of this device, the on/off button may give difficulty for handling of the device.

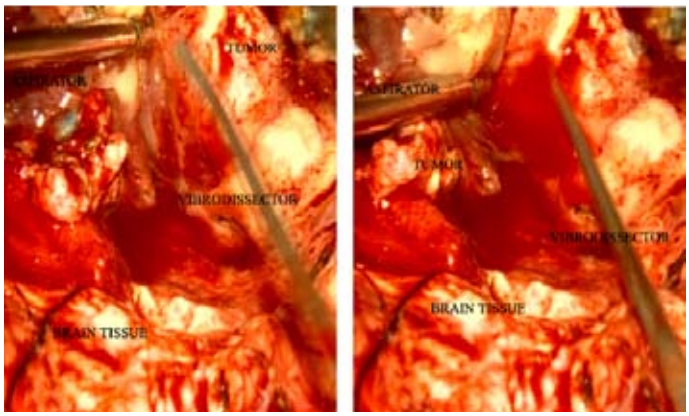

Fig. 5. Intraoperative figure shows using of vibrodissector during surgery.

3.3. Dissection and separation

The connective tissue of the brain is different from other organs. The gray matter largely includes neuronal cells. In the other hand white matter largely covers the fibre tracts. The relatively blunt dissection reinforced with vibration seems useful neurosurgical instrument in comparison with the tip of bipolar coagulator and metallic aspirator. According to our surgical experience, harmful effect of aspirator can be reduced with using of vibration producing dissector during surgical intervention to the brain tissue. According to evaluation degree we can describe the effect of vibration dissector as moderate in comparison with bipolar forceps and the tip of aspirator.

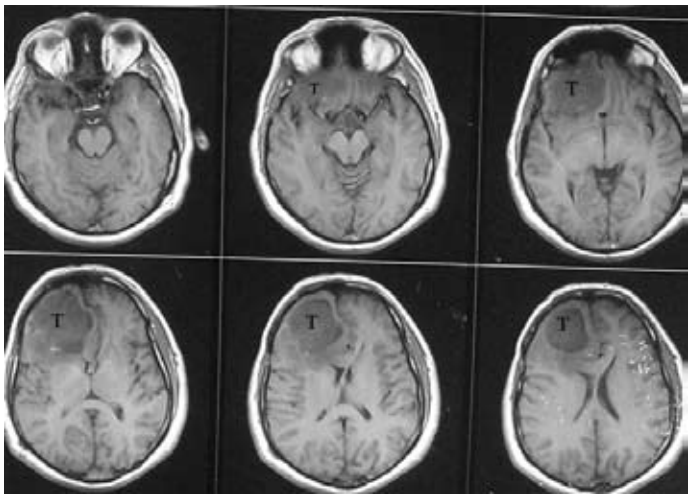

Fig. 6. Preoperative magnetic resonance imaging shows right frontal tumor.

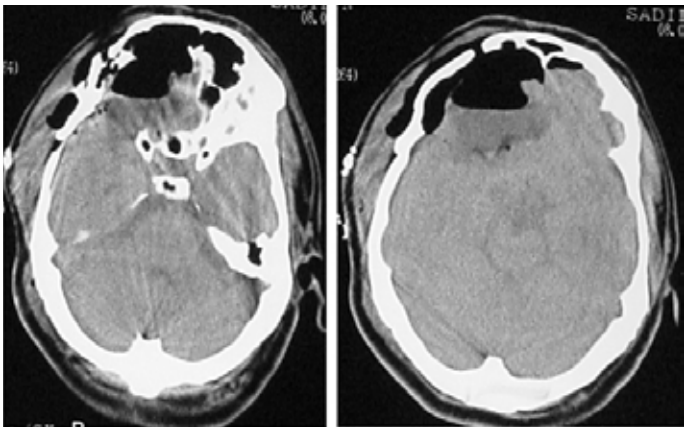

Fig. 7. Postoperative computerized topographic image shows total tumor removal without postoperative hematoma.

Vibrato-dissection technique was superior to those of conventional technique in the aspect of dissection and separation of brain tissue. Preoperative magnetic resonance imaging of a demonstrative case was shown in Fig. 6. Fig. 7 shows total tumor removal without postoperative hematoma in the computerized topographic images. Fig. 8 shows total tumor removal without postoperative contusion around tumor bed in the magnetic resonance images.

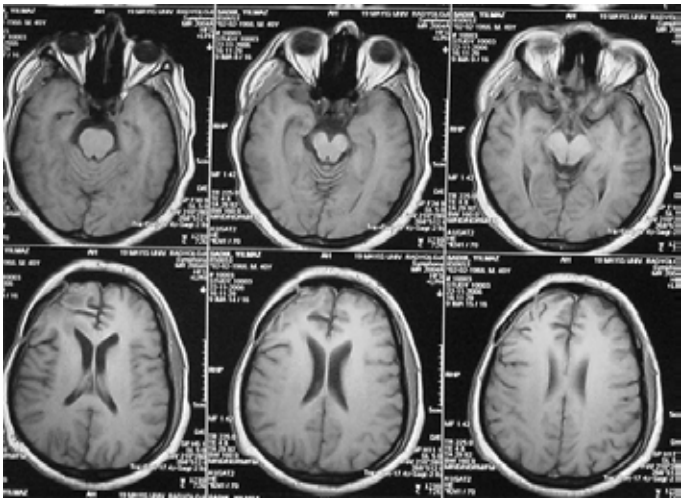

Fig. 8. Postoperative magnetic resonance imaging shows total tumor removal without any perilesional contusion

3.4. Fragmentation

The fragmentation power of this device is weaker than those of ultrasonic vibration device in terms of tumor fragmentation. In the other hand, micro-vibration dissector for trans-cortical dissection and separation is superior to those of ultrasonic vibration. The tip of this device is not sharp; because of this we cannot use this device as a cutting device. The concept of fragmentation is used to describe big size fragment of tumor tissue. This is relatively safe fragmentation in terms of protection big size vascular structures hiding inside the tumor tissue. This device may be categorized as a blunt dissection technique. Fragmentation is available in soft tumor tissue, in the other hand tough and tight tumors do not allow vibrational fragmentation by using this kind of dissector.

4. Discussion

This instrument is a simple machine includes two different parts. The first part is a vibrato-generator. This is an electrical part. It converts electrical power into vibration (150-250 Hz). The mechanism of vibration producing is an unbalanced turning of an electrical motor inside the metallic cup. The speed of the turning of the electrical motor depends on the electrical power. The second part is a metallic micro-dissector. The system utilizes rapidly vibrating blunt metallic tip of the instrument for dissection of the brain tissue. A diapason is a simple model for this instrument. The arms of a diapason produce vibration. Vibration generator inside the metallic cup rapidly vibrates the tip of the metallic dissector attached at the metallic cup.

Vibration is transmitted by two different ways. One of them is air transmission. Another of them is tissue transmission. The effects of micro-vibrato-dissection on the brain tissue are distortion, separation, compression and fragmentation. The tissue response to the vibration may be different depends on the tissue characteristics. The composition of the extracellular matrix proteins, cell composition, and water content may be responsible from this response. Because of this, the response of tumors and brain tissue will give different response to vibration effect.

Proper dissection of brain tissue is an important step in the microsurgical techniques for brain surgery. After opening the brain coverings including the pia mater, a surgeon should dissect and separate the delicate and eloquent or relatively eloquent brain parenchyma. In this stage, dissection and separation appears as a specific surgical technique. These techniques are also extremely important in the step by step removing of brain lesions. In the literature, some methods had been described for this purpose (Shahbabian et al., 1983; Madrazo et al., 1990; Hirsch and Sainte-Rose, 1991; Abraham et al., 2003; Cokluk et al., 2004). These methods aimed maximal protection of normal tissue and maximal dissection and separation of pathologic tissues (Shahbabian et al., 1983; Madrazo et al., 1990; Hirsch and Sainte-Rose, 1991; Abraham et al., 2003; Cokluk et al., 2004). We previously made an experimental study. In this previously conducted experimental study, we evaluated the dissection capacity of vibrato-dissector in fresh ship cadaver brains. According to our evaluations from this study, we concluded that this device is superior to conventional dissection techniques. After this study we decided to use tumor dissection and separation during surgery. In the classical dissection techniques, the tip of metallic aspirator and the tip of metallic dissector touch the brain surface. The gentle movement of surgeon's hands performs the dissection and separation under the operative microscope. The tip of the aspirator has the suction capacity on the brain surface. This effect can damage the brain and may result the loss of brain tissue along the way of dissection. If we are working in the sensitive areas of the brain such as motor or sensitive cortex, the person who does the operation much should be careful for protecting of this area in terms of reducing the postoperative neurological deficits. In this step we should take into account the blunt dissection technique performing by using vibration dissector. The gentle vibration with very small sized frequency will be more effective in the protecting of brain tissue loss during surgical intervention. This device can be used alone with nude tip and/or may be used with cotton pads.

If cortical split technique necessary to reach the tumour pia mater should be opened as possible as the least vascular area. Sharp dissection technique can be used to open the pia mater. After opening the pia mater

there is no need to use the sharp dissection technique. The instruments for conventional dissection techniques such as the tip of bipolar forceps and the tip of metallic aspirator can be dangerous to the brain tissue because of the previously mentioned reasons such as loss of brain tissue, contusion, and primary injury. Before reaching the tumour tissue, some injuries may be seen. It is very clear that micro-vibrato-dissection is more useful in the more gentle dissection of brain tissue.

During the surgical intervention we used the micro-vibrato-dissector with bipolar bayonet forceps and the tip of the aspirator. In this situation, aspirator is used to aspirate the cerebrospinal fluid and necrotic tissues. It is not used for dissection of the tissue. We observed that this kind of dissection has less damaged effect to the vessels in the brain tissue. We concluded that the device producing vibration may be useful in the dissection of brain tissue in terms of protection brain tissue from surgical trauma.

After reaching the tumour tissue, the primary purposes are the dissection of the tumour boundary, separation from the surroundings and completely removing from the brain tissue. The appearance of the tumour tissue is extremely important in the differentiation of the brain from the brain tissue. But in the other hand, the appearance of low grade tumours is similar to the normal brain tissue. After determining the boundaries between brain and tumour, micro-vibrato-dissector may be used in the separation of tumour tissue from the brain. We concluded that this device make easier the dissection of tumours. But at this point we should mention the useful effect of ultrasonic aspirator in the de-bulking of the tumour before separation of the tumour from surrounding brain. In the very soft tumours, even without ultrasonic aspirator, the tumour may be aspirated by using the force of suction producing by normal aspirator. In malignant tumours, after removing the majority of the tumour, the border invaded by the tumour can be cleaned by using micro-vibrato-dissection techniques.

One of the problems observed during surgery is the lack of increasing vibration frequency. In some situation the frequency of vibration was found as inadequate, but we could not increase. The other disadvantage is that it is also frequently needed the bipolar coagulation especially in the vascular tumours. Thus a vibration generator device may be added to the bipolar forceps. With this device we can use the bipolar coagulation and vibrato-dissection same time during tumour surgery. The blunt tip of the device reduces the power of the fragmentation capability. Some roughness on the tip of the device may be useful in the fragmentation of the tumours. Brain tissue contusion did not occur during our surgical intervention. Routinely obtained computerized tomography scans revealed this finding.

5. Conclusion

In conclusion, the newly designed instrument, the micro-vibrato-dissector may be a useful tool in brain surgery the separation and dissection of brain tissue.

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